Lakefarm Retreat Ballajura
District Water Management Strategy

July 2025

Client: Land Group WA

Contents

Appendices

Figures

Tables

Disclaimer

Executive Summary

This District Water Management Strategy (DWMS) has been prepared by Hyd2o on behalf of Land Group WA in support of the Metropolitan Region Scheme (MRS) rezoning of Lots 11 to 23 Lakefarm Retreat, Ballajura (herein referred to as the site).

The site is located within the City of Swan and approximately 13 km north of the Perth CBD.

The proposed rezoning of the site and its indicative concept plan have considered the opportunities and constraints of the existing environment and used this information to inform the development of this document.

The site is generally characterised as having sandy permeable soils with moderate to low Acid Sulphate Soils (ASS) risk. The maximum groundwater level according to the DWER online Perth Groundwater Map and current monitoring program is identified to be several meters below the natural surface across most of the site and suitable for stormwater infiltration. The site contains a mapped multiple use wetland crossing the site from north to east which is not a constraint to development and a resource enhancement wetland at its western boundary. This area has been appropriately used to inform the indicative site plan, and the water management strategy detailed in this document.

The site is currently classified as a Public Drinking Water Source Priority 2 area. This classification will require reclassification to P3*, which Hyd2o understands is a decision of the Western Australian Planning Commission based on a government led strategic planning assessment and greater public good decision-making process.

This document provides an integrated total water cycle management approach to the rezoning application, with an assessment of the pre-development environment, development of water use sustainability initiatives, a stormwater management strategy, nutrient and groundwater management strategy and a plan for implementation. The document provides a clear direction for future planning in terms of adopting best management practices to achieve water sensitive design based on existing site conditions and protect environmental assets.

The DWMS has been prepared in accordance with the principles, objectives, and criteria of Better Urban Water Management (BUWM) (Western Australian Planning Commission, 2008), and also addresses additional requirements of the Department of Water and Environmental Regulation’s Priority 3* (P3*) Areas, Water Quality Protection Note 38 (DWER, 2018)

Implementation of the strategy will be undertaken in accordance with BUWM through the development and implementation of a local water management strategy (LWMS) to support the local structure planning process, and urban water management plan’s (UWMP’s) at the subdivision stage of development.

1. Introduction

This District Water Management Strategy (DWMS) has been prepared by Hyd2o on behalf of Land Group WA in support of the Metropolitan Region Scheme (MRS) rezoning of Lots 11 to 23 Lakefarm Retreat, Ballajura (herein referred to as the site).

The site is located within the City of Swan and approximately 13 km north of the Perth CBD (Figure 1). A concept structure plan for the site prepared to support the MRS Amendment is included as Figure 2.

This document provides an integrated total water cycle management approach to support the rezoning application, with an assessment of the pre-development environment, development of water use sustainability initiatives, a stormwater management strategy, nutrient and groundwater management strategy and a plan for implementation.

The document provides a clear direction for future planning in terms of adopting best management practice, to achieve water sensitive design based on existing site conditions and protect environmental assets.

A completed copy of Department of Water and Environmental Regulation (DWER) DWMS Checklist for Developers is included as Appendix A to assist agencies in the review of this document.

1.1 Planning Context

The site is currently zoned Rural Water Protection under the Metropolitan Region Scheme, and General Rural under the City of Swan Local Planning Scheme No 17 (2024).

The site is located within the North Ballajura area identified as a planning investigation area under the Perth and Peel @ 3.5 million Sub-regional Planning Frameworks released in 2018, which noted the sites strategic location in proximity to the future METRONET Malaga Station.

This DWMS supports the proposed application for changing the zoning of the site to Urban under the MRS to facilitate future urban development.

A summary of the urban water management planning process is detailed in Table 1.

Following this DWMS, two further water management planning documents are likely to be required to facilitate future development of the site, A Local Water Management Strategy (LWMS), and an Urban Water Management Plan (UWMP).

Table 1: Urban Water Management Process

Planning Phase	Planning Document	Urban Water Management Documents
MRS Amendment	MRS Amendment	Lakefarm Retreat Ballajura District Water Management Strategy (DWMS) **THIS DOCUMENT**
Local Structure Plan	Local Structure Plan	Local Water Management Strategy (LWMS) **FUTURE PREPARATION**
Subdivision	Subdivision Application	Urban Water Management Plan (UWMP) **FUTURE PREPARATION**

1.2 Key Documents

Key water management planning documents used to guide the development of this DWMS include:

- Stormwater Management Manual for Western Australia (DWER,2022a)
- Draft State Planning Policy 2.9 Planning for Water (WAPC, 2021a)
- Draft State Planning Policy 2.9: Planning for Water Guidelines for the implementation of Stage Planning Policy 2.9 Planning for Water (WAPC, 2021b)
- Priority 3* (P3*) Areas, Water Quality Protection Note 38 (DWER, 2018)
- Decision Process for Stormwater Management in WA (DoW, 2017)
- Guidelines for District Water Management Strategies (Department of Water, 2013)
- Better Urban Water Management (Western Australian Planning Commission, 2008)

2. Pre-Development Environment

2.1 Site Conditions

A site conditions plan is included as Figure 3.

The total site area is estimated to be approximately 53.6 ha, and is bound by Hepburn Avenue and existing urban development to the south and west, Bush Forever to the north, and largely cleared undeveloped land to the east. The site currently is a rural residential area, and comprises scattered vegetation, houses, local driveways, gardens, firebreaks, a nursery, and the Lakefarm Retreat road reserve.

DWER 1m LiDAR data indicates the site elevation ranges from maximum elevation of approximately 38 mAHD near some of the houses to a minimum of approximately 34 mAHD at the artificial lake in Lot 23.

2.2 Climate

Climate in the region is defined as Mediterranean, experiencing warm dry summers and cool wet winters. Mean annual rainfall for the site over the period 2004-2023 is 736 mm/yr (BoM station: Whiteman Park 009263), with the majority rainfall occurring in the winter months from May to September. Evaporation predominantly exceeds rainfall, with the exception of the wettest months. Temperatures at the site range from a mean minimum of 8.1°C in July to a mean maximum of 31.7°C in February (BoM station: Perth Metro 009225.

2.3 Geotechnical

Environmental geology mapping of the 1:50,000 Perth Sheet 2034 II and Part 2034 III and 2134 III (Gozzard, 1986) is shown in Figure 4. The site is characterised as:

- S8: SAND – Bassendean Sand, very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin.
- S10: SAND - as S8, thin Bassendean Sand over Guilford Formation.

Galt Geotechnics conducted a geotechnical investigation in September 2024, including machine auger boreholes at 11 locations, extending to a depth of 3.0 m, Dynamic Probing Super Heavy (DPSH) tests adjacent at each borehole location, extending to a depth of 3.0 m, and infiltration tests using the 'inverse auger' technique at 7 locations, at depths between 0.55 and 1.76 m. Borehole logs shows that the subsurface conditions were generally similar across the site, consisting of:

- (TOPSOIL) SAND – fine to medium grained, sub-angular to sub-rounded, grey to dark grey, trace fines, trace organics, from surface to depths of up to 0.3 m; overlying
- (SP) SAND – fine to medium grained, sub-angular to sub-rounded, grey/brown/yellow, trace fines, interbedded with a thin lens of a weakly cemented iron indurated sand – coffee rock (typically recovered as gravel size particles) at depths between 1.0 and 2.5 m, extending to a maximum depth investigated of 3 m.

Permeability test results are shown in Table 2. Sites where permeability testing was performed at surface and at depth indicated a generally lower permeability at depth. Most testing at shallow depth recorded rates in excess of 15 m/day.

Table 2: Permeability Test Results (Galt Geotechnics, 2024)

Test Location	Test Depth (m)	Minimum Unsaturated Hydraulic Conductivity (m/day)
IT01 - Shallow	0.55	12.7
IT01 - Deep	1.69	4.9
IT02 - Shallow	0.63	7.9
IT02 - Deep	1.57	>15
IT03	0.84	>15
IT04	0.82	>15
IT05 - Shallow	0.48	14.8
IT05 - Deep	1.62	2
IT06	0.81	>15
IT07 - Shallow	0.52	>15
IT07 - Deep	1.76	3.4
Low levels for deep tests likely to reflect proximity to the water table rather than low permeability soils		

Bore logs for groundwater monitoring bores installed within the site by Hyd2o in May 2024 are shown in Appendix C and similarly showed sand profiles (with traces of coffee rock in some locations), consistent with environmental geology map and Galt Geotechnics testing.

Western Australian Planning Commission mapping identifies the risk of Acid Sulphate Soils (ASS) as a moderate to low risk of occurring within 3 m of natural surface (Figure 4). Galt Geotechnics (2024) testing classified all tested materials as non-acid sulfate soils.

The Department of Environment Contaminated Sites database indicates there are no known contaminated sites within the site area. The nearest contaminated site is located approximately 350m north west of the site and is associated with the Cullacabardee Community area, where a portion of that area has been used for uncontrolled landfill.

2.4 Environmental

Wetland mapping is shown in Figure 5. There is a multiple use wetland crossing the site from north to east (which does not preclude development), and a resource enhancement wetland within the western portion of the site. Lots 124 and 800 located at the northern boundary have mapped conservation category wetlands.

A search of the Aboriginal Heritage Inquiry System indicates the site is located within the boundary of Aboriginal Cultural Heritage (ACH) Register Place 3692 Bennett Brook, a large area which extends over the developed urban areas south of the site.

2.5 Gnangara UWPCA

The site is located within the Gnangara Underground Water Pollution Control Area (UWPCA) (Figure 6a). The Gnangara UWPCA defines the central area of Gnangara groundwater system that provides public water supply as part of the Water Corporations Integrated Water Supply Scheme (IWSS). It has an area of approximately 815 km^2, and is located within the City's of Wanneroo, Swan, and Stirling, and Shires of Gingin and Chittering.

The Gnangara groundwater system includes four wellfields: Mirrabooka, Wanneroo, Pinjar, and Lexia. The site is located within the area of the Mirrabooka wellfield. Bores M110 and M120 are part of Mirrabooka wellfield and are located adjacent to the northern boundary of the site. Abstracted water is conveyed through collector mains to the Mirrabooka Groundwater Treatment Plant (GWTP) where it is treated prior to distribution.

Within the UWPCA, three levels of priority protection are defined, P1, P2 and P3.

1. Priority 1 (P1) areas are defined to ensure there is no degradation to the water resource, and were declared over land where the provision of the highest quality public drinking water was the prime beneficial use.
2. Priority 2 (P2) areas are defined to ensure there is no increased risk of pollution to the water course and where declared over land where the provision of public water supply was a high priority.
3. Priority 3 (P3) areas are defined to minimise the risk of pollution to the water source and were declared over land where water supply needs co-exist with other land uses such as residential, commercial and light industrial developments. Protection of P3 areas are achieved through management guidelines rather than restrictions on land use.

A further category P3* was recently introduced to consider that government may rezone P1 or P2 areas to urban. This situation occurs when the strategic development benefit has been determined to be greater than the water quality protection benefit.

Once rezoning is complete, P1 or P2 area are amended by DWER to P3*. This P3* is a variation of the P3 management approach, to address the increased water quality risks and cumulative impact resulting from the approved land use intensification

The site is currently classified as a Rural-Water Protection zone, which correlates with the Priority 2 (P2) area (Figure 6b). This classification provides an incompatibility with future land use (Urban), and reclassification to P3* is therefore required to facilitate land use change. P3 areas are noted to already co-exist with Water Corporation superficial abstractions bores in close proximity to the site on the other side of Hepburn Avenue.

Wellhead protection zones are shown on Figure 6b. Water Corporation bores have a 300 m radius wellhead protection zone (WPZ) in Public Drinking Water Source Area (PDWSA) Priority 2 and Priority 3 areas.

Advice from DWER indicates urban development within WPZ areas is permitted consistent with the underlying Priority 3 classification, although some restrictions/exclusions may apply such as locating a sewer pump station or petrol stations in these areas which are not permitted. Specific details of prohibited land uses as specified in Priority 3* (P3*) Areas, Water Quality Protection Note 38 (DWER, 2018) are provided in Section 6.

2.6 Surface Water

A surface water plan is shown in Figure 7.

A review of historical aerial imagery and LiDAR Digital Elevation Models (DEMs) indicate the site previously received surface water from external catchments located to its north which then flowed through the site through its lower lying areas toward the east.

A drain was constructed in the late 1960s along this natural pathway. However, in the mid-1980s, with the implementation of Lakefarm Retreat rural residential area, declining groundwater levels, and following earthworks on internal lots these drains are no longer appear to be active within the site, and flow from external catchments to the north no longer occurs. While the site contains several drainage easements, none however currently appear to be functioning to convey flows through the site.

Currently all stormwater appears to be infiltrated within the site through the sandy subsurface profile, as groundwater levels have lowered over time. Appendix D contains historical aerial photos and recent site images to demonstrate the evolution of the sites surface drainage system.

It is important to note the drain constructed in the 1960 is still present downstream of the site and this will provide a potential flow path for post development flows if required.

2.7 Groundwater

In mid 2023, DWER revised the groundwater information reported on their Perth Groundwater Map (online) to report the Gnangara Jandakot maximum and minimum water table contours for 2019. Advice from DWER indicates these revised contours account for the declines and rises in water tables in recent decades and the impacts of current climate trends. These contours are understood to be based on the contouring of the actual recorded maximum and minimum groundwater levels at DWER bores in 2019.

Based on this dataset the site’s 2019 maximum water table elevation ranges from approximately 33.5 to 35.8 mAHD, flowing in a southeast direction.

To refine site groundwater levels, Hyd2o installed 9 bores within the site in May 2024, and have been monitoring groundwater levels monthly since June 2024 as part of an 18-month baseline groundwater investigation. Bore locations are shown in Figure 8. Two nearby DWER bores (MM53 and M60) are also monitored. Long term hydrographs for nearby DWER bores are shown in Appendix E

Groundwater levels in the general area have been recorded by DWER since 1976 (M60), and 1977 (MM53). The average annual maximum groundwater levels (AAMGL) for DWER bores are shown in Table 3 calculated across the period from 2000 – 2023, considered representative of recent climate. Calculations of other groundwater statistics (MinGL, AAMinGL, MGL) are also provided in Table 3.

Site bore monitoring data and hydrographs are shown in Appendix F with monitoring data for site bores shown in Appendix F. In winter 2024, maximum groundwater levels occurred in September at all site bores.

Recorded levels at site bores were used with a correction factor applied based on DWER bore levels relative to their calculated AAMGL (2000-2023) to determine the sites AAMGL.

Site AAMGL's and AAMinGL's are shown in Table 4 and contoured on Figure 8. These contours were marginally lower, but broadly similar to DWER regional mapping.

Based on DWER LiDAR topographic contours the natural surface clearance above AAMGL at the site ranges from approximately a minimum of 1.5 to a maximum of 3.5 m.

Table 3: DWER Monitoring Bore MinGL, AAMinGL, AAMGL, and MGL

Bore	Period of Record	2000-2023 MinGL (mAHD)	2000-2023 AAMinGL (mAHD)	2000-2023 AAMGL (mAHD)	2000-2023 MGL (mAHD)	Sep 2024 Reading (mAHD)	Difference to AAMGL (m)	Depth to AAMGL [1] (m)
MM53	1977 – 2024	32.83	33.15	34.00	34.49	34.22	-0.22	2.67
M60	1976 – 2024	22.36	22.97	23.72	24.13	23.97	-0.25	1.47
	Correction Factor to Apply to Site Bore for AAMGL/AAMinGL (m)[2]						-0.24	

1. Depth to AAMGL approx. only as no detailed natural survey and based on DWER survey TOC and approx. stickup
2. Correction for Jun 2024 to AAMinGL for Bore MM53 was found to be the same (-0.24m) as for AAMGL correction

Table 4: Site Bores AAMinGL & AAMGL

Bore	Nat Surface mAHD	GWL Jun 2024 (mAHD)	Corr Factor (m)	AAMinGL (mAHD)	Depth to (m)	GWL Sept 2024 (mAHD)	Corr Factor (m)	AAMGL (mAHD)	Depth to (m)
GW1	37.64	33.90	-0.24	33.66	3.98	34.83	-0.24	34.59	3.05
GW2	37.28	33.73	-0.24	33.49	3.79	34.70	-0.24	34.46	2.82
GW3	37.34	33.74	-0.24	33.5	3.84	34.78	-0.24	34.54	2.80
GW4	36.82	33.52	-0.24	33.28	3.54	34.53	-0.24	34.29	2.53
GW5	36.82	33.70	-0.24	33.46	3.36	34.70	-0.24	34.46	2.36
GW6	37.62	33.84	-0.24	33.6	4.02	34.82	-0.24	34.58	3.04
GW7	37.94	33.26	-0.24	33.02	4.92	34.33	-0.24	34.09	3.85
GW8	35.88	33.58	-0.24	33.34	2.54	34.60	-0.24	34.36	1.52
GW9	37.30	33.83	-0.25	33.83	3.47	34.82	-0.24	34.58	2.72

2.8 Nutrient Input Assessment & Existing Groundwater Quality

The Urban Nutrient Decision Outcomes (UNDO) model is a decision support tool developed by DWER that evaluates nutrient reduction decisions for urban developments on the Swan Coastal Plain in south-west Western Australia. It is designed for ease-of-use by urban development proponents and for assessment by local and state government authorities.

The tool was developed to assess the nutrient impact of urban development on the Swan Coastal Plain in a consistent and scientifically rigorous manner, and improve understanding relating to nutrient issues, and efficiencies in the investment to manage nutrients. The tool provides users with the ability to implement a range of structural or non-structural design options to evaluate and reduce nutrients exported from urban development.

Modelling outputs of the site's existing land use using UNDO are detailed in Appendix G. The results indicate a predevelopment nutrient export of 340.47 kg/yr of TN and 16.52 kg/yr of TP to the environment annually based on typical nutrient application rate estimates. These estimates consider soil types, groundwater gradients, and depth to groundwater in its calculation. Note the calculations do not however consider the impact of the site nursery and therefore are likely to be conservative (ie provide a low estimate).

Estimates of post development nutrient input and export are addressed in Section 5.3.

To establish a groundwater quality baseline, Hyd2o has been collecting groundwater quality samples quarterly as part of an 18 month predevelopment monitoring program. Results obtained from samples to date are summarised in Appendix H for physical parameters, nutrient and metals, with laboratory reports included as Appendix I covering all tested parameters.

Due to existing land uses and on-site wastewater management, Hyd2o included analysis of pathogens at all bores and pesticides and herbicides at bores GW5, GW6 and GW9 located near the Lot 16 nursery, for the sampling event in September 2024.

Tables 5 and 6 summarise the mean values of all groundwater sampling events undertaken to date. The results were compared to ANZECC (2000) guideline trigger levels for wetlands in South-west Australia.

- Mean pH showed acidic values and were below the ANZECC (2000) guideline range of 6.5 – 8.0 at all bores.
- Electrical Conductivity (EC) mean falls within the ANZECC (2000) guideline range of 0.3 – 1.5 mS/cm at all bores, apart from bores GW2, GW5 and GW8 which were below the guideline range.
- Mean nutrient levels for Total Nitrogen (TN) ranged from 0.84 to 5.41 mg/L while Total Phosphorus (TP) were below the laboratory detectable limit (0.05 mg/L) at all bores apart from GW6 (0.07 mg/L) and GW8 (0.14 mg/L). These values are within the range of expected values or nutrients on the Swan Coastal Plain given current site and surrounding land use. ANZECC (2000) guideline trigger values are 1.50 mg/L for TN and TP is 0.06 mg/L.
- Minor metals exceedances were observed for Chromium, Copper, Lead, Nickel and Zinc, based on ANZECC (2000) guidelines.
- Pesticides and herbicides analysis showed levels below laboratory detectable limit for all parameters at all bores.
- Pathogens were below laboratory detectable limit for E.coli and Thermotolerant coliforms for all bores, apart from GW3 with Thermotolerant coliform as 480 cfu/100mL.

Table 5: Groundwater Physiochemical and Nutrients Summary

Parameters		**Bore**								
		GW1	**GW2**	**GW3**	**GW4**	**GW5**	**GW6**	**GW7**	**GW8**	**GW9**
pH	Minimum	3.54	4.16	3.99	3.67	4.48	3.19	4.35	5.00	5.01
	Mean	**3.80**	**4.82**	**4.40**	**4.46**	**4.68**	**3.96**	**4.68**	**5.22**	**5.26**
	Median	3.83	4.84	4.26	4.41	4.52	3.92	4.54	5.14	5.11
	Maximum	3.99	5.62	5.38	5.34	5.23	4.83	5.14	5.49	5.70
EC (µS/cm)	Minimum	0.35	0.14	0.14	0.74	0.15	0.80	1.03	0.21	0.59
	Mean	**0.39**	**0.16**	**0.35**	**1.10**	**0.26**	**1.13**	**1.12**	**0.24**	**0.79**
	Median	0.38	0.14	0.34	1.02	0.29	1.14	1.07	0.24	0.82
	Maximum	0.46	0.25	0.55	1.82	0.38	1.55	1.29	0.27	1.02
Total Nitrogen (mg/L)	Minimum	1.10	0.75	0.82	1.10	0.59	0.90	0.65	0.88	1.70
	Mean	**1.30**	**5.41**	**2.44**	**1.86**	**0.91**	**3.43**	**0.84**	**4.64**	**2.16**
	Median	1.40	6.50	1.20	1.70	0.68	3.10	0.82	1.40	1.90
	Maximum	1.40	9.70	7.70	2.80	1.80	6.50	1.00	18.00	2.80
TKN (mg/L)	Minimum	0.91	0.42	0.40	1.00	0.18	0.73	0.65	0.80	1.60
	Mean	**1.26**	**0.99**	**1.17**	**1.80**	**0.79**	**3.05**	**0.80**	**1.41**	**2.02**
	Median	1.40	0.74	0.71	1.70	0.68	2.00	0.81	1.00	1.70
	Maximum	1.40	2.50	3.00	2.60	1.60	5.90	0.99	3.00	2.80
NOx (as N) (mg/L)	Minimum	0.01	0.26	0.02	0.05	0.01	0.01	0.01	0.02	0.04
	Mean	**0.04**	**4.43**	**1.26**	**0.09**	**0.14**	**0.40**	**0.05**	**3.24**	**0.16**
	Median	0.01	5.70	0.19	0.05	0.05	0.17	0.02	0.05	0.19
	Maximum	0.19	7.20	4.70	0.22	0.41	1.10	0.18	15.00	0.33
Total Phosphorus (mg/L)	Minimum	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.05
	Mean	**0.05**	**0.05**	**0.05**	**0.06**	**0.05**	**0.07**	**0.05**	**0.14**	**0.05**
	Median	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.09	0.05
	Maximum	0.05	0.05	0.05	0.09	0.05	0.13	0.05	0.36	0.05
Phosphate as P (mg/L)	Minimum	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Mean	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.04**	**0.01**
	Median	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01
	Maximum	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.01
Nitrate-N (mg/L)	Minimum	0.01	0.26	0.02	0.05	0.01	0.01	0.01	0.02	0.04
	Mean	**0.04**	**4.41**	**1.26**	**0.08**	**0.14**	**0.40**	**0.05**	**3.22**	**0.15**
	Median	0.01	5.70	0.18	0.05	0.05	0.17	0.02	0.05	0.18
	Maximum	0.19	7.20	4.70	0.21	0.41	1.10	0.18	15.00	0.31
Nitrite-N (mg/L)	Minimum	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Mean	**0.01**	**0.01**	**0.01**	**0.03**	**0.01**	**0.01**	**0.01**	**0.05**	**0.02**
	Median	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.05	0.01
	Maximum	0.01	0.01	0.05	0.05	0.05	0.01	0.01	0.14	0.06
Ammonia as NH_3-N (mg/L)	Minimum	0.29	0.01	0.05	0.10	0.12	0.05	0.22	0.04	0.01
	Mean	**0.53**	**0.02**	**0.11**	**0.22**	**0.13**	**0.10**	**0.27**	**0.13**	**0.09**
	Median	0.55	0.02	0.14	0.24	0.13	0.10	0.27	0.14	0.05
	Maximum	0.65	0.03	0.16	0.39	0.16	0.15	0.31	0.19	0.27

Table 6: Groundwater Metals Summary

Parameters		**Bore**								
		GW1	**GW2**	**GW3**	**GW4**	**GW5**	**GW6**	**GW7**	**GW8**	**GW9**
mg/L										
Arsenic	Minimum	0.0010	<0.0010	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Mean	**0.0011**	**<0.0010**	**0.0011**	**0.0011**	**0.0012**	**0.0016**	**<0.0010**	**<0.0010**	**<0.0010**
	Median	0.0011	<0.0010	0.0010	0.0010	0.0010	0.0010	<0.0010	<0.0010	<0.0010
	Maximum	0.0014	<0.0010	0.0013	0.0014	0.0016	0.0026	<0.0010	<0.0010	<0.0010
Cadmium	Minimum	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Mean	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.00012**	**<0.0001**	**<0.0001**	**0.0001**
	Median	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0001
	Maximum	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00019	<0.0001	<0.0001	0.0002
Chromium	Minimum	<0.0001	<0.0010	0.0010	0.0020	0.0012	0.0024	0.0020	0.0013	0.0019
	Mean	**<0.0001**	**<0.0010**	**0.0017**	**0.0028**	**0.0024**	**0.0064**	**0.0022**	**0.0034**	**0.0029**
	Median	<0.0001	<0.0010	0.0017	0.0026	0.0024	0.0063	0.0023	0.0039	0.0028
	Maximum	<0.0001	<0.0010	0.0022	0.0037	0.0036	0.0100	0.0024	0.0041	0.0046
Copper	Minimum	0.0010	<0.0010	0.0010	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Mean	**0.0012**	**<0.0010**	**0.0012**	**0.0012**	**<0.0010**	**0.0027**	**<0.0010**	**<0.0010**	**0.0029**
	Median	0.0012	<0.0010	0.0010	0.0010	<0.0010	0.0034	<0.0010	<0.0010	0.0027
	Maximum	0.0015	<0.0010	0.0018	0.0016	<0.0010	0.0045	<0.0010	<0.0010	0.0061
Lead	Minimum	<0.0010	<0.0010	0.0010	0.0010	0.0010	0.0021	0.0010	<0.0010	0.0010
	Mean	**0.0011**	**<0.0010**	**0.0011**	**0.0013**	**0.0011**	**0.0113**	**0.0012**	**0.0012**	**0.0034**
	Median	0.0010	<0.0010	0.0010	0.0010	0.0010	0.0055	0.0010	0.0010	0.0022
	Maximum	0.0013	<0.0010	0.0017	0.0024	0.0014	0.0240	0.0021	0.0018	0.0071
Mercury	Minimum	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
	Mean	**<0.00005**	**<0.00005**	**<0.00005**	**<0.00005**	**<0.00005**	**<0.00005**	**<0.00005**	**<0.00005**	**<0.00005**
	Median	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
	Maximum	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	Minimum	0.0087	0.0010	0.0017	0.0044	<0.0010	0.0032	0.0039	<0.0010	<0.0010
	Mean	**0.0125**	**0.0010**	**0.0031**	**0.0059**	**<0.0010**	**0.0042**	**0.0061**	**0.0011**	**0.0031**
	Median	0.0120	0.0010	0.0025	0.0045	<0.0010	0.0047	0.0066	0.0010	0.0030
	Maximum	0.0180	0.0011	0.0059	0.0100	<0.0010	0.0048	0.0073	0.0016	0.0048
Zinc	Minimum	0.0012	0.0010	0.0013	0.0019	0.0010	0.0010	0.0010	0.0013	<0.0010
	Mean	**0.0032**	**0.0016**	**0.0037**	**0.0052**	**0.0023**	**0.0104**	**0.0031**	**0.0042**	**0.0062**
	Median	0.0022	0.0015	0.0023	0.0060	0.0028	0.0110	0.0029	0.0031	0.0041
	Maximum	0.0069	0.0029	0.0094	0.0070	0.0038	0.0190	0.0049	0.0086	0.0170

2.9 Opportunities and Constraints

Based on the above assessment of the sites existing environment, the following key constraints and opportunities guide the development of this water management strategy:

- The site has a reasonable clearance to groundwater and permeable soils suitable for infiltration of stormwater post development.
- With regards to surface water, there are no currently active natural or constructed watercourses within the site, and no external catchments currently drain into the site. Downstream of the site the historical drains still exist and may provide a flow path for the site post development if required.
- Water Corporation bore wellhead protection zones (WPZ) which extend into the site will be permitted to have urban development within the WPZs consistent with their underlying Priority 3 classification although some land use restrictions/exclusions may apply.
- Opportunities exist with land use change to improve the existing stormwater management and water quality treatment outcomes for the site.

Based on this assessment the site is considered relatively unconstrained hydrologically, and it is considered the water management processes of Better Urban Water Management (WAPC, 2008) will be suitable for guiding water management during land use change.

3. Water Management Principles and Objectives

Key design principles and criteria used to formulate the water management strategy for the site are shown in Table 7 and have been established consistent with the key reference documents previously detailed in Section 1.2, and reflect the sites constraints and opportunities identified in Section 2.

Table 7: Design Principles and Objectives

Strategy Elements	DWMS Method and Approach
Water Use Sustainability	
Water Efficiency	• Water efficiency implementation to be consistent with Building Codes of Australia requirements. • Establish "Waterwise" Public Open Spaces and landscaping. • Maximise infiltration and retention of stormwater within the site.
Water Supply	• Water Corporation IWSS for lots, rainwater tanks (non-mandated) • Minimise use of scheme water for non-drinking purposes. • Use of groundwater for POS irrigation.
Wastewater	• Water Corporation reticulated sewerage.
Stormwater	
Ecological Protection	• Application of best management practices • Avoidance of land uses in compliance with DWER (2017) for P3* areas • Use of infiltration systems at lot scale to infiltrate 15mm on site. • Establishment of biofiltration area for treatment and infiltration of first 15mm road runoff within POS and road reserves.
Serviceability	• Piped drainage system sized to convey 20% annual exceedance probability (AEP) event. • 20%AEP event to be infiltrated/managed within POS area.
Flood Protection	• Overland flow paths within road reserves for safe conveyance of flows exceeding pipe drainage system capacity. • 1%AEP event to be infiltrated/managed within POS area, with potential use of downstream existing drains for off-site discharge if required. • Establish minimum habitable floor levels at 0.5m above the 1%AEP flood level. • All stormwater to be infiltrated within a period not exceeding 96hrs to prevent mosquito and midge breeding.
Groundwater	
Fill & Subsoil	• Cut and fill earthworks and subsoil (if required) to minimised fill importation
Acid Sulphate Soils	• If required, any management of Acid Sulphate Soils to be handled as a separate process consistent with DoE (2004) requirements and reported in future water management documents.
Implementation	
Process	• Future stages of planning and post development monitoring consistent with BUWM (WAPC, 2008).

4. Water Use Sustainability Initiatives

4.1 Water Use Efficiency

Development of the site will lead to an increased local demand for potable water and irrigation of POS areas. Water conservation measures will be implemented to reduce scheme water consumption within the development consistent with Water Corporation's "Waterwise" land development criteria. Measures to be adopted will include:

- Promotion of the use of Waterwise practices including water-efficient fixtures and fittings (taps, showerheads, toilets, rainwater tanks, Waterwise landscaping).
- Buildings to be built to 6-star building standards.
- Water-efficient POS design including the use of native plants.
- Use of groundwater bores for irrigation of POS.
- Maximising on-site retention and infiltration of stormwater at source.

More specific details on measures and approaches to be adopted to achieve water use efficiency objectives will be appropriately presented in later stages of planning and landscape design.

4.2 Water Supply

Potable water supply is proposed to all lots in the site via the Water Corporation Integrated Water Supply System (IWSS).

With respect to groundwater availability for POS irrigation, the site is located within the Mirrabooka groundwater area, and the Perth-Superficial Aquifer is fully allocated. DWER's online Water Register indicates there are three groundwater licences currently within the site comprising a total allocation of 75,960 kL/year. These licences are summarised in Table 8.

With respect to POS irrigation, based on the concept structure plan the extent of POS area within the site requiring long term irrigation is estimated to be approximately 4.08 ha. Based an irrigation estimate for POS of 6750 kL/ha/year, it is estimated approximately 30,600 kL/yr will be required to irrigate the sites POS. The current allocation of 75,960 kL is more than sufficient to meet this requirement.

POS irrigation bores will be located in consultation with agencies. Hyd2o understands bores are required to be located outside of wellhead protection zones (WPZ's) based on DWER advice.

Table 8: Existing Groundwater Licences

Groundwater Licence	Licence Allocation kL/year	Expiry Date
154916	15350	17/12/2029
154918	45100	15/1/2035
170283	15510	17/12/2029

4.3 Wastewater Management

Wastewater will be managed by the Water Corporation via a reticulated sewerage system.

Consistent with DWER (2018) requirements sewerage plans will be developed in due course with a risk assessment process that considers PDWSAs, particularly the location of wellhead protection zones (WHPZs) and giving them the highest protection.

5. Stormwater Management Strategy

Stormwater management at the site will be in undertaken in accordance with Better Urban Water Management (WAPC, 2008), DWER' s Priority 3* (P3*) Areas, Water Quality Protection Note 38 (2018), the City of Swan's principles for water quality management, and the Stormwater Management Manual for Western Australia (DWER, 2022), and will be conducted consistent with water sensitive design practices.

The system will broadly consist of at source lot infiltration systems, piped road drainage, distributed biofiltration areas, and stormwater storage areas and swales in POS aimed at retaining, treating, and maximising infiltration within the site.

Best management practices suited to the site to be implemented at lot, street and estate scale include:

- **Lot Scale**: infiltration systems, water-wise landscaping, rainwater tanks.
- **Street Scale**: piped stormwater conveyance system with bottomless manholes.
- **Estate Scale**: Ephemeral biofiltration and flood storage areas integrated with POS, use of amended soils and plantings in bioretention areas, monitoring and reporting.

The location of all estate scale stormwater management areas are proposed to be located outside of CCW buffer areas and retained vegetation within the proposed conservation POS areas, with due consideration of the sites existing topography and historical flow paths.

5.1 Stormwater Management

Although an MRS Amendment does not typically require a structure plan level of detail, the implementation of the above strategy on an indicative concept plan for the site (Figure 2) has been performed for this DWMS to inform the approximate location, area, and volume for stormwater management based on preliminary modelling.

This modelling has been undertaken to provide proof of concept and inform an agreed approach to stormwater management post development and will be refined as part of the LWMS and local structure planning process and UWMP.

Preliminary stormwater storage design was undertaken using the infiltration modelling program PONDS. This numerical infiltration model is specifically designed for modelling groundwater-surface water interactions for the design of stormwater infiltration areas, based on finite difference computer program MODFLOW, developed by the US Geological Survey.

The design storms modelled by PONDS were calculated internally by the model with reference to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers, Australia 2016) and the Bureau of Meteorology Computerised Design IFD Rainfall System. The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 1 to 72 hours.

Key stormwater modelling runoff parameters are shown in Table 9. These rates have been based on Hyd2o's CURRV Runoff Calculator (Appendix J). Hyd2o's CURRV runoff calculator is a standardised approach used by Hyd2o across all development projects to estimate runoff rates. In estimating runoff rates CURRV considers rainfall IFD's, land use breakdown, percentages of impervious and pervious areas within land use type and likely initial and continuing loss of soil types. Importantly it also considers Book 5 Chapter 3 of Australian

Rainfall and Runoff (Ball, et al 2106), which details the relationship between Effective Impervious Area (EIA) and Total Impervious Area (TIA) and considers the different behaviour in runoff that occurs from areas which are directly connected and those impervious areas which are only indirectly connected. Research has found the Effective Impervious Area is typically in the range of 55-65% of TIA for Australian catchments.

Other key parameters used in modelling include:

- Base of superficial aquifer at -7 mAHD from the DWER Perth Groundwater Map (online).
- Biofiltration area side slopes set at 1:6 with maximum depth 0.3m.
- Side slopes for flood storage were set at 1:6 with a maximum total depth of 1.20m.
- Storage inverts set a minimum 0.4m above the sites MGL (0.85m above AAMGL).
- Saturated horizontal hydraulic conductivity for modelling purposes of 5 m/day.

Modelled storage volumes, areas, flood rise, and inverts are detailed in Table 9 and Figure 9 for managing 15mm water quality treatment requirements and 20% and 1& AEP events. Note that these estimates are based on infiltrating all stormwater on site and smaller storages may be possible with downstream discharge along the historical flow path, which will be considered at LWMS stage.

Further details on the adopted stormwater management measures will be provided at later LWMS and UWMP stages of planning based on refined modelling and detailed site-specific investigations.

5.2 Groundwater Management

5.2.1 Fill and Subsoil Drainage

A copy of the engineering servicing report is included as Appendix L. Based on the sites groundwater levels and existing clearances to natural surface, cut to fill earthworks will be conducted in order to minimise fill importation.

The need for subsoil drainage will be reviewed at LWMS stage based on the final earthworks strategy and with consideration of opportunities for downstream discharge and refined water balance modelling outcomes.

Note final proposed lot levels and cut/fill calculations are a detailed design issue to be addressed during the preparation of detailed engineering design drawings and preparation of the UWMP and will be ultimately submitted for council approval at that stage.

5.2.2 Acid Sulphate Soils

As previously discussed in Section 2.3, the whole site is classified as moderate to low risk of ASS at <3 m depth, and Galt Geotechnics (2024) testing classified all tested materials as non-acid sulfate soils

Notwithstanding, any required management of acid sulphate soils (ASS) will be addressed by a separate study if required depending on possible disturbance and excavation depths for engineering services. Details regarding the outcomes of any ASS studies required will be included as part of later water management planning document for the site. All assessment and management of ASS will be conducted in accordance with the Acid Sulphate Soil Guideline Series documentation (Department of Environmental Regulation, 2015a & b).

Table 9: Stormwater Management Summary

Land Use & Runoff Parameters	**Catch 1**	**Catch 2**	**Catch 3**	**Catch 4**	**Catch 5**
Residential Lots (ha)	12.57	6.93	4.29	3.58	3.88
Roads (ha)	5.11	2.41	2.11	0.99	1.51
POS (ha)	0.97	1.69	0.83	0.59	-
Equiv Imp Area (ha) (15 mm)	3.17	1.54	1.37	0.62	0.97
Equiv Imp Area (ha) (20% AEP)	5.41	2.76	2.10	1.24	1.62
Equiv Imp Area (ha) (1% AEP)	8.95	4.85	3.47	2.22	2.70
Storage Parameters					
Indicative Invert (mAHD)	35.50	35.50	35.50	35.20	35.40
Side Slopes (v:h)	1:6	1:6	1:6	1:6	1:6
Groundwater Level (mAHD)	34.50	34.40	34.35	34.35	34.20
MGL (2000-2023)	34.95	34.85	34.80	34.80	34.65
Water Quality Treatment: 15mm Event Biofiltration Storage					
Base Area (m^2)	840	1050	650	364	222
Flood Rise from Biofiltration Invert (m)	0.27	0.07	0.13	0.09	0.24
TWL (mAHD)	35.57	35.57	35.63	35.29	35.64
TWL Area (m^2)	1262	1110	751	409	452
Volume (m^3)	283	76	91	35	81
Flood Management: 20%AEP (inclusive of 15mm Event Storage)					
Flood Rise from Biofiltration Invert (m)	0.41	0.32	0.38	0.37	0.51
TWL (mAHD)	35.91	35.82	35.88	35.57	35.91
TWL Surface Area (m^2)	2502	1337	958	566	731
Volume (m^3)	806	381	304	171	240
Critical Storm (hr)	1	1	1	1	1
Flood Management: 1% AEP (inclusive of 15mm Event Storage)					
Flood Rise from Biofiltration Invert (m)	1.19	1.20	1.18	1.18	1.20
TWL (mAHD)	36.69	36.70	36.68	36.38	36.60
TWL Surface Area (m^2)	4666	2280	1743	1145	1538
Volume (m^3)	3590	1956	1372	851	1015
Critical Storm (hr)	6	6	6	6	6

5.3 Nutrient Management

Post development UNDO modelling of the site is detailed in Appendix M, showing the change with respect to nutrient application and export for the site compared to current use.

Modelling was performed on the indicative concept plan used for stormwater modelling in Figure 2. The modelling indicates land use change will result in nutrient exports of 131.56 kg/yr for TN and 9.68 kg/yr TP post development. Following water sensitive urban design implementation, exports are reduced to 123.48 kg/yr for TN and 9.08 kg/yr for TP.

These rates are far lower than pre development calculated levels, as 340.47 kg/yr for TN and 16.52 kg/yr for TP (Section 2.8).

5.4 Water Balance Modelling

Results of pre and post development water balance modelling for the site are presented in Table 10. Modelling has been based on regional estimates of key parameters at annual scale, with the balance outcomes of the site primarily influenced by rainfall inputs and evapotranspiration losses.

Key parameters used in modelling are presented as follows for the predevelopment model:

- Annual average rainfall of 736 mm/yr (BoM station: Whiteman Park 009263, 2004-2023).
- Recharge the shallow groundwater of 18% for vegetated areas and 45% for pasture based on Xu et al (2009).
- Groundwater throughflow estimated based on site groundwater mapping with water table gradient (1 in 2000), aquifer thickness (~42m) and transmissivity of 600 m/d (Davidson & Yu, 2008).
- Evapotranspiration for pasture estimated as 339 mm/yr (Scott & Sudemeyer, 1993).
- Evapotranspiration for vegetation areas estimated as 400 mm/yr (Silberstein et al, 2007).
- Evapotranspiration for urban hardstand areas (eg roads) estimated to be negligible.
- Existing superficial aquifer use of 75,960 kL/yr consistent with existing licencing.

The balance of input water is assumed to be discharged via surface runoff. On this basis, to balance the model, surface runoff was estimated as 0% of rainfall for the predevelopment (existing)condition, which is consistent with current site observations.

Parameters were then adjusted to represent a post development urban residential site condition based on the indicative concept plan as follows:

- Water supply for POS irrigation will be via groundwater abstraction. An irrigation rate of 6,750 kl/ha/yr was assumed (consistent with DWER allocation rates) over a 4 ha area.
- Scheme water used for lot irrigation post development applied over 15% of the lot area.
- Evapotranspiration for residential areas assumed to be 350 mm/yr (Silberstein et al, 2007).
- Groundwater recharge for urban residential to be 50% of rainfall (Xu et al ,2009).

Surface runoff post development was assumed to match pre-development flows based on stormwater being infiltrated on site. Groundwater throughflow was similarly considered to remain similar to the predevelopment condition.

The balance of input water in the model is assumed to be discharged from site via sub-soil drainage to maintain existing groundwater levels. To balance the model, post development subsoil drainage was estimated to represent approximately 25% of the overall post development water balance. This is largely due to the reduction in groundwater abstraction and introduction of garden scheme water. This modelling outcome will be considered in LWMS stage planning and the refinement of the proposed stormwater system.

Table 10: Pre and Post Development Water Balance

Pre-Development		**Use**	**Area (ha)**	**Quantity mm/yr**		**Total kL/yr**	**%**
Inputs	Rainfall		54	736		397,440	76
	Groundwater In					123,188	24
					Total	**520,628**	**100**
Outputs	Evapotranspiration	Vegetation	11	400		44,000	9
		Pasture	38	339		128,820	25
	Recharge	Vegetation	11	132		14,573	3
		Pasture	38	331		125,856	24
	Groundwater Out					131,400	25
	Water Use					75,960	15
	Surface Water (Balance)					19	0
					Total	**520,628**	**100**
Post Development							
Inputs	Rainfall		54	736		397,440	69
	Scheme Water		31			54,675	10
	Groundwater In					123,188	21
					Total	**575,303**	**100**
Outputs	Evapotranspiration	Vegetation	11	400		44,000	8
		Lots	31	350		108,500	19
	Recharge	Vegetation	11	132		15,898	3
		Lots	31	331		103,040	18
	Groundwater Out					131,400	23
	Water Use					27,000	5
	Surface Water					719	0
	Balance (subsoil export)					145,446	25
					Total	**575,303**	**100**

6. Water Quality Protection Note 38

The Priority 3* (P3*) Areas, Water Quality Protection Note 38 (DWER, 2018) provides additional recommendations above WAPC (2008) requirements to be considered in the development of water management strategies and plans for P3* areas. These recommendations as specified in DWER (2018) as follows:

- Early DWER involvement in the planning process to maximise the potential to protect drinking water quality and public health
- Exclusion of the following land uses within P3* Areas ; airport, amusement park, aquatic centre (unless backwash disposed to reticulated sewerage), caravan and park home park, campground (unless connected to reticulated sewerage), cemetery, hospital , education – tertiary and scientific research, golf course, landfill, waste transfer station, recycling depot, light, heavy and rural industry (including dry cleaner), motor vehicle repair, wash, sales and racing, service station, fuel depot, works depot, underground fuel and chemical storage, bulk chemical storage/handling (e.g. warehouse), wastewater treatment plant, ponds, irrigation and managed aquifer recharge (if not treated to drinking water standards).
- Application of best management practices to appropriate land uses.

Although an MRS Amendment does not typically require a structure plan level of detail, the implementation of the above recommendations are reflected in an indicative concept plan for the site (Figure 2) which has been used for this DWMS to inform modelling to determine the approximate location, area, and volume for stormwater management. It is important to note the plan is however only an initial indicative concept at this stage and will be subject to considerable review during the local structure planning process, which will ensure the local structure plan alignment with WQPN 38 requirements in due course.

Table 11 provides a summary of how the DWMS has addressed requirements of WQPN 38 (DWER, 2018) commensurate for this stage of planning as detailed in Table 3 of that document. Requirements for future planning are provided in Section 7.1.

Table 11: WQPN 38 (DWER,2018) DWMS Requirements

Consideration	WQPN 38 DWMS Requirement	DWMS Compliance
Land Uses	Restricted to certain types of land uses.	Refer Section 7.1. Land use restrictions are stated as per WQPN 38 advice
	Determine potential impact of proposed land use change on water quality, using *Australian drinking water guidelines.*	Refer Section 6.1 Risk Assessment and Appendix N
Sewerage	Pre-development water quality monitoring program and sampling and analysis plan, including for pathogens, nutrients and other contaminants.	In progress Refer Section 2.8 (Data) & 7.2 (Program) Tables 5, 6 (Data), & 12 (Program) Appendices F, H, and J (Data, Lab Reports)
	Sewerage plans should be developed with a risk assessment process that considers PDWSAs, particularly, location of wellhead protection zones (WHPZs) and giving them the highest protection.	Refer Section 4.3 and Appendix L Servicing Report. Reticulated sewerage plans are to be developed as part of later stages of planning compliant with WQPN 38 specifications

Consideration	WQPN 38 DWMS Requirement	DWMS Compliance
Public Open Space	Incorporate WHPZs into public open space where possible, preferably in conservation open space.	Requirement noted as where possible. To be addressed during local structure plan development with consideration of potential irrigation bore locations, POS quantities, stormwater management locations, and other retained conservation areas.
Stormwater and Groundwater Management	Use the Stormwater management manual for Western Australia and Decision process for stormwater management in Western Australia	Refer Section 1.2, Section 3 and Table 7 Use of these document represents standard practice for urban development in WA.
	Site-responsive design to direct surface and subsoil drainage away from drinking water extraction points such as via slopes and road cambers (curve upwards in the middle).	Refer Figure 9 Stormwater Management Plan catchment and preliminary biofilter and storage locations away from WHPZ’s. To be refined at LSP stage.
	Recognise that current water infiltration rates and groundwater levels may change as a result of urbanisation.	Noted. Stormwater modelling Section5.1 utilises reduced infiltration rates compared to geotechnical testing results (Section 2.3, Table 2)
Managing Chemicals Fuels Fertilisers and Litter	Adequate contingency planning in case of groundwater or surface water contamination, i.e. emergencies	Refer Appendix N Preventative Strategies
	Risk assessment in accordance with Australian drinking water guidelines.	Refer Section 6.1 Risk Assessment and Appendix N
	Basic raw materials extraction needs to consider protection of drinking water, for example retain areas of native vegetation in WHPZs, and recontouring prior to development.	Raw material extraction not proposed.
	Retain areas of existing native vegetation as much as possible.	Refer Figure 2 areas of native vegetation proposed to be retained in Conservation POS areas
	No underground fuel or chemical storage, i.e. no service stations	None proposed. Permissible land uses specified in Section 6.1 in compliance with WQPN 38.
Education and Awareness	Commit to education and raising awareness about PDWSA protection	Commitment in Section 7.1 and specified as a Preventative Strategy in Appendix N.
Recycled water	The use of recycled water is generally not supported (subject to (a) and the level of treatment).	Water Supply approach detailed in Section 4.2, Use of recycled water is not proposed.
Infrastructure	Planned, constructed and maintained to protect drinking water source, particularly wellhead protection zones	Requirement noted for future detailed planning. Servicing report contained as Appendix L. Stormwater biofiltration areas located away from WHPZ’s.
Bores	Bores need to be appropriately located and constructed to prevent contamination of the public drinking water source.	Noted. Bore locations are subject to future assessment by DWER as a standard part of the groundwater licencing process.
	Bores should not be located in wellhead protection zones.	Noted. Bore locations are subject to future assessment by DWER as a standard part of the groundwater licencing process.
	Bores no longer used should be properly decommissioned	Noted. To be decommissioned appropriately during construction.

6.1 Risk Assessment

A risk assessment evaluating the impacts of the proposed development on the surrounding environment, specifically focusing on water quality, groundwater resources, and the overall integrity of the PDWSA is provided in Appendix N. This risk assessment has been prepared in accordance with the Australian Drinking Water Guidelines (Australian Government ,2022) and DWER's Water Quality Protection Note 77 (DWER,2022).

In this assessment, potential risks related to various development activities, such as land use changes, stormwater management, wastewater disposal, and contamination, are identified and analysed. The aim of the assessment is to ensure that the development does not compromise the ability to protect the drinking water supply and that any risks are adequately mitigated through appropriate management measures and strategies.

The outcome of the risk assessment is to identify key actions to inform the sustainable development of the site in later stages of planning, ensuring alignment with environmental protection guidelines and regulatory frameworks. By evaluating and managing these risks effectively, the development will contribute to the ongoing protection of water quality and availability, while supporting reclassification to a P3* area.

The risk assessment detailed in Appendix N was based on the implementation of the indicative concept plan for the site. This plan is likely to change during the local structure planning phase and refined further in consultation with agencies.

In accordance with Water Quality Protection Note 77 (DWER,2022) recommendations, the evaluation of consequence in the risk assessment has been based on site specific evaluation and assessment, with DWER default consequence ratings also tabulated in Appendix N for reference purposes. The site specific evaluation considers local factors such as groundwater flow direction to assess consequence in the context of the Integration Water Supply Scheme for Perth and impact of a potential future loss of the two water supply bores adjacent to the site given their relatively minor contribution to the scheme.

The sites existing risks under current land use are detailed in the Gnangara Underground Drinking Water Source Protection Review (Water Corporation, 2007). This document contains a comprehensive assessment of risks to water quality in the Gnangara Underground Water Pollution Control Area, detailing land uses, hazards, and management strategies to protect the public drinking water source.

The site is identified in Water Corporation (2007) as Precinct 66 (Lakefarm area) and a number of existing hazards to groundwater quality are identified.

These hazards include wastewater management in the area currently relying on septic tanks, which pose a risk of pathogen contamination to the groundwater if not properly maintained. Additionally, the area includes one lot with intensive holding of sheep and another lot with mixed livestock, where animal excreta pose a hazard of pathogen and nutrient contamination of groundwater. Other risks arise from two lots that having citrus orchards, and one lot has large scale plant nursery. The application of fertilisers and pesticides associated with these orchards and nursery pose existing risks of nutrient and chemical contamination to groundwater.

Existing risks for the site under current land use were deemed Medium to High Priority in Water Corporation (2007).

7. Implementation Framework

7.1 Considerations and Requirements for Local Planning

This document supports the proposed amendment to the Metropolitan Region Scheme to rezone the site to Urban. The level of detail provided in this document is consistent with typical district water management strategy requirements and provides a proof of concept for future stormwater management within the site.

A number of additional documents will be required to progress further stages of planning and subdivision/development of the site. Local Water Management Strategy's (LWMS's) will be required for the site to support the preparation of local structure plans.

Subject to approval of a relevant LWMS, an Urban Water Management Plan (UWMP) will then need to be prepared as a condition of subdivision. Depending on the staging of development, several UWMP's may be required.

The preparation of these future plans will be consistent with this DWMS, Better Urban Water Management (WAPC 2008), DWER water quality protection notes, and other relevant DWER and City of Swan guideline documents. These documents will demonstrate that the impacts of land use change at the site from a water management view can be readily managed via the WAPC (2008) process.

Key additional information to be reported in the LWMS will include:

- Any additional site geotechnical investigations and reporting, including permeability testing in proposed stormwater management areas.
- Refinement of groundwater mapping based on the additional predevelopment monitoring data.
- Additional survey to confirm key stormwater infrastructure levels and details.
- Detailed engineering earthworks and refinement of post development catchments.
- Detailed stormwater modelling to refine volumes, areas and levels and ensure management and infiltration of stormwater within the site post development within designated areas.
- Refinement of UNDO nutrient modelling based on the final LSP.
- Landscape planning for POS and stormwater management areas, including cross sections showing the interactions of stormwater areas with POS, Reserves, and surrounding areas.
- Develop a post development monitoring program based on predevelopment outcomes, including the establishment of targets.
- Develop a contingency management plan based on established targets
- Outcomes of continued liaison key agencies and stakeholders.

With respect to complying with WQPN 38 (DWER, 2018), it is acknowledged the LWMS will be required to address the following matters as detailed in Table 3 of that document:

- Bores should not be located in wellhead protection zones.

- If sewage pump stations cannot be located outside PDWSAs, they are, at the very least, to avoid WHPZs.
- Sewage pump stations should be sized for capacity and use of the development only (i.e. not to service a larger catchment area extending beyond the development).
- Design to reduce demand for local water supplies, fertiliser and pesticides e.g. use local native species and minimise turf.
- Make a commitment to refer the urban water management plan to DWER prior to finalisation.
- End of conveyance stormwater infrastructure and subsoil drains should not outlet within WHPZs.
- Infiltration areas should be outside WHPZs where possible, but if unavoidable, biofiltration should be used.
- Fertiliser application rates and irrigation requirements should be matched to local soils and plant requirements, to manage leaching and contamination of local water sources.
- Only use clean fill that is suitable for protecting drinking water quality, i.e. doesn’t introduce contaminants.
- Use appropriate herbicides.
- Include PDWSA awareness-raising strategies targeted at community, land sales and purchasers, and builders such as brochures, signs, and notices.

7.2 Monitoring

7.2.1 Pre Development

No site-specific groundwater monitoring is typically required to support a DWMS.

Pre-development monitoring for the site was however commenced by Hyd2o in June 2024 in accordance with DWER guidelines. The program will run over a period of 18 months inclusive of two winter periods.

Two winter peaks of predevelopment monitoring is typically required to be completed to support and inform development of the Local Water Management Strategy (LWMS), which is the next phase of planning for this site.

The program being undertaken is currently well advanced and is detailed in Table 12. The programme covers groundwater level and quality monitoring of nine bore locations across the site. Two nearby DWER long term groundwater bores are also measured to enable site levels to be correlated to long term DWER records.

Outcomes will appropriately be provided and analysed to support the LWMS. The current status of monitoring is detailed in Sections 2.7 and 2.8 of this DWMS and all data collected to date presented in Appendix F, H and I.

Table 12: Pre-Development Monitoring Program (In Progress)

Monitoring	Parameter	Location	Method	Frequency and Timing
Groundwater level	Water Level (mAHD)	9 bores within site area and 2 DWER bores	Electrical depth bore or similar	Monthly (18 occasions)
Groundwater quality	Physical, nutrients and heavy metals + pesticides/herbicides and pathogens	9 bores within the site area	Pumped bore sample	Quarterly (physical, nutrients & metals) (6 occasions)

7.2.2 Post Development

Department of Water (2012) indicates a minimum of 3 years post development monitoring is required, and defines post development as "*from completion of first subdivision to five years after 80 per cent of the development (by land area) has been completed*".

The program will therefore be designed at LWMS stage based on pre development outcomes to operate over a three year post development period, with the timing for commencement of the program to be negotiated at UWMP stage with the City of Swan.

The program may need to be modified as data is collected to increase or decrease the monitoring effort in a particular area, or to alter the scope of the program itself.

Post-development monitoring locations, trigger values and targets will be identified in the LWMS based on pre-development (existing) monitoring outcomes and ANZECC (2000) guidelines.

All water quality testing will be conducted by a NATA approved laboratory.

7.3 Funding and Ongoing Maintenance Responsibilities

Key implementation actions and responsibilities are detailed in Table 13.

The development and implementation of this DWMS will be the responsibility of the future site developer. Ongoing funding and maintenance responsibilities will be appropriately detailed at LWMS and UWMP stages and will include a summary of responsibility for both the developer, the City of Swan, and other relevant agencies.

Table 13: Implementation and Responsibilities

Implementation Action	Developer	DWER	City of Swan
Review and approval of DWMS		✓	✓
Preparation of LWMS to support local structure planning	✓		
Review and approval of LWMS		✓	✓
Preparation of a UWMP for development stages	✓		
Review and approval of UWMP			✓
Construct stormwater system and maintenance post construction until council handover	✓		
Long term stormwater system operation & maintenance			✓
Post development monitoring program	✓		
Review of monitoring data and reporting		✓	✓

8. References

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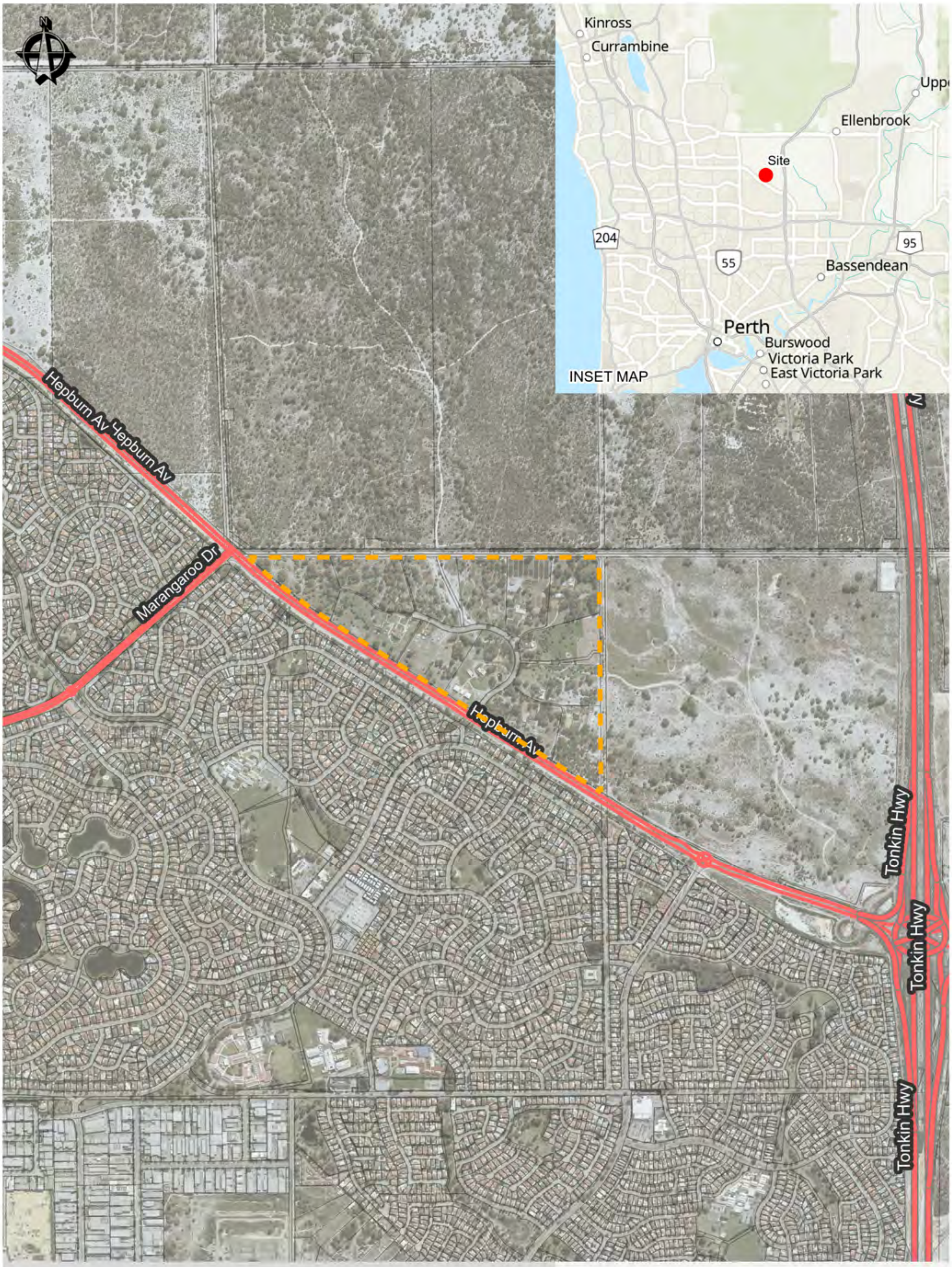
FIGURES

Date: 04/10/2024 Job No. H24009



▭ Site Boundary

0 140 280 420 560 Meters

Source of Data: Landgate SLIP

hyd2o

Lakefarm Retreat Ballajura DWMS

Location Plan

Figure 1

Date: 4/10/2024 Job No. H24009

LandGroupWA

CONCEPT CELL STRUCTURE PLAN - V5

Lakefarm Retreat, Ballajura
A LandGroup WA Project

DRAFT
SUBJECT TO DETAILED DESIGN

Date: 25 September 2024
Scale: 2000@A3
Job: LgwLf\3. Plans\2. CPT\3. 240820 Concept Cell Structure Plan

cdp
Town Planning & Urban Design

hyd2o
Lakefarm Retreat Ballajura DWMS
Concept Structure Plan
Figure 2

Date: 04/10/2024 Job No. H24009

🟧	Site
—	LiDAR Topography Contours (mAHD)

Source of Data: DWER SLIP DataWA

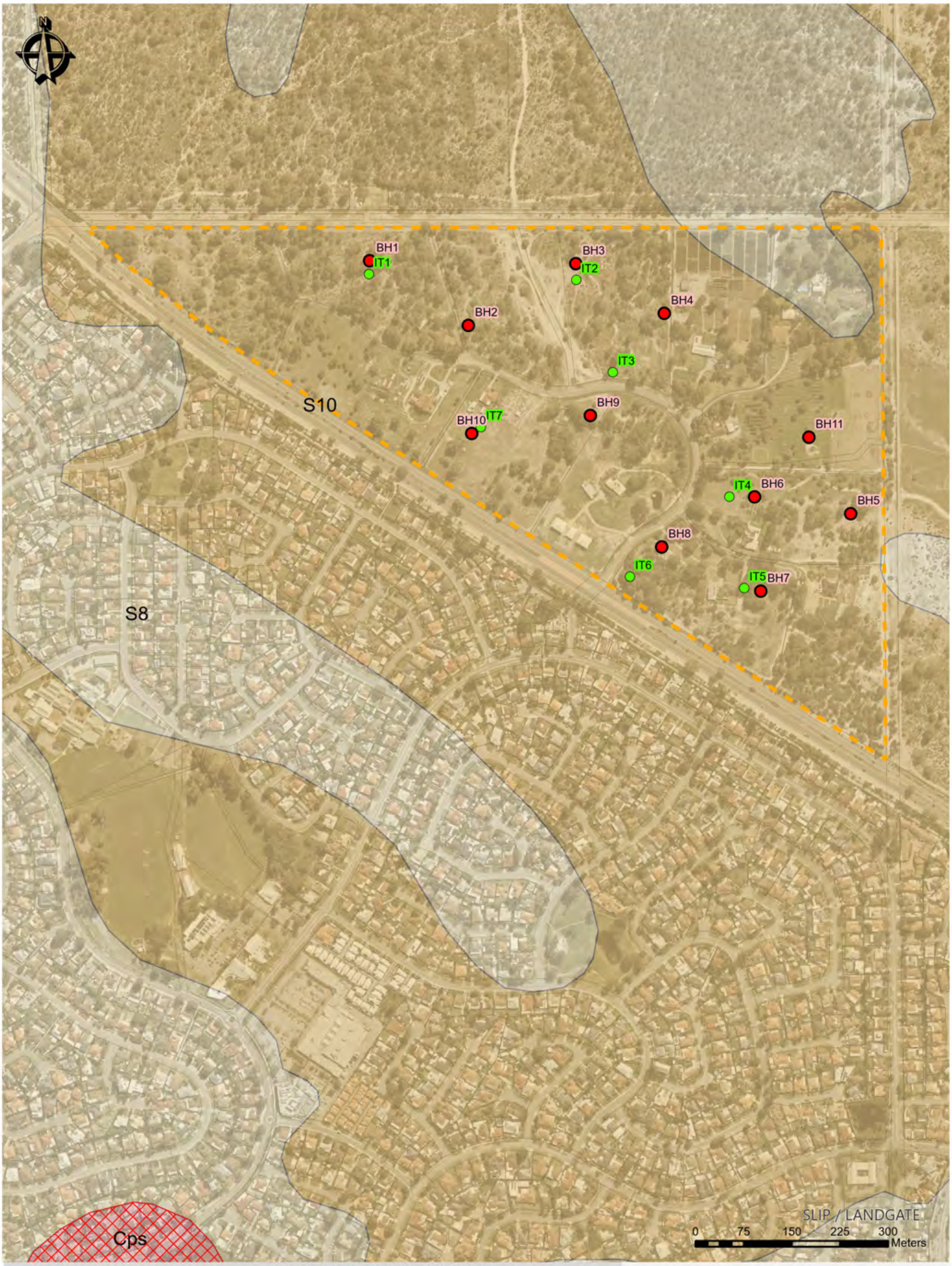
hyd2o

Lakefarm Retreat Ballajura DWMS

Site Conditions Plan

Figure 3

Date: 23/10/2024 Job No. H24009



▭ Site Boundary

Acid Sulphate Risk Classification

▨ High to moderate risk

All other areas: Moderate to low risk

Geological Survey of WA Map

▭ S8: SAND - very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz, moderately well sorted of eolian origin.

▭ S10: as S8

● Infiltration Test (Galt Geotechnics, 2024)

● Borehole (Galt Geotechnics, 2024)

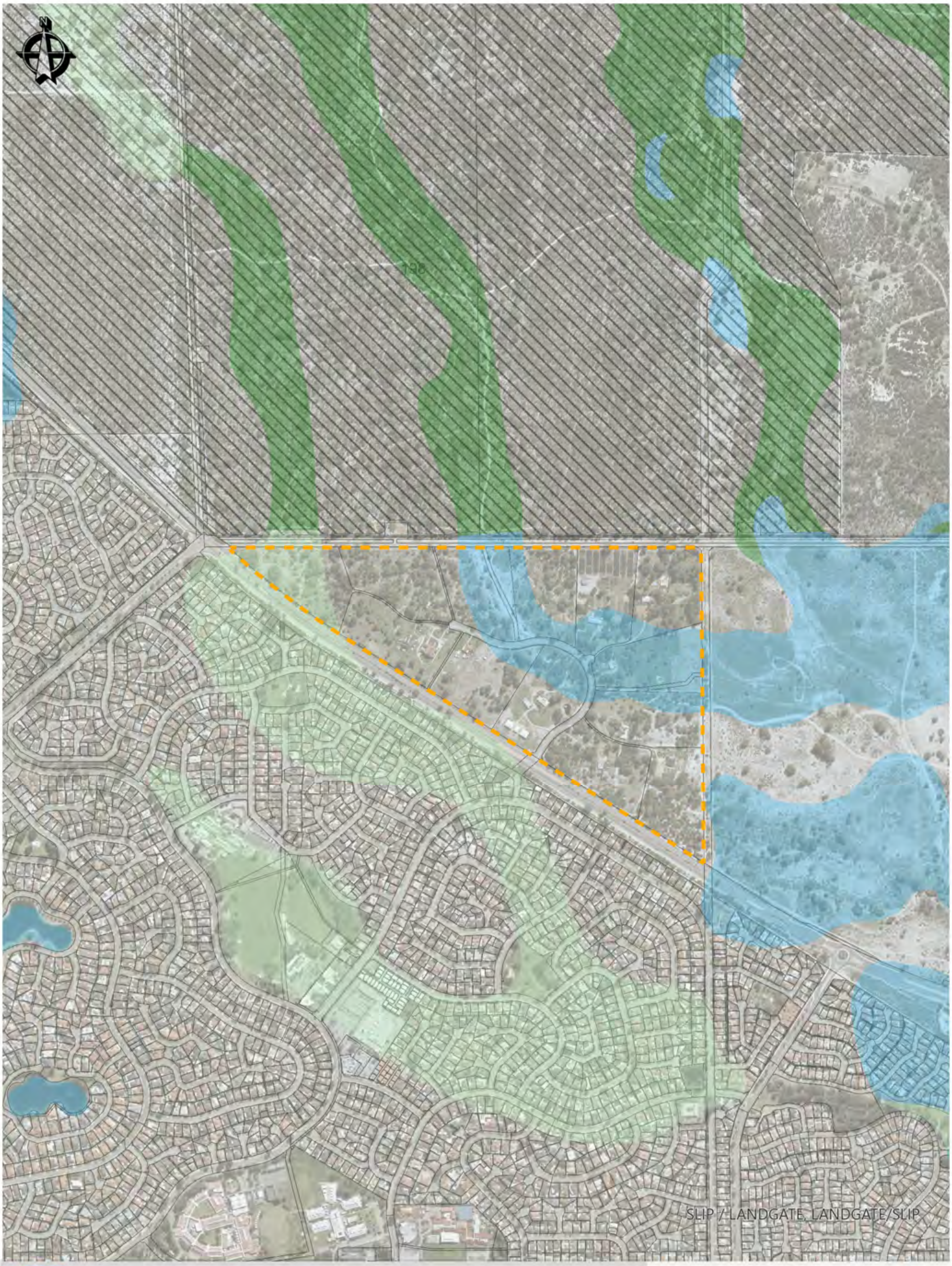
hyd2o

Lakefarm Retreat Ballajura DWMS

Geotechnical Plan

Figure 4

Date: 04/10/2024 Job No. H24009



▭ Site Boundary

▨ Bush Forever Site No 198 Beechboro Road Bushland Cullacabardee/Ballajura

Geomorphic Wetlands SCP

🟩 Conservation

🟦 Multiple Use

🟩 Resource Enhancement

Source of Data: Bush Forever Areas 2000 (DPLH-019) Geomorphic Wetlands Swan Coastal Plain (DBCA-019)

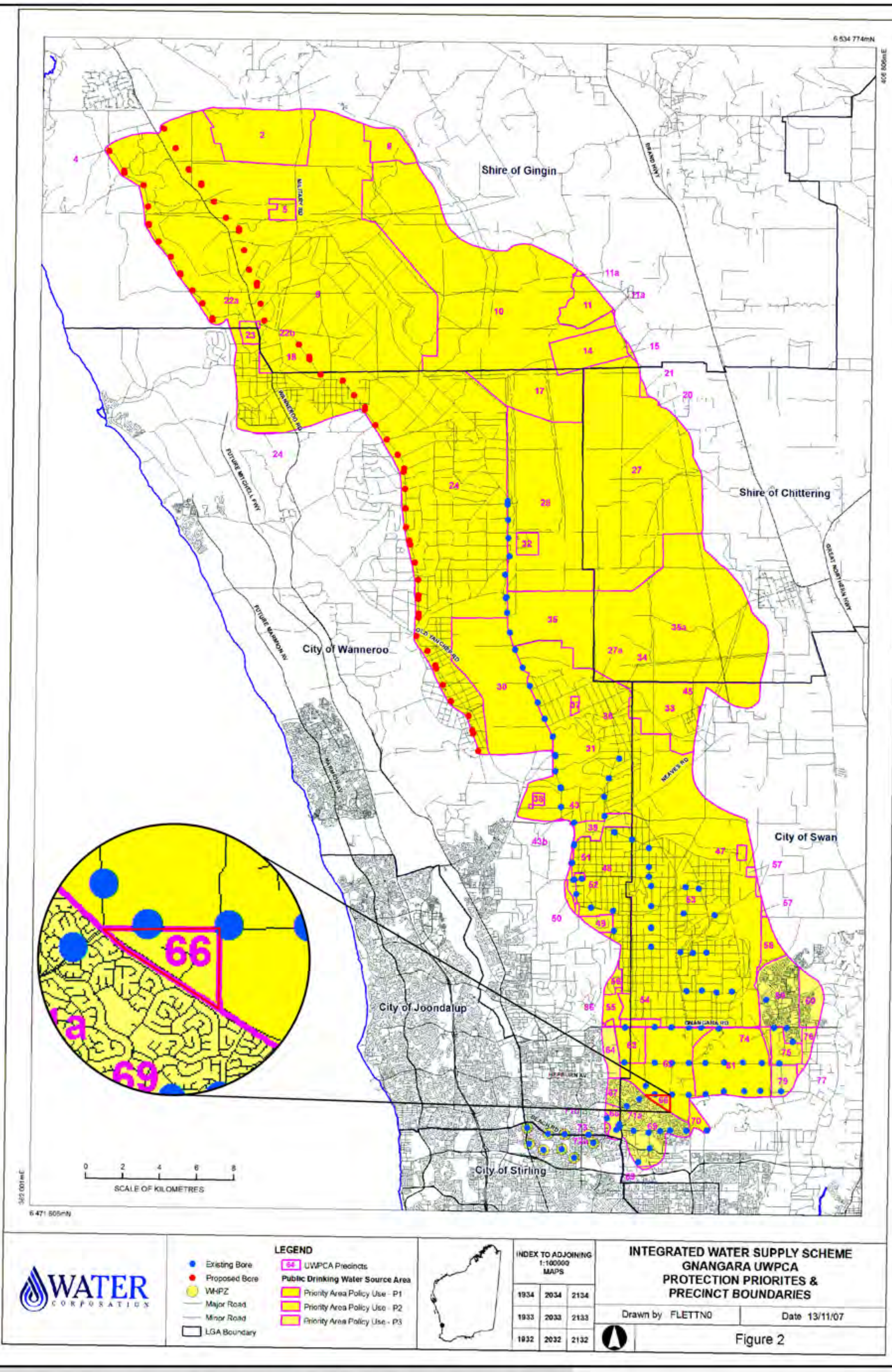
hyd2o

Lakefarm Retreat Ballajura DWMS

Environmental Plan

Figure 5

Date: 07/10/2024 Job No. H24009



This map was extracted from Gnangara Underground Water Pollution Control Area - Drinking Water Source Protection Review, Integrated Water Supply Scheme, Water Corporation 2007.

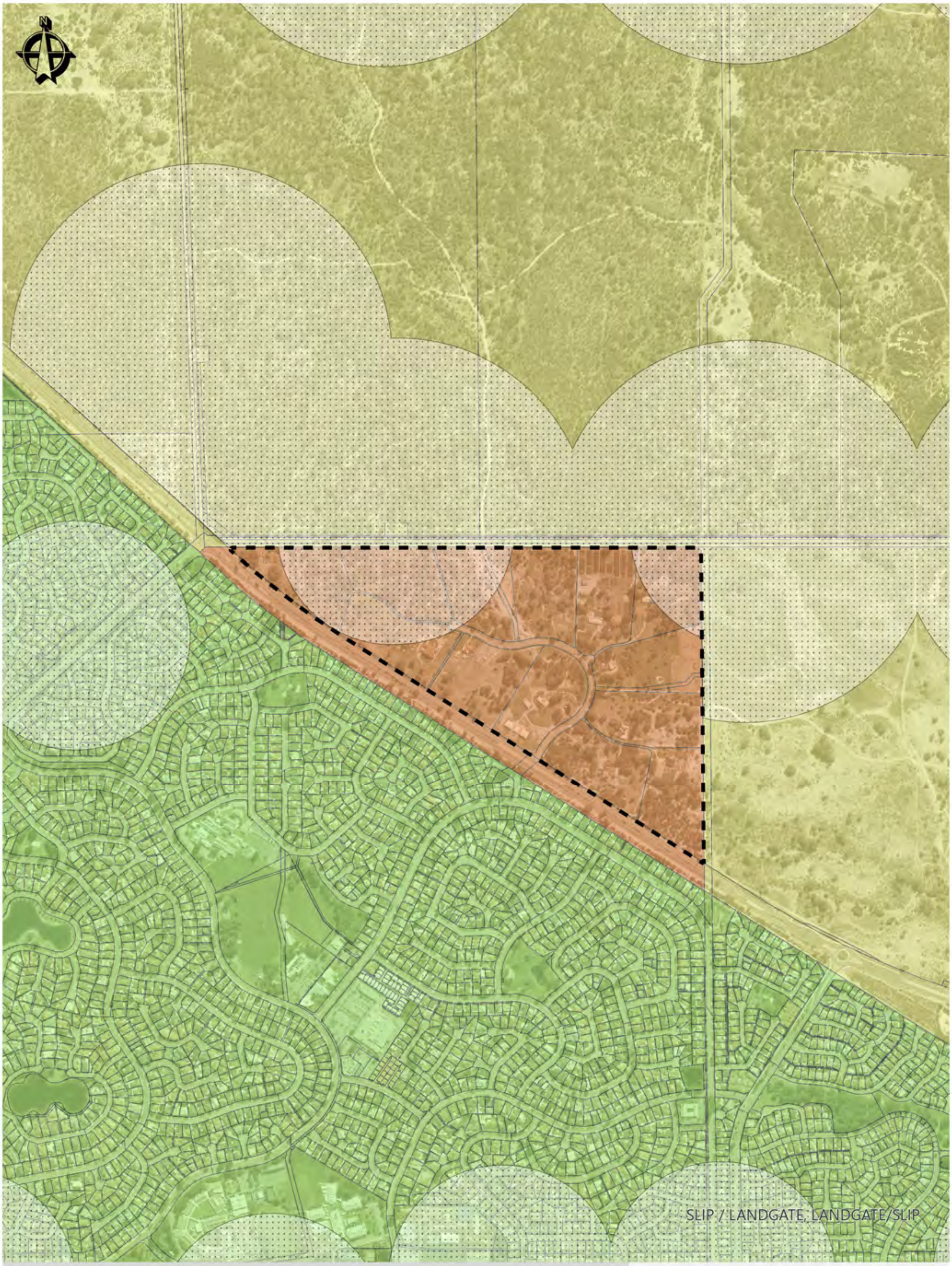
hyd2o

Lakefarm Retreat Ballajura DWMS

Gnangara UWPCA Boundary

Figure 6a

Date: 04/10/2024 Job No. H24009



- ⬚ Site Boundary
- ▨ DWER Wellhead Protection Zone

Public Drinking Water Source Areas

- 🟨 Priority 1 - Source Protection Area
- 🟧 Priority 2 - Source Protection Area
- 🟩 Priority 3 - Source Protection Area

0 160 320 Meters

Source of Data: State Planning Policy 2.2 Gnangara Groundwater Protection (DPLH-050)
DWER Public Drinking Water Source Area Map

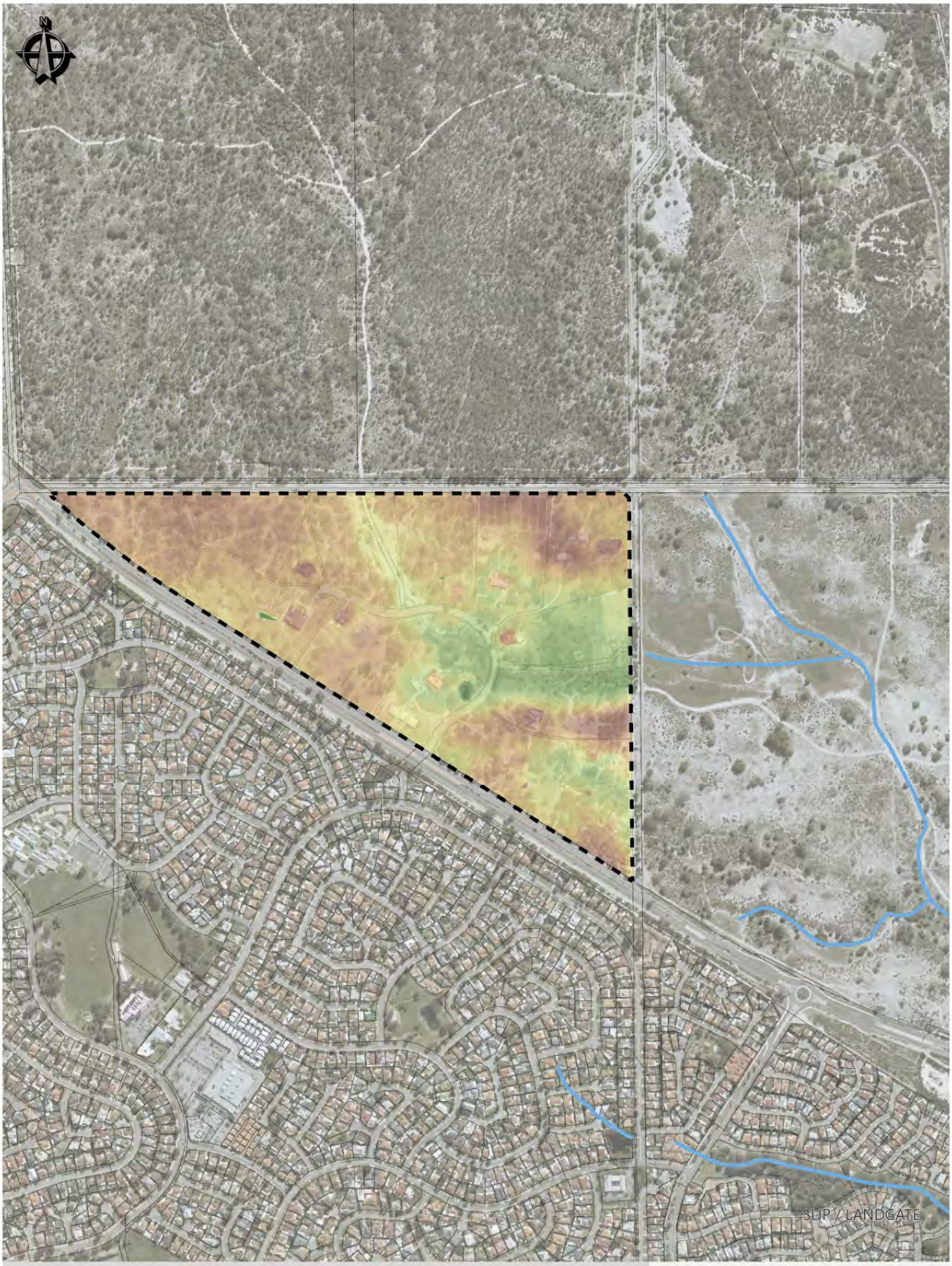
hyd₂o

Lakefarm Retreat Ballajura DWMS

Public Drinking Water Source Plan

Figure 6b

Date: 04/10/2024 Job No. H24009



Source of Data: Hydrography Linear DWER-031
LiDAR DEM - Perth

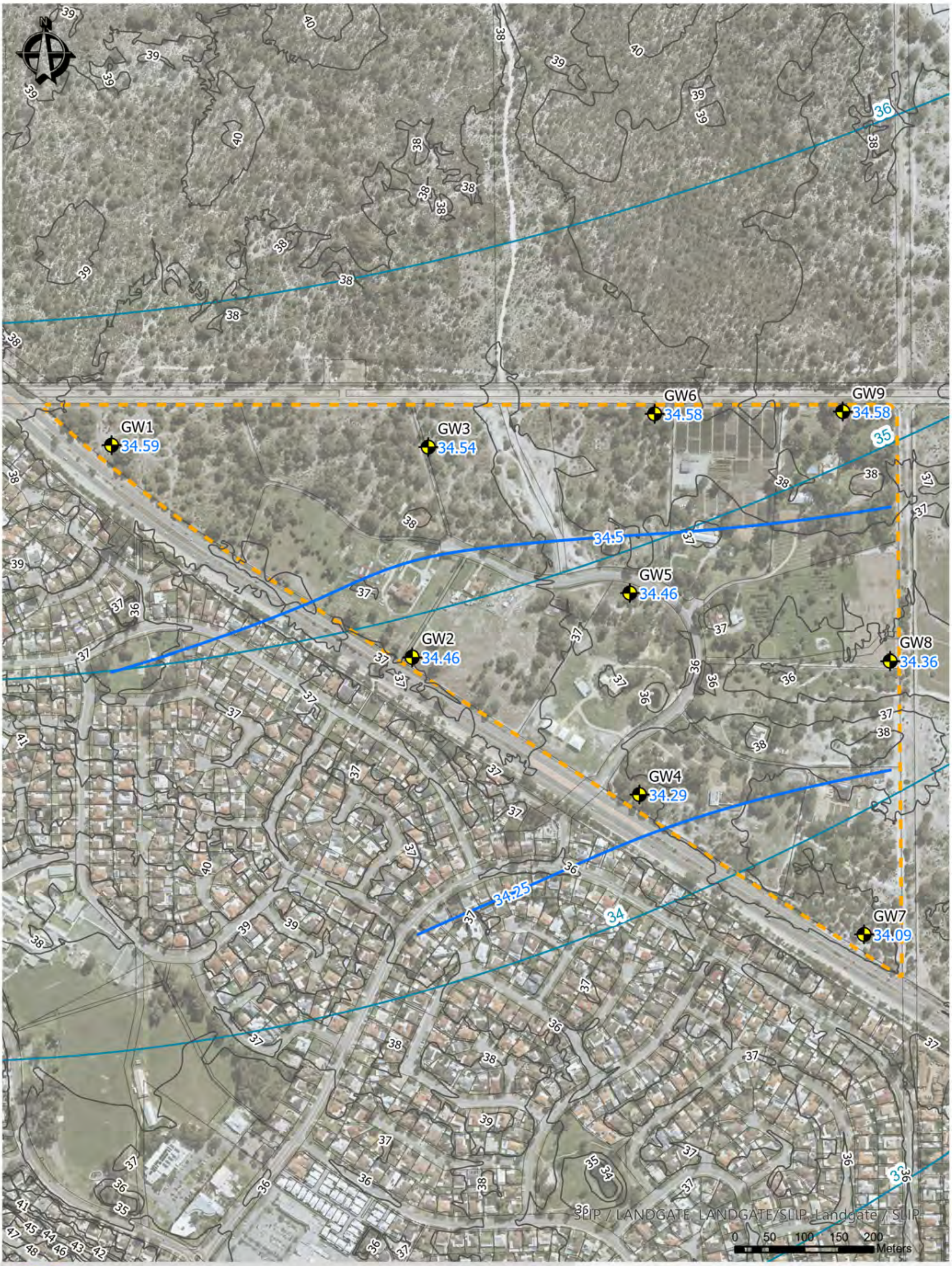
hyd2o

Lakefarm Retreat Ballajura DWMS

Surface Water Plan

Figure 7

Date: 04/10/2024 Job No. H24009



▭ Site

⊕ Groundwater Monitoring Bores Hyd2o September 2024 Readings (mAHD)

— Groundwater Contours 2019 Maximum (mAHD)

— AAMGL Contour (mAHD)

— LiDAR Topography Contours (mAHD)

hyd2o

Lakefarm Retreat Ballajura LWMS

Groundwater Plan

Figure 8

Date: 03/10/2024 Job No. H24009

Catchment 1
15mm Event
Invert Level (mAHD): 35.50
Side Slopes (1:v): 6
Flood Rise (m): 0.27
TWL Area (m2): 1262
Volume (m3): 283

20% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 0.41
TWL Area (m2): 2502
Volume (m3): 806
Critical Storm (hr): 1

1% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 1.19
TWL Area (m2): 4666
Volume (m3): 3590
Critical Storm (hr): 6

Catchment 3
15mm Event
Invert Level (mAHD): 35.50
Side Slopes (1:v): 6
Flood Rise (m): 0.13
TWL Area (m2): 751
Volume (m3): 91

20% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 0.38
TWL Area (m2): 958
Volume (m3): 304
Critical Storm (hr): 1

1% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 1.18
TWL Area (m2): 1743
Volume (m3): 1372
Critical Storm (hr): 6

Catchment 5
15mm Event
Invert Level (mAHD): 35.40
Side Slopes (1:v): 6
Flood Rise (m): 0.24
TWL Area (m2): 452
Volume (m3): 81

20% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 0.51
TWL Area (m2): 731
Volume (m3): 240
Critical Storm (hr): 1

1% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 1.20
TWL Area (m2): 1538
Volume (m3): 1015
Critical Storm (hr): 6

Catchment 2
15mm Event
Invert Level (mAHD): 35.50
Side Slopes (1:v): 6
Flood Rise (m): 0.07
TWL Area (m2): 1110
Volume (m3): 76

20% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 0.32
TWL Area (m2): 1337
Volume (m3): 381
Critical Storm (hr): 1

1% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 1.20
TWL Area (m2): 2280
Volume (m3): 1956
Critical Storm (hr): 6

Catchment 4
15mm Event
Invert Level (mAHD): 35.20
Side Slopes (1:v): 6
Flood Rise (m): 0.09
TWL Area (m2): 409
Volume (m3): 35

20% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 0.37
TWL Area (m2): 566
Volume (m3): 171
Critical Storm (hr): 1

1% AEP Event
Side Slopes (1:v): 6
Flood Rise (m): 1.18
TWL Area (m2): 1145
Volume (m3): 851
Critical Storm (hr): 6

Site Boundary
Catchment Boundary
Biofiltration
▨ 1% AEP Storage

Land Use
Lots
Roads
🟩 POS

Existing Drain
Potential future living stream to existing drain
AAMGL Contours mAHD (MGL = AAMGL + 0.45m)
Preliminary Stormwater Modelling at 5m/day

0 40 80 160
Meters

hyd2o
Lakefarm Retreat Ballajura DWMS
Preliminary Stormwater Management Plan
Figure 9

APPENDIX A

DWMS Checklist

District water management strategy guide

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

District water management strategy item	☑	**Notes**
Executive summary		
Describe proposed water management objectives and how the objectives will be met.	☑	Executive Summary
Planning background and previous studies		
Map the location of the site.	☑	Location or site context plan Figure 1
State which planning document the strategy is supporting.	☑	District structure plan if available Section 1.1 Planning Context, Figure 2
Provide references to the key state and/or local policies, guidelines, strategies and their relevance.	☑	Section 1.2 Key Documents Chapter 7 References
Design criteria		
Recognise water management principles, objectives and design criteria.	☑	Chapter 1 Introduction Section 3 Water Management Principles & Objectives
Design objectives from previous water strategies and/or plans.	☑	Chapter 1 Introduction Section 3 Water Management Principles & Objectives
Pre-development environment (identification of assets, risks and constraints)		
Describe site characteristics: provide preliminary desktop assessments and/or field investigations (if required)	☑	Include existing data Chapter 2 and associated figures & appendices
Describe climate.	☑	Description Section 2.2
Describe and map topography, landform and geotechnical conditions.	☑	Aerial photo Section 2.1, Figure 3 Geotechnical plan Section 2.3 Figure 4 Appendix B & C Acid sulfate soil risk mapping Figure 4 Section 2.3

District water management strategy item	☑	**Notes**
Describe the existing land use.	☑	Description Section 2.1
Identify environmental assets and their significance.	☑	Environmental plan plus supporting data where available Figure 5 & 6 Section 2.4 and 2.5
Detail the social, cultural and heritage considerations.		Section 2.4
Describe the hydrology and hydrogeology of the area: • surface water • groundwater • water-dependent ecosystems • water resource issues.	☑	Surface water hydrology plan Section 2.6 Figure 7 Appendix D Groundwater and topographic contours plan (or depth to groundwater) Section 2.7 Figure 8 Appendix E & F Waterways and wetlands plan Figure 5 & 7 Indicative water balance (pre- and post-development water balances can be presented together – see below) Section 5.4
Describe existing drainage infrastructure and other infrastructure likely to affect management of water resources.	☑	Arterial drainage plan (if available) including local drainage Section 2.6
Post-development water management		
Identify the proposed broad scale management strategies that will address water resource issues and meet the objectives and design criteria.	☑	Chapter 5, Figure 9
Calculate an indicative water balance.	☑	Indicative water balance. May be presented as a diagram including pre- and post-development Section 5.4
Describe the impacts to water resources and/or impacts to proposed change in land use from water issues.	☑	Chapter 5
Surface water – Estimate land requirements for water management. – Identify water quality issues and scope for improvement. – Describe proposed strategy for management of small, minor and major surface flows.	☑	Include any existing data Section 5.1 Figure 9 Table 9 Appendix K Section 2.8, Section 5.3 Appendices G & M Section 5.1
Describe groundwater levels, use, management and maintenance.	☑	Include data if available Section 5.2

District water management strategy item	☑	**Notes**
Identify water-dependent ecosystems	☑	Section 2.4
Identify contamination issues – high risk acid sulfate soils, contaminated sites or areas with historical high nutrient and/or non-nutrient contaminants.	☑	Include data or plans if available Section 2.4 & 2.5, Figures 4 & 5
Water services and efficiency initiatives		
Describe potable water supply – options including details of technical, environmental and regulatory feasibility – regulatory approvals, technical investigations and any obtained written approvals – recommendations for water efficiency and conservation	☑	Written evidence if obtained Section 4.1 & 4.2 Appendix L
Identify wastewater servicing – options including preferred option, location, treatment process, level of treatment, disposal, buffers and infrastructure – approvals and investigations required and any obtained written approvals – recommendations for water efficiency and conservation	☑	Written evidence if obtained Section 4.3 , Appendix L
Identify non-potable (fit-for-purpose) water supply – non-potable water source options. Highlight preferred option with consideration of pre and post development water balance – approvals and investigations required and any obtained written approvals – recommendations for water efficiency and conservation	☑	Written evidence if obtained Section 4.1 & 4.2

District water management strategy item	☑	**Notes**
Implementation framework		
Describe commitments and obligations for the next stage of the planning process (e.g. LWMS). Identify issues that need specialised investigation and management for the subsequent LWMS. Make recommendations for implementing the DWMS.	☑	Commitments and obligations may be displayed in table format Chapter 7, Tables 11 & 12

APPENDIX B

Geotechnical Report

Report on:

PRELIMINARY GEOTECHNICAL AND ACID SULFATE SOIL STUDY
PROPOSED RESIDENTIAL SUBDIVISION
LAKEFARM RETREAT
BALLAJURA

WAG240411-01 001 R Rev0

Submitted to:

Land Group (WA)
578 Murray Street
WEST PERTH WA 6005

16 October 2024

CONTENTS

1. INTRODUCTION

This report presents the outcomes of Galt Geotechnics' (Galt's) preliminary geotechnical and Acid Sulphate Soil ("ASS") study for the proposed residential subdivision development, at Lake Farm Retreat, Ballajura ("the site").

This report is to be read in conjunction with the appended "Geotechnical Definitions, Recommendations, Requirements and Limitations". 'Clause GDR1', etc. refer to this Appendix, found at the back of this report.

2. KEY FINDINGS

The site is underlain by SAND to at least 3 m depth in the areas investigated. A "Class A" site class to AS2870-2011 is considered appropriate with normal site preparation measures. The site-derived soils should be suitable for structural fill and maintaining 'Class A' lots.

Stormwater disposal via soak wells is considered suitable for the site provided the base of soak wells are at least 0.5 m above the design groundwater level. A design unsaturated hydraulic conductivity of no more than 5 m/day may be used for the insitu sand. A hydrological assessment is required to inform design groundwater levels.

All soil samples tested were classified as non-acid sulfate soils (NASS). As such, no further treatment or management is required.

3. SITE DESCRIPTION

Table 1: Summary of Site

Item	Comment
Site Extent	refer Figure 1, Site and Location Plan
Site Area	About 52 ha (13 x ~ 4 ha rural residential lots)
Current Site Surface Levels[1]	About RL 36 m AHD to RL 38 m AHD
Vegetation	Mature trees, grass and native shrubs.
Current Land Use	Rural residential lots
Existing Infrastructure	Some single storey buildings, access way and associated infrastructure.
Site History[2]	**Prior to 1985**: Native bushland. Aerial photos indicate central portion of site was a Palusplain (seasonally waterlogged area). **1985 to 1989**: subdivided into residential lots. **1989 to presen**t: relatively unchanged. Some single storey building constructed.

NOTES: ***1.*** *Site levels based on publicly available data (DWER 2019)*

2. *Site history based on aerial imagery (Landgate)*

4. PROPOSED DEVELOPMENT

Table 2: Summary of Proposed Development

Item	Comment
Proposed Development	Residential subdivision – Stage 1, 2, 3A and 3B (refer Appendix B, Supplied information).
Cut/Fill	Assumed cut and fill up to about 2 m depths.
Assumed Foundation Type	Shallow footings.
Assumed Retaining Walls	Gravit walls typically less than 1 m.
Assumed Stormwater Disposal	On site via soak wells / drainage basins.

NOTES: ***1.*** *FFL – finished floor level*

2. *Proposed development details based on supplied information presented in Appendix B, Supplied information*

5. PROJECT OBJECTIVES

The objectives of the study were to:

- assess possible presence of swamp deposits in areas where surface water has been present;
- assess possible presence of loose sandy soils which may have an impact on site classification;
- assess potential presence of sand for borrow in higher areas of the site;
- assess acid sulfate soil risk across the site; and
- assess the drainage performance of sands at the site.

6. FIELDWORK

6.1. Summary

Fieldwork was carried out in the presence of a representative from Galt on 19 and 20 September 2024 and comprised:

Table 3: Summary of Field Data

Type	Results Appendix	Summary	GDR Clause	Equipment Used	No. Tests	Depth Range (m)
Site Plan	Figure 1	-	-	Hand held GPS[1]	-	-
Photographs	A	-	-	-	-	-
Machine Auger Boreholes (BH)	C	Section 9	GDR3.3	Melville Super Rig	11	3.0
Dynamic Probing Super Heavy (DPSH)	D	Section 9	GDR3.6	GRIZZLY tracked rig	11	3.0
Infiltration Tests (I)	E	Section 6.2	GDR3.7	Inverse auger hole	11	0.55 – 1.76

NOTES: ***1.*** *Hand held GPS is accurate to ±5 m.*

6.2. Infiltration Test Results

Table 4: Infiltration Test Results

Test Location	Soil Description	Depth (m)	Minimum Unsaturated Hydraulic Conductivity, k_{unsat} (m/day)
IT01 - Shallow	SAND (SP)	0.55	12.7
IT01 – Deep		1.69	4.9
IT02 - Shallow		0.63	7.9
IT02 – Deep		1.57	>15
IT03		0.84	>15
IT04		0.82	>15
IT05 - Shallow		0.48	14.8
IT05 – Deep		1.62	2
IT06		0.81	>15
IT07 - Shallow		0.52	>15
IT07 – Deep		1.76	3.4

NOTES:

1. *Infiltration test method using inverse auger is explained in GDR3.7*

2. *Conductivities greater than 15 m/day not reported due to inaccuracies of the test in highly permeable soils.*

3. *The low values observed in tests conducted at depths greater than 1.5 m are likely due to the proximity of the groundwater table, rather than the presence of low-permeability soils.*

7. LABORATORY TESTING

Table 5: Summary of Laboratory Testing Undertaken

Type	Testing Done?	Results Summary	Results Appendix
Geotechnical Index Tests	Yes	Attached Table 1	F
Acid Sulfate Soil Tests	Yes	Appendix G	H

8. SITE CONDITIONS

8.1. Geology

Table 6: Summary of Geology Mapping

Map Sheet	Map Scale	Mapped Soils	Site Findings
Perth	1:50,000	Bassendean SAND (S8 and S10) over clayey strata of Guildford Formation	SAND (SP) interbedded with weakly cemented iron indurated sand (“Coffee Rock’) to maximum depth investigated of 3 m.

8.2. Groundwater

Table 7: Summary of Groundwater Levels

Item	Date	Depth Range (m)	Elevation Range (m AHD)	Comment
Perth Groundwater Atlas	1997	0.00 – 1.00	37.00	Historical maximum groundwater levels
	2004	2.00 – 5.00	33.00 – 34.00	End of summer groundwater level in May 2003
	2019	1.00 – 4.00	34.00 – 35.00	Winter groundwater elevation recorded in 2019
Site observations	July 2024	2.00 – 4.50	33.44 – 34.02	GWT readings provided by Hyd2o
	September 2024	1.90 – 3.22	-	GW2, GW4 and GW8 (monitoring well installed by others)
	September 2024	2.00 – 3.00	-	Groundwater was not observed during our investigation due to hole collapse on extraction of auger / DPSH rods. Groundwater depths are inferred based on the moisture content of soil samples recovered and collapsed depths of test holes during withdrawal of the auger rods.
Design Groundwater Level	-	-	-	Hydrological study by others

NOTES: ***1.*** *Depth range for Perth Groundwater Atlas observations based on mapped levels dating from 1997 – 2019.*

2. *Depths for mapped levels based on an approximate mapped ground level of about RL 36 m AHD to RL 38 m AHD.*

3. *Depth range for site observations based on the site surface level at the time of investigation.*

9. GROUND MODEL

The encountered subsurface conditions can be summarised as comprising:

- **TOPSOIL: SAND,** fine to medium grained, sub-angular to sub-rounded, grey/dark grey, trace fines, trace organics; overlying
- **SAND (SP),** fine to medium grained, sub-angular to sub-rounded, grey/pale grey/white/brown/yellow layers, trace fines, interbedded with weakly cemented iron cemented sand (“Coffee Rock”) which is typically recovered as gravel size particles, very loose to loose within the upper 1.0 m to 1.5 m and then becomes typically loose to medium dense, extends to maximum investigated depth of 3 m.

Geotechnical design parameters for the generalised subsurface units are described in Table 8.

.

Table 8: Geotechnical Model Units and Design Parameters

Unit Name	γ_{bulk} (kN/m^3)	ϕ' (°)	E_v (MPa)	k_0	Wall Friction=0		Wall Friction=0.5ϕ	
					k_a	k_p	k_a	k_p
Approved Fill Refer Table 9	18	36	50	0.41	0.26	3.85	0.22	6.54
Very Loose to Loose SAND To about 1.5 m depth	17	32	2 to 15	0.47	0.31	3.25	0.27	4.96
Loose to Medium Dense SAND Below about 1.5 m depth.	18	35	20 to 40	0.43	0.27	3.69	0.24	6.08

NOTES:

1. *These units are a generalization of results from individual tests, which should be referred to for more information.*
2. *Topsoil is not included as a discrete unit.*
3. *For all earth pressure coefficients (retaining wall design) refer to clause GDR11.2 for more detail and interpretation. Unit weights for retaining structure design should be as per GDR11.2 or 1 kN/m^3 greater than the values in the table above.*

γ_{bulk} – *bulk unit weight*

ϕ' – *effective friction angle*

E_v – *vertical elastic modulus*

k_a – *coefficient of active earth pressure (Coulomb – AS4678-2002, Appendix E)*

k_p – *coefficient of passive earth pressure (Coulomb – AS4678-2002, Appendix E)*

k_0 – *coefficient of at-rest earth pressure (Jaky)*

10. GEOTECHNICAL ASSESSMENT

10.1. Summary

Table 9: Summary of Geotechnical Assessment

Type	Clause	Parameter	Comment
Site Suitability	-	-	We consider the site to be geotechnically suitable for the proposed development.
Construction Methodology and Suitability	-		Shallow footings in accordance with AS2870-2011 will be suitable for this site. Mass retaining will be suitable for retaining above groundwater. Stormwater disposal via infiltration is suitable subject to appropriate clearance to groundwater.
Site Classification (AS2870)	GDR5	A	-
Site Preparation	GDR6	-	**GDR6.2.1 Common Measures** followed by **GDR6.2.2 Sand Sites**. Possible localised requirement for **GDR6.2.3 Deep Loose Sand Sites** if any deep loose sand zones are encountered. Test results to date do not indicate the requirement for treatment of deep loose sands provided the upper ~1.0 m of in situ loose sand can be effectively compacted.
Compaction Control	GDR7	Approved granular fill or in situ sand – 95% MMDD	A PSP may be used for compaction control on site-derived SAND. Deemed to comply values for 'Bassendean' sand in GDR7.4 are applicable. **Note:** Difficulty may be experienced achieving compaction when the groundwater is within about 1 m of the surface (local dewatering maybe required for services trenches).
Approved Fill	GDR8	-	**Approved Fill** for this site is to comprise **Permeable Sand**. In situ sand may be assumed to be **Permeable Sand**. If additional fill is required, imported **Permeable Sand** will be needed.
Shallow Footings	GDR9	q_{all} = 100 kPa	In accordance with AS2870-2011 for residential buildings up to 2 storeys high
Earth Pressure Coefficients	GDR11	-	Earth pressure coefficients can be used for the generalised subsurface units presented in Table 8.
Batters	GDR12	1V:2H (temporary) 1V:3H (permanent)	Batter angles apply to units in Table 8 above the water table. Excavations below / near groundwater will require temporary retention.
Excavatability	GDR12	10 tonne excavator	Potential for obstructions (buried concrete, Soakwells etc…), cemented soils and surficial pavement layers must be considered when selecting earthmoving plant.
Unsaturated Hydraulic Conductivity	GDR13	k_{unsat} = 5 m/day	k_{unsat} values apply where disposing into **Approved Fill (Permeable Sand)** or in situ sand, minimum 0.5 m above the design groundwater level.
Pavement Subgrade CBR	GDR16	CBR = 10%	Subgrade to comprise compacted in situ sand or **Approved Fill.**

NOTES: ***1.*** *q_{all} – allowable bearing pressure (maximum for all footings, refer to footing tables for further details)*

11. ACID SULFATE SOIL ASSESSMENT

11.1. Fieldwork

Soil samples were collected at 0.25 m intervals at each test pit location using dedicated nitrile gloved and place in laboratory supplied samples bags. All samples were stored with adequate packing and ice and transported to the laboratory to ensure that they arrived intact and at the appropriate temperature to ensure preservation of sample integrity.

Samples were collected from the borehole in accordance with the following guidelines:

- Department of Environmental Regulation (DER) (2015) Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes

The lateral borehole distribution and the vertical sample interval is considered appropriate for the project and in accordance with the aforementioned regulatory guidelines

Soil samples were field tested in accordance with the following guidelines:

- DER (2015a); and
- DAWR (2018).

Soil samples were tested for pH before (pH_F) and after (pH_{FOX}) rapid oxidation with hydrogen peroxide (H_2O_2). The field tests were undertaken to provide an indication of soil types likely to have the potential to generate acidity as a result of oxidation during earthworks.

Selected soil samples were couriered to the laboratory with adequate packing and ice to ensure that they arrived intact and at the appropriate temperature to ensure sample preservation. Laboratory analysis was undertaken on selected soil samples using the chromium reducible sulfur (CRS) method which provides acid base accounting and quantification of potential acid generation. The selection of samples for laboratory analysis was based on soil type and the results of field testing. All laboratory analysis was undertaken using NATA-accredited methods of analysis.

11.2. Results

A total of 101 samples were field tested. During field testing all samples displayed a low reaction rate. pH_F results ranged from 4.9 to 7.3 with pH_{FOX} results ranging from 4.0 to 5.6. The largest pH change noted was 2.0 units.

Soil samples were then selected based on pH change, reaction rate and soil type for laboratory analysis using the chromium reducible sulfur method (CRS). It was noted that all samples contained net acidity were either below the laboratory LOR conforming to the adopted assessment criterion of 0.03 %S. Therefore, all material is classified as non-acid sulfate soils (NASS).

Acid sulfate soil laboratory results along with field testing results are presented in Appendix G. Laboratory certificates of analysis are presented in Appendix H.

12. CLOSURE

GALT GEOTECHNICS

Owen Woodland CPEng
Geotechnical Engineer

William Yukun Feng
Geotechnical Engineer

Attached Table 1: Summary of Geotechnical Index Test Results

Test Name	Sample Depth (m)	Soil Class (AS1726 2017)	Gravel (%)	Sand (%)	Fines (%)	Org %
BH02	0.2 – 1.0	SAND	0	97	3	0.2
BH02	1.0 – 2.0	SAND	0	96	4	-
BH06	0.1 – 1.0	SAND	0	98	2	0.3
BH06	1.0 – 2.0	SAND	0	98	2	-

Notes

1. *Particle size distribution (by mass)*

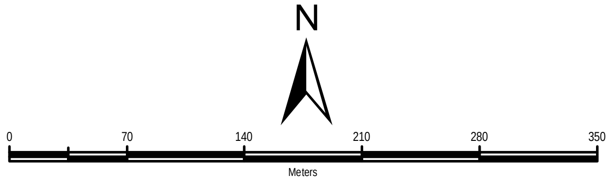
   Gravel: 2.36 mm – 63 mm *Sand: 0.075 mm – 2.36 mm* *Fines: <0.075 mm*

2. *Org: Organic content (by mass)*

Figures

Legend

▭	Site Boundary
✚	Borehole
◆	Borehole / Dynamic Probing Super Heavy Test
●	Infiltration Test



NOTES

Aerial Imagery and Cadastre sourced from Landgate/SLIP

SCALE	1:4,500	(A3)
DRAWN	CED	
DATE DRAWN	27/9/2024	
CHECKED	_	
DATE CHECKED	_	
PROJECTION	GDA 1994 MGA Zone 50	

Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Address : 50 Edward Street
Osborne Park WA 6017

CLIENT	**LAND GROUP (9WA) - GROVES ST PTY LTD**
PROJECT	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION	LAKEFARM RETREAT BALLAJURA
TITLE	SITE & LOCATION PLAN
Job No	WAG240411-01
Fig No	FIGURE 2
Rev	A

Appendices

Appendix A: Site Photographs

Photograph 1:Typical soil profile (BH05)

19 Sept 2024, 10:32:35 am

Photograph 2: Aerial view of the site

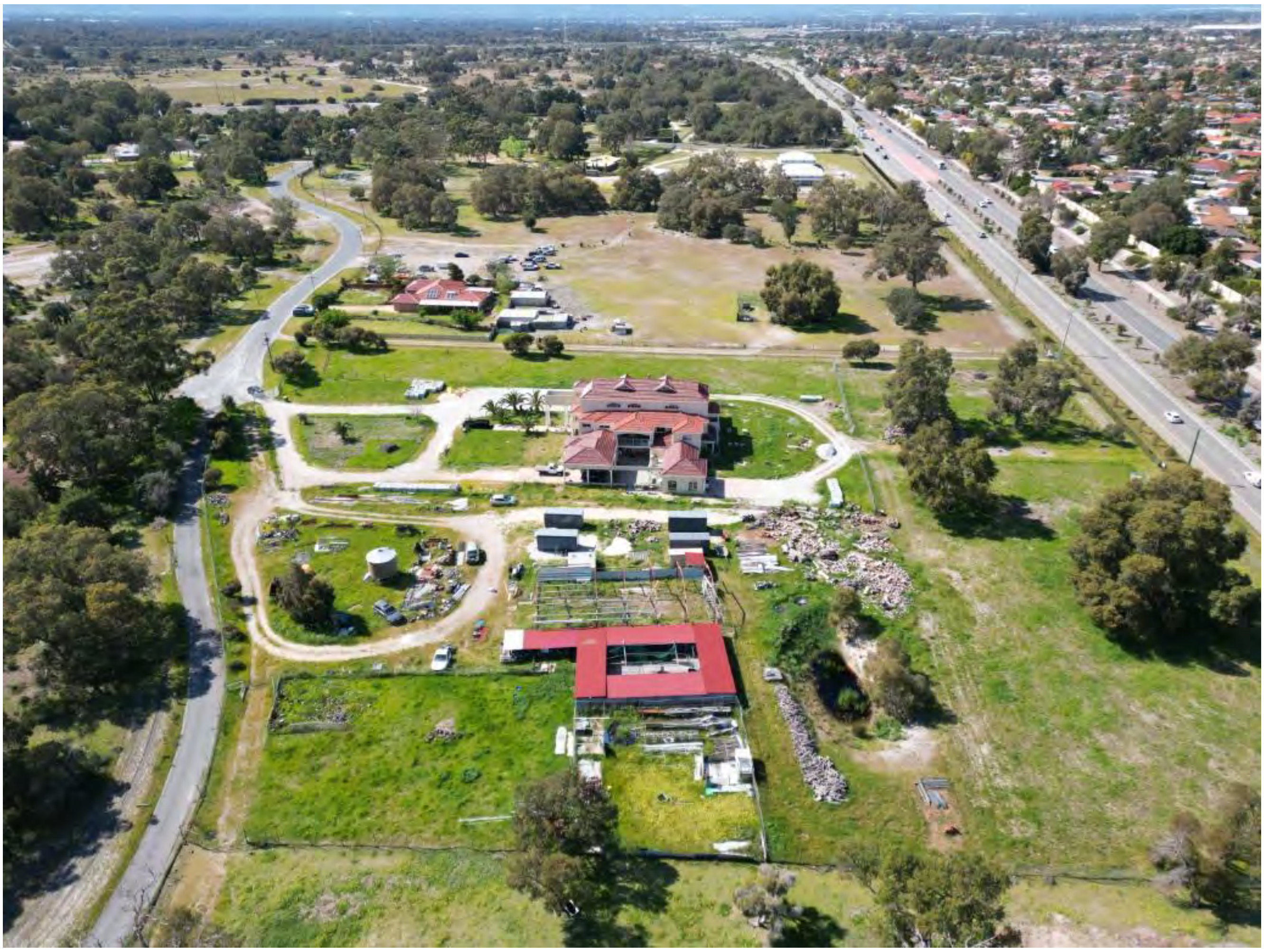
Photograph 3: Aerial view of the site

Photograph 4: Aerial view of the site

Photograph 5: Aerial view of the site

Photograph 6: Aerial view of the site

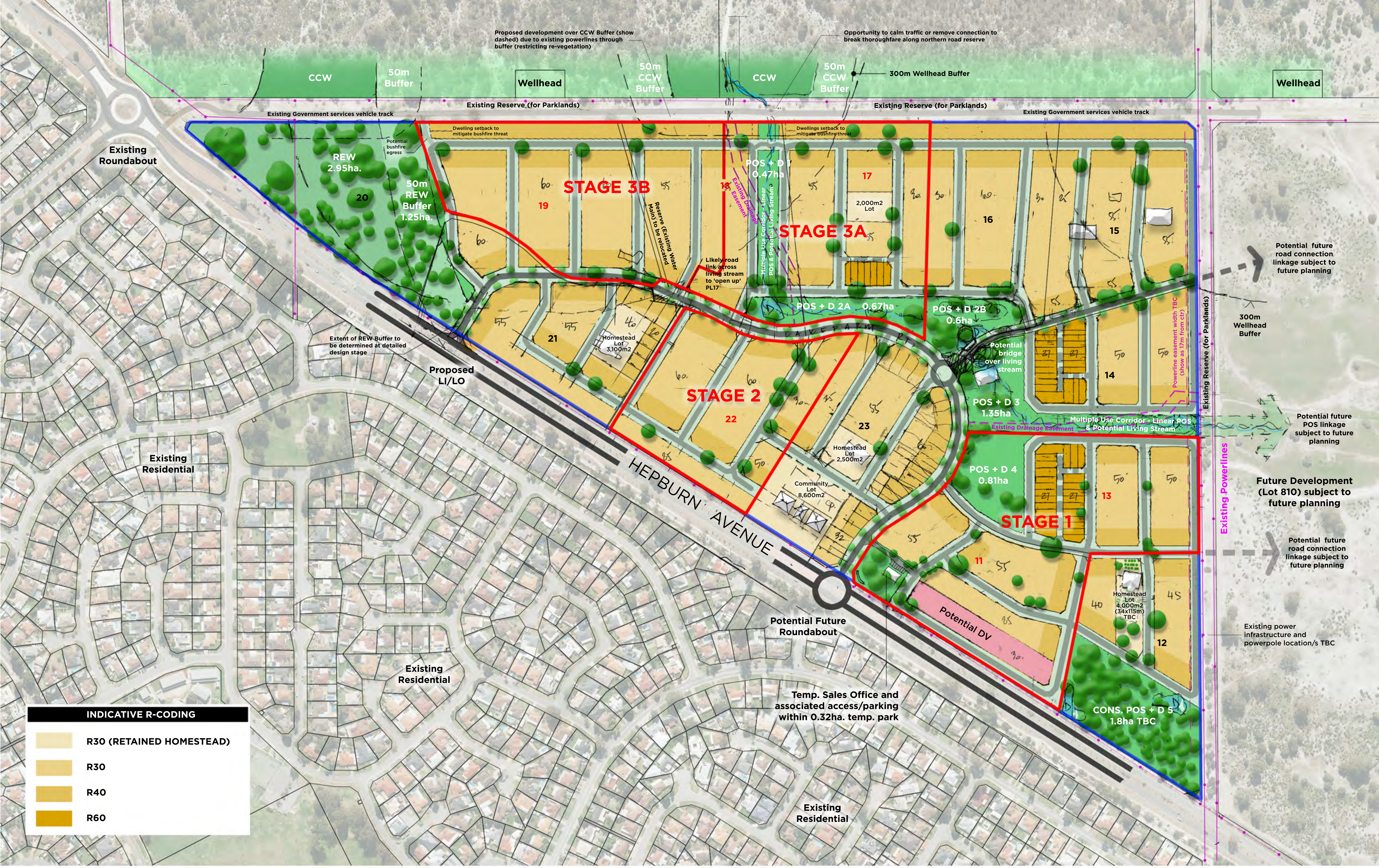
Photograph 7: Aerial view of the site



Photograph 8: Aerial view of the site

Photograph 9: Aerial view of the site

Appendix B: Supplied Information



CONCEPT CELL STRUCTURE PLAN - V5

Lakefarm Retreat, Ballajura
A LandGroup WA Project

LandGroupWA

DRAFT
SUBJECT TO DETAILED DESIGN

Date: 25 September 2024
Scale: 2000@A3
Job: LgwLf\3. Plans\2. CPT\3. 240820 Concept Cell Structure Plan

cdp
Town Planning & Urban Design

Date: 14/08/2024 Job No. H24009

▭ Site

Hyd2o July 2024 Readings (mAHD)

DWER 2019 Groundwater Maximum (mAHD)

DWER Topography Contours (m)

Lakefarm Retreat Ballajura LWMS

Groundwater Plan

Figure 1

Appendix C: Borehole Reports

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
▨		FILL (various types)
▨		COBBLES / BOULDERS
▨	GP	GRAVEL (poorly graded)
▨	GW	GRAVEL (well graded)
▨	GC	Clayey GRAVEL
▨	GM	Silty GRAVEL
▨	SP	SAND (poorly graded)
▨	SW	SAND (well graded)
▨	SC	Clayey SAND

Graphic	USCS	Soil Name
▨	SM	Silty SAND
▨	ML	SILT (low liquid limit)
▨	MH	SILT (high liquid limit)
▨	CL	CLAY (low plasticity)
▨	CI	CLAY (medium plasticity)
▨	CH	CLAY (high plasticity)
▨	OL	Organic SILT (low liquid limit)
▨	OH	Organic SILT (high liquid limit)
▨	Pt	PEAT

NOTE: Dual classification given for soils with a fines content between 5% and 12%.

SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

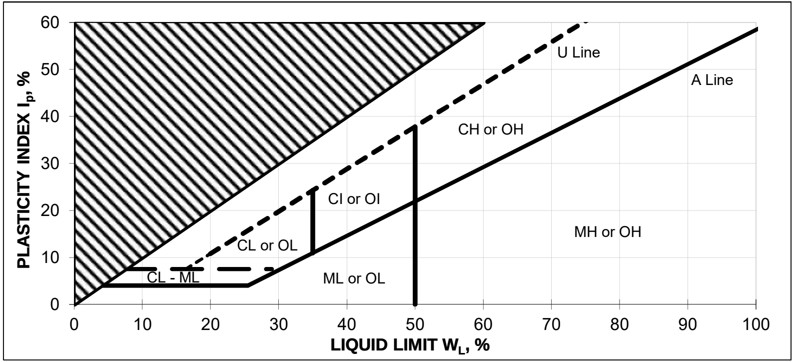
Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).

NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



RESISTANCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION

Symbol	Term
D	Dry
M	Moist
W	Wet

CEMENTATION

Cementation	Description
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY

Symbol	Term	Undrained Shear Strength (kPa)
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS

Material	Organic Content % of dry mass
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY

Symbol	Term	Density Index (%)
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC > 100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

BOREHOLE: BH01

Sheet 1 OF 1

Job Number: WAG240411-01
Client: Landgroup WA
Project: Proposed Residential Subdivision
Contractor: GBI
Location: Lakefarm Retreat, Ballajura
Drill Rig: Melvelle
Inclination: -90°
Date: 19/09/2024
Logged: PF
Checked Date: 02/10/2024
Checked By: TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, grey, trace fines, trace organics	D		BH01/0.00		0.00 : Patchy grass and mature trees in surrounds
			0.5					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey/white, trace fines	D - M		BH01/0.50		
			1.0						Becomes brown			BH01/1.00		
									Becomes dark brown, with gravel size weakly to moderately cemented sand					
	E		1.5						Becomes orange brown			BH01/1.50		
									Becomes brown					
			2.0						Includes gravel sized weakly cemented zones	M		BH01/2.00		
			2.5						Becomes pale grey/brown	M - W		BH01/2.50		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH01/3.00		
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH02

Sheet 1 OF 1

Job Number:	WAG240411-01	**Contractor:**	GBI	**Drill Rig:**	Melvelle	**Date:**	19/09/2024
Client:	Landgroup WA	**Location:**	Lakefarm Retreat, Ballajura	**Inclination:**	-90°	**Logged:**	PF
Project:	Proposed Residential Subdivision					**Checked Date:**	02/10/2024
						Checked By:	TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH RL*	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, grey, trace fines and roots	D		BH02/0.00		
			0.5					SP	SAND: fine to medium grained, sub-angular to sub-rounded, pale grey, trace fines			BH02/0.50		
			1.0						Weakly cemented, brown			BH02/1.00		
			1.5						Brown yellow/pale grey			BH02/1.50		
			2.0									BH02/2.00		
			2.5							M - W		BH02/2.50		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH02/3.00		
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH03

Sheet 1 OF 1

Job Number:	WAG240411-01	**Contractor:**	GBI	**Drill Rig:**	Melvelle
Client:	Landgroup WA	**Location:**	Lakefarm Retreat, Ballajura	**Inclination:**	-90°
Project:	Proposed Residential Subdivision				

Date: 19/09/2024
Logged: PF
Checked Date: 02/10/2024
Checked By: TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
	E		0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, grey/dark grey, trace fines, trace organics	D		BH03/0.00		0.00 : Small patches of grass and mature trees in surrounds
			0.5					SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines	D - M		BH03/0.50		
			1.0						Becomes white			BH03/1.00 BH03/1.50 BH03/2.00		
			1.5											
			2.0						Becomes pale grey/brown	M				
			2.5							M - W		BH03/2.50 BH03/3.00		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered					
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH04

Sheet 1 OF 1

Job Number:	WAG240411-01	**Contractor:**	GBI	**Drill Rig:**	Melvelle
Client:	Landgroup WA	**Location:**	Lakefarm Retreat, Ballajura	**Inclination:**	-90°
Project:	Proposed Residential Subdivision				

Date: 19/09/2024
Logged: PF
Checked Date: 02/10/2024
Checked By: TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, grey/dark grey, trace fines, trace organics	D		BH04/0.00		0.00 : Surrounded by grass patches and mature trees
			0.5						SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines	D - M		BH04/0.50		
			1.0						Becomes white			BH04/1.00		
E			1.5					SP	Becomes white/pale brown			BH04/1.50		
			2.0						Becomes brown, with gravel size weakly to moderately cemented sand	M		BH04/2.00		
			2.5						Becomes pale brown/grey	M - W		BH04/2.50 BH04/3.00		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered					
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH05

Sheet 1 OF 1

Job Number: WAG240411-01
Client: Landgroup WA
Project: Proposed Residential Subdivision

Contractor: GBI
Location: Lakefarm Retreat, Ballajura

Drill Rig: Melvelle
Inclination: -90°

Date: 19/09/2024
Logged: PF
Checked Date: 02/10/2024
Checked By: TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, grey/dark grey, trace fines and roots			BH05/0.00		
									SAND: fine to medium grained, sub-angular to sub-rounded, grey/dark grey, trace fines					
			0.5							D		BH05/0.50		
			1.0						Becoming pale grey			BH05/1.00		
			1.5					SP				BH05/1.50		
			2.0							M - W		BH05/2.00		
			2.5						Becoming brown/grey			BH05/2.50		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH05/3.00		
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH06

Sheet 1 OF 1

Job Number:	WAG240411-01	**Contractor:**	GBI	**Drill Rig:**	Melvelle	**Date:**	19/09/2024
Client:	Landgroup WA	**Location:**	Lakefarm Retreat, Ballajura	**Inclination:**	-90°	**Logged:**	PF
Project:	Proposed Residential Subdivision					**Checked Date:**	02/10/2024
						Checked By:	TM

Drilling					**Sampling**	**Field Material Description**								
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, pale grey, trace fines and roots			BH06/0.00		
									SAND: fine to medium grained, sub-angular to sub-rounded, pale grey, trace fines					
			0.5									BH06/0.50		
										D				
			1.0									BH06/1.00		
			1.5					SP	Becoming grey at depths			BH06/1.50		
			2.0									BH06/2.00		
										M - W				
			2.5									BH06/2.50		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH06/3.00		
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 GLB Log GH_EXCAVATION WAG240411-01.GPJ <<DrawingFile>> 08/10/2024 13:52 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

BOREHOLE: BH07

Sheet 1 OF 1

Job Number:	WAG240411-01	**Contractor:**	GBI	**Drill Rig:**	Melvelle
Client:	Landgroup WA	**Location:**	Lakefarm Retreat, Ballajura	**Inclination:**	-90°
Project:	Proposed Residential Subdivision				

Date: 19/09/2024
Logged: PF
Checked Date: 02/10/2024
Checked By: TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
	E		0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, dark grey, trace fines, trace organics	D		BH07/0.00		0.00 : Patches of grass on surface, surrounded by large mature trees
			0.5					SP	SAND: fine to medium grained, sub-angular to sub-rounded, grey, trace fines	D - M		BH07/0.50		
									Becomes white					
			1.0						Becomes grey			BH07/1.00		
									Becomes dark brown, with gravel size weakly to moderately cemented sands (COFFEE ROCK)					
			1.5						Becomes brown mottled yellow			BH07/1.50		
			2.0						Becomes white			BH07/2.00		
			2.5						Becomes pale grey/brown	M M - W		BH07/2.50 BH07/3.00		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered					
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH08

Sheet 1 OF 1

Job Number: WAG240411-01
Client: Landgroup WA
Project: Proposed Residential Subdivision

Contractor: GBI
Location: Lakefarm Retreat, Ballajura

Drill Rig: Melvelle
Inclination: -90°

Date: 19/09/2024
Logged: PF
Checked Date: 02/10/2024
Checked By: TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
	E		0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, pale grey-brown, trace fines and roots	D		BH08/0.00		0.00 : Grass patches on surace, surrounded by large mature trees
								SP	SAND: fine to medium grained, sub-angular to sub-rounded, yellow, trace fines	D - M				
			0.5									BH08/0.50		
			1.0									BH08/1.00		
			1.5									BH08/1.50		
			2.0						Becomes pale yellow/white			BH08/2.00		
									Becomes pale grey/brown					
			2.5						Becomes grey/brown	M		BH08/2.50		
									Becomes pale grey/brown	M - W				
									Becomes pale brown/yellow			BH08/3.00		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered					
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH09

Sheet 1 OF 1

Job Number:	WAG240411-01	**Contractor:**	GBI	**Drill Rig:**	Melvelle	**Date:**	19/09/2024
Client:	Landgroup WA	**Location:**	Lakefarm Retreat, Ballajura	**Inclination:**	-90°	**Logged:**	PF
Project:	Proposed Residential Subdivision					**Checked Date:**	02/10/2024
						Checked By:	TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, grey, trace fines, trace organics	D		BH09/0.00		0.00 : Grass patches on surface, surrounded by large mature trees
									SAND: fine to medium grained, sub-angular to sub-rounded, pale grey, trace fines					
			0.5									BH09/0.50		
									Becomes white					
									Becomes pale brown/grey	D - M				
			1.0									BH09/1.00		
E			1.5					SP				BH09/1.50		
			2.0							M		BH09/2.00		
			2.5									BH09/2.50		
										M - W				
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH09/3.00		
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH10

Sheet 1 OF 1

Job Number: WAG240411-01
Client: Landgroup WA
Project: Proposed Residential Subdivision

Contractor: GBI
Location: Lakefarm Retreat, Ballajura

Drill Rig: Melvelle
Inclination: -90°

Date: 19/09/2024
Logged: PF
Checked Date: 02/10/2024
Checked By: TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, pale grey/brown, trace fines, trace organics	D		BH10/0.00		0.00 : Patches of grass on surface
									SAND: fine to medium grained, sub-angular to sub-rounded, white, trace fines					
			0.5									BH10/0.50		
									Becomes grey					
			1.0							D - M		BH10/1.00		
									Becomes pale brown					
									Becomes yellow					
	E		1.5					SP	Becomes white			BH10/1.50		
			2.0									BH10/2.00		
									Becomes pale brown/yellow	M				
			2.5							M - W		BH10/2.50		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH10/3.00		
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

BOREHOLE: BH11

Sheet 1 OF 1

Job Number: WAG240411-01
Client: Landgroup WA
Project: Proposed Residential Subdivision

Contractor: GBI
Location: Lakefarm Retreat, Ballajura

Drill Rig: Melvelle
Inclination: -90°

Date: 19/09/2024
Logged: PF
Checked Date: 02/10/2024
Checked By: TM

Drilling					Sampling		Field Material Description							
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	SAMPLE		STRUCTURE AND ADDITIONAL OBSERVATIONS
	E		0.0					SP	TOPSOIL: SAND, fine to medium grained, sub-angular to sub-rounded, pale brown, trace fines, trace organics	D		BH11/0.00		0.00 : Grass on surface
									SAND: fine to medium grained, sub-angular to sub-rounded, pale brown, trace fines					
			0.5									BH11/0.50		
			1.0							D - M		BH11/1.00		
			1.5					SP	Gravel size weakly to moderately cemented sand (COFFEE ROCK)			BH11/1.50		
			2.0							M		BH11/2.00		
			2.5							M - W		BH11/2.50		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			BH11/3.00		
			3.5											

Sketch & Other Observations

Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

Appendix D: DPSH Test Results

DPSH01

Sounding : DPSH01
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 395623 | 6477959
Altitude : 33.8 m
Tracking :

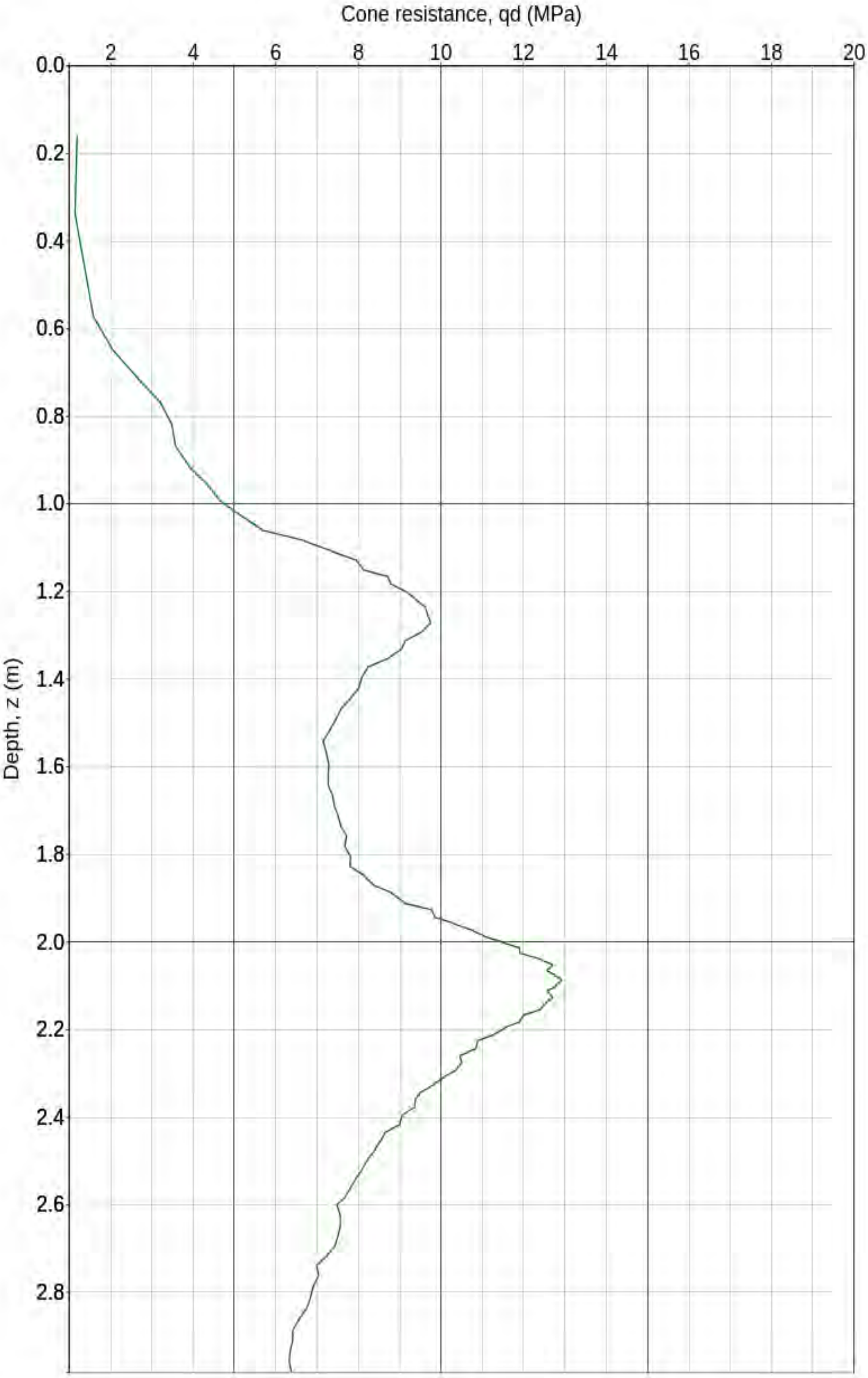
Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.01 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²

GRIZZLY®



Processing

Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 2.4m

Galt GEOTECHNICS

DPSH02

Sounding :	DPSH02
Site :	WAG240411-01 BALLAJU
Date :	20/09/2024 00:00
Company :	Groundbreaking Inves
User :	Chris Harkin
Supervisor :	MS
UTM area :	50J
UTM E,N :	395768 | 6477850
Altitude :	36.7 m
Tracking :	

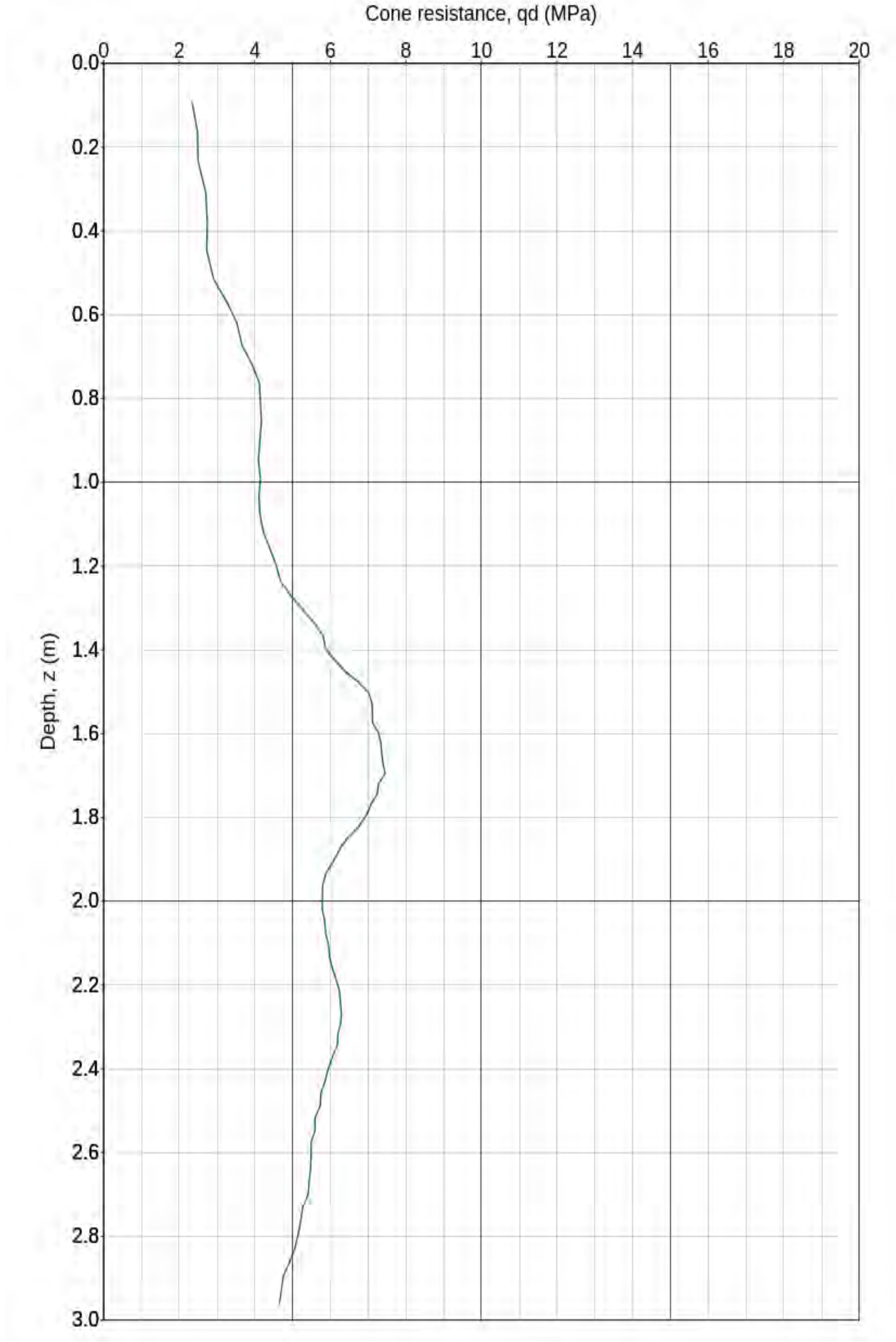
Test

Target depth :	3.0 m
Pre-drilling depth :	
Stop condition :	Temporary
Reached depth :	3.02 m
Water table :	Not found
Stable level :	
Unstable level :	

Characteristics

Device type :	Grizzly
Hammering mode :	63.5 kg
Cone section :	20 cm²

GRIZZLY®



Processing

Smoothing step :	100 mm
Regularization step :	1 mm
Clipping :	No

Observation

Target Depth 3m. Dry @ 2.5m

DPSH03

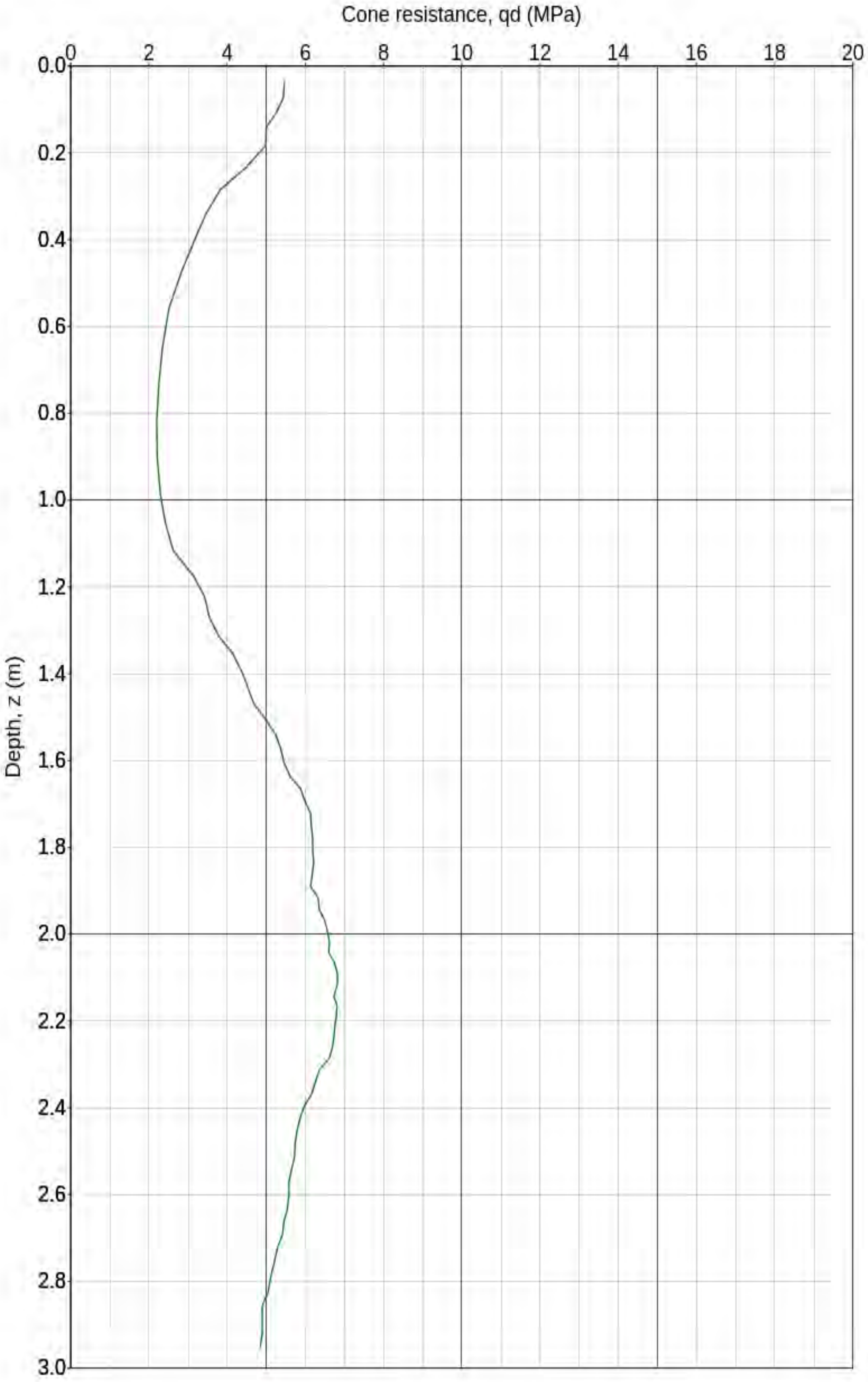
Sounding : DPSH03
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 395941 | 6477941
Altitude : 36.3 m
Tracking :

Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.02 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²



Processing

Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 2.5m

DPSH04

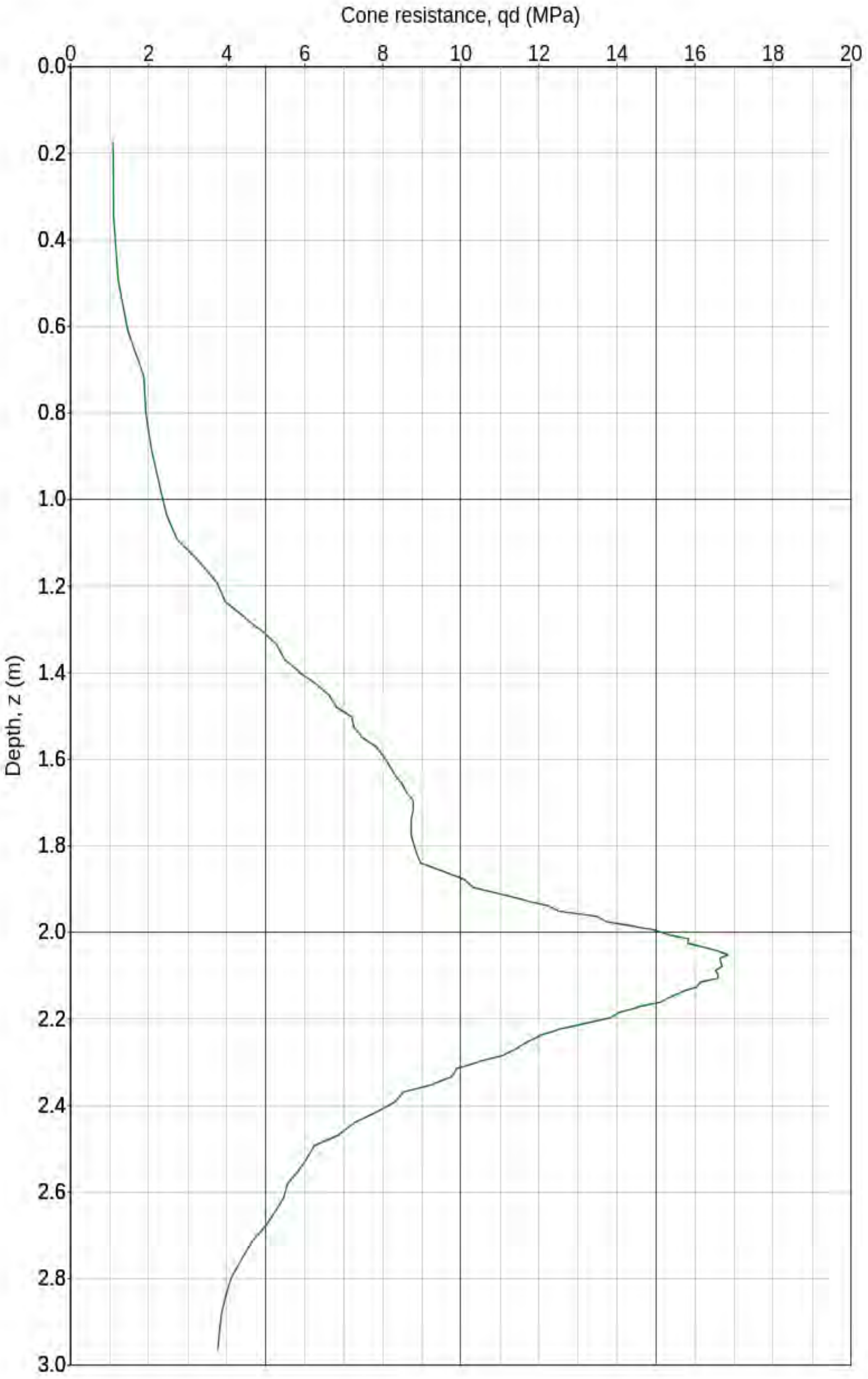
Sounding : DPSH04
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 396083 | 6477863
Altitude : 37.5 m
Tracking :

Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.0 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²



Processing

Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 2.3m

DPSH05

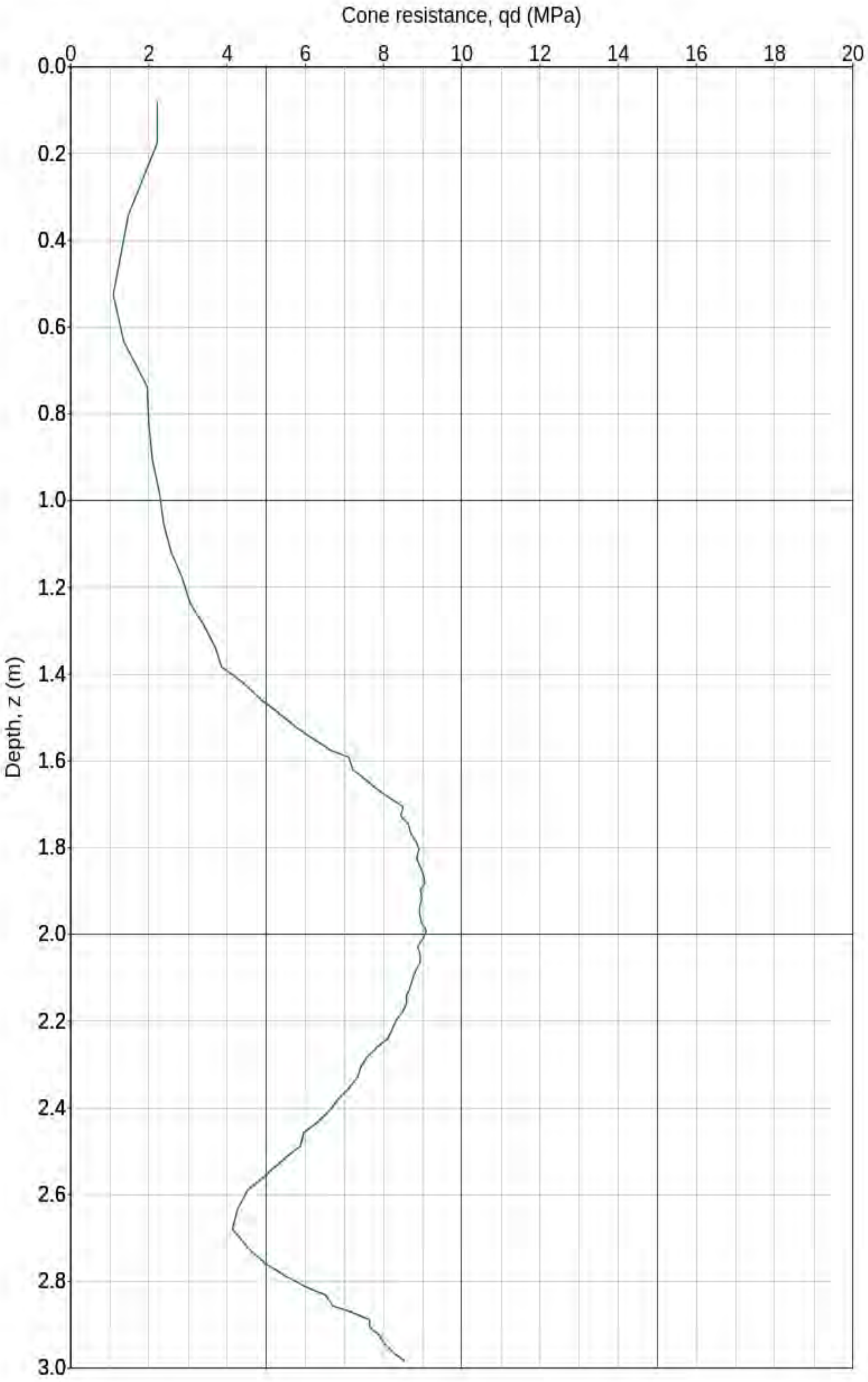
Sounding :	DPSH05
Site :	WAG240411-01 BALLAJU
Date :	20/09/2024 00:00
Company :	Groundbreaking Inves
User :	Chris Harkin
Supervisor :	MS
UTM area :	50J
UTM E,N :	396368 | 6477553
Altitude :	35.3 m
Tracking :	

Test

Target depth :	3.0 m
Pre-drilling depth :	
Stop condition :	Temporary
Reached depth :	3.01 m
Water table :	Not found
Stable level :	
Unstable level :	

Characteristics

Device type :	Grizzly
Hammering mode :	63.5 kg
Cone section :	20 cm²



Processing

Smoothing step :	100 mm
Regularization step :	1 mm
Clipping :	No

Observation

Target Depth 3m. Dry @ 1.6m

DPSH06

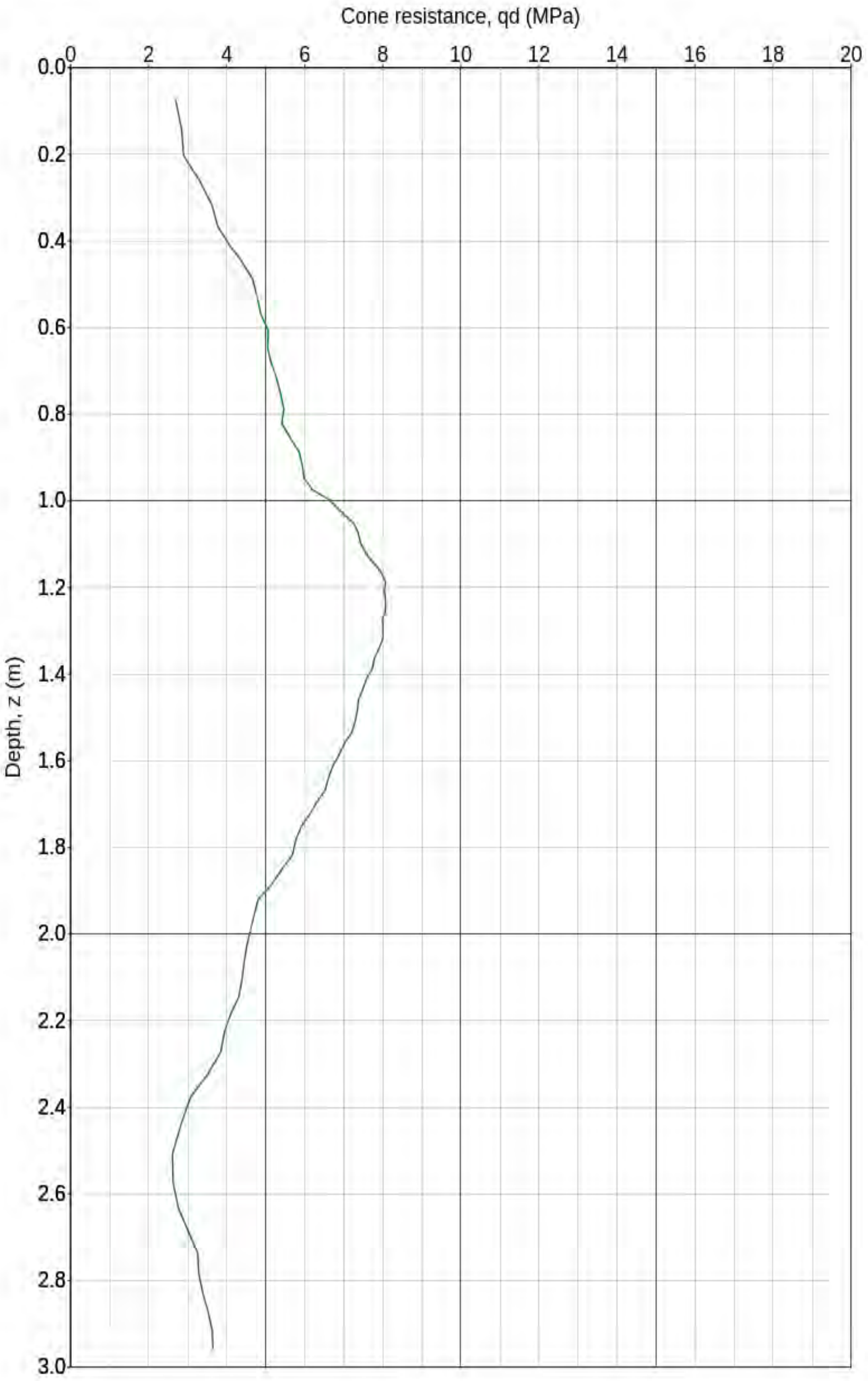
Sounding : DPSH06
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 396226 | 6477576
Altitude : 41.1 m
Tracking :

Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.03 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²



Processing

Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 1.4m

DPSH07

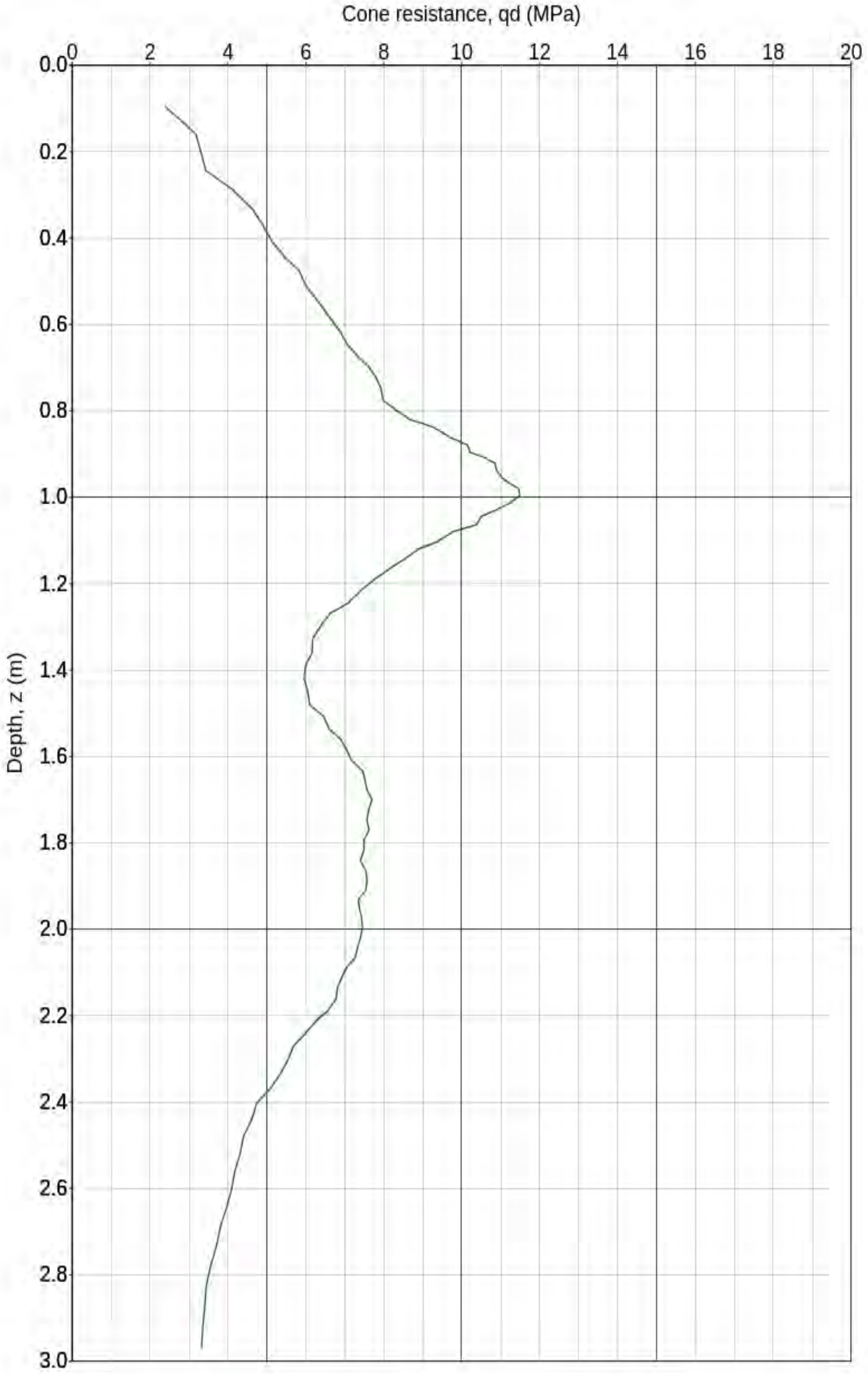
Sounding : DPSH07
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 396248 | 6477416
Altitude : 34.4 m
Tracking :

Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.01 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²



Processing

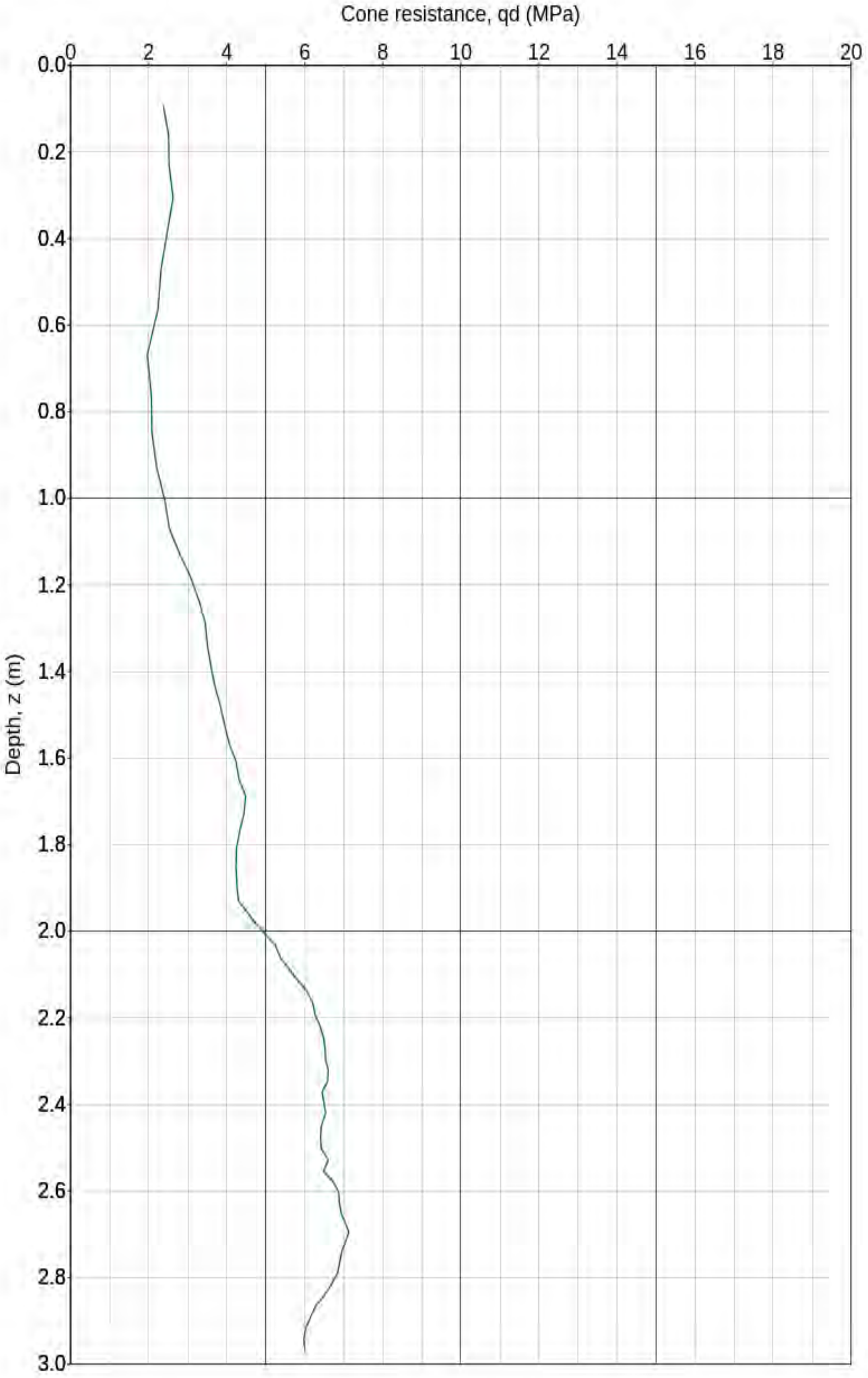
Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 1.6m

	DPSH08

Sounding : DPSH08
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 396075 | 6477501
Altitude : 39.4 m
Tracking :



Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.02 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²

Processing

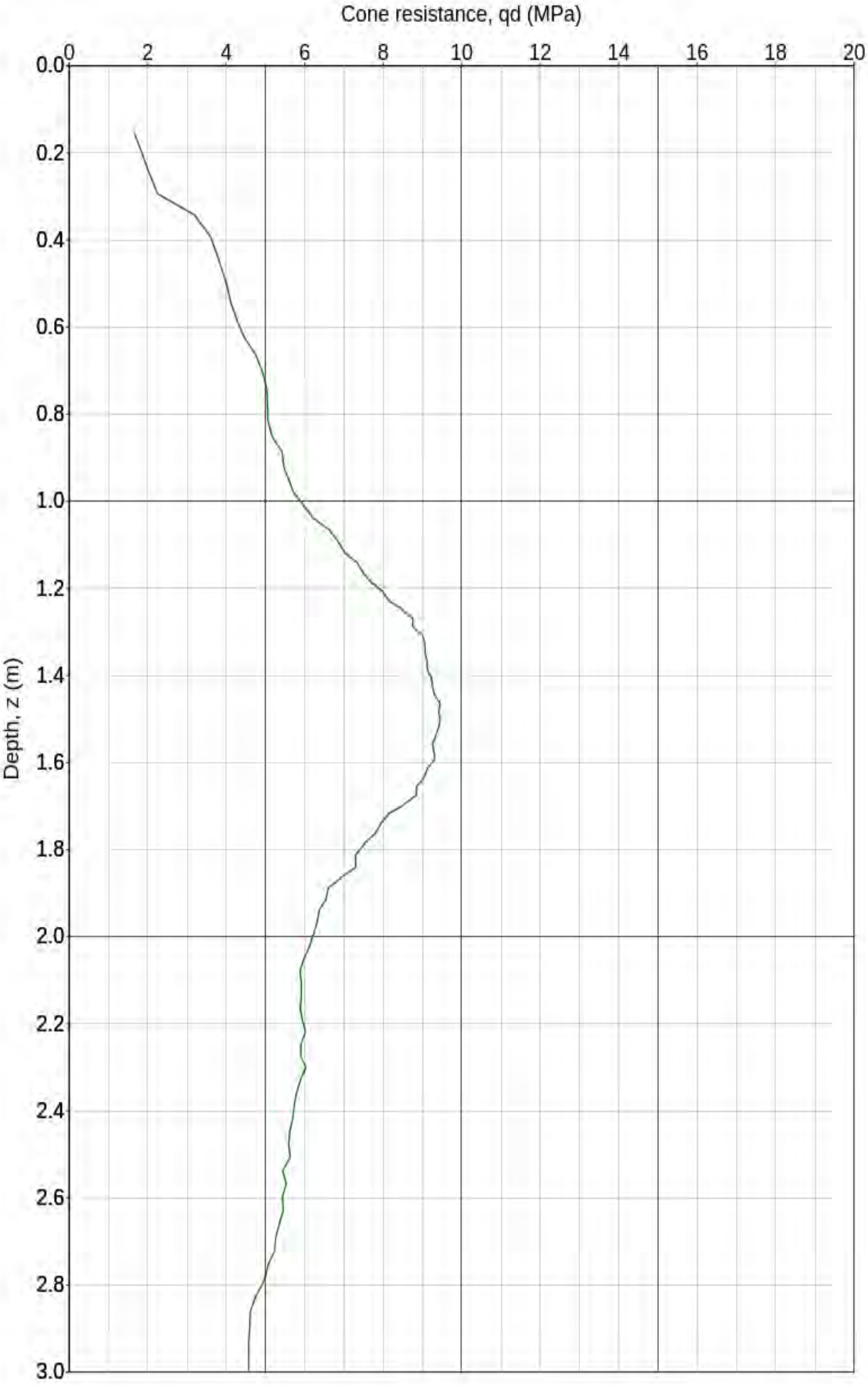
Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 2.0m

DPSH09

Sounding : DPSH09
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 395960 | 6477718
Altitude : 36.3 m
Tracking :



Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.03 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²

Processing

Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 1.9m

DPSH10

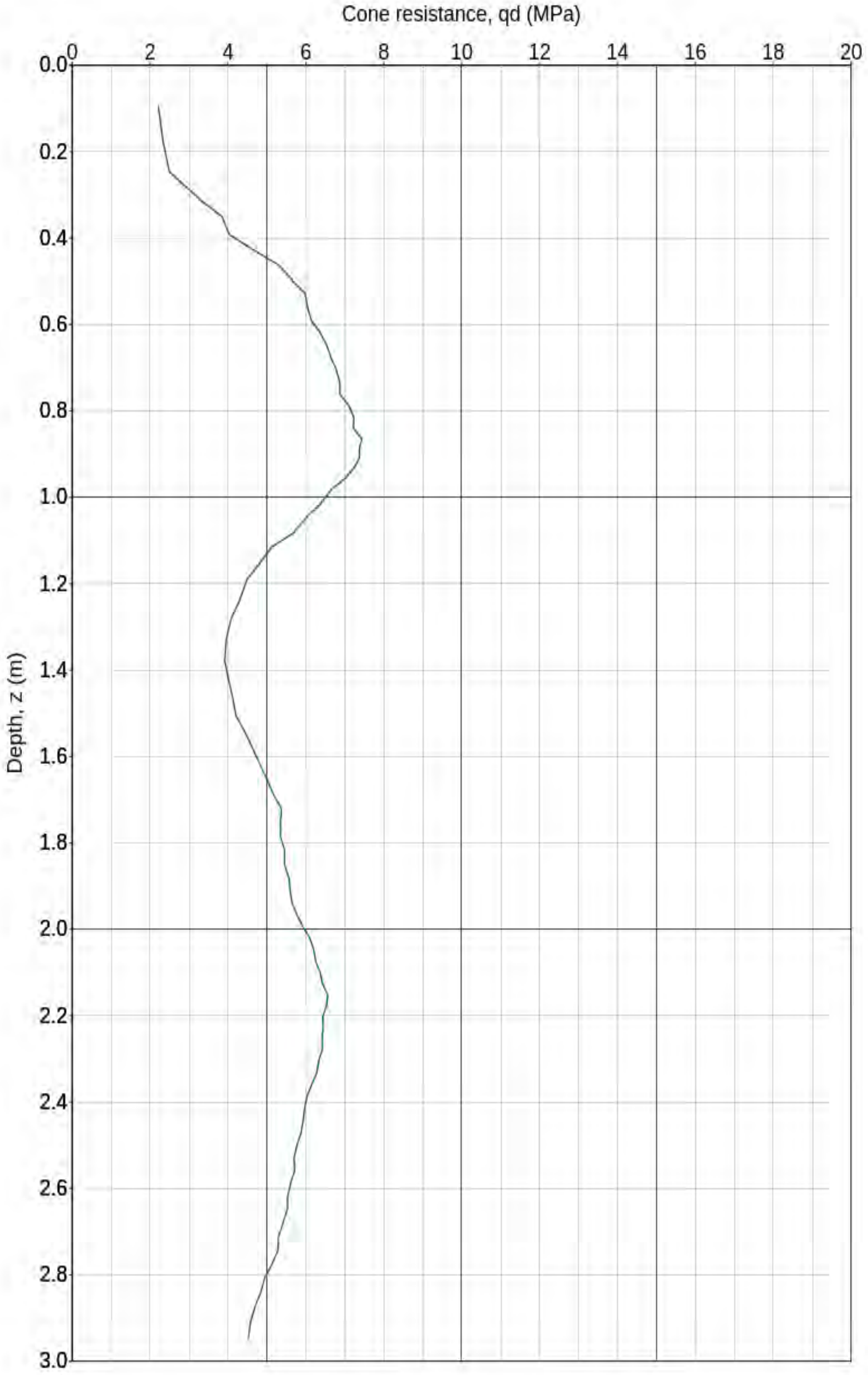
Sounding : DPSH10
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 395773 | 6477669
Altitude : 37.4 m
Tracking :

Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.02 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²



Processing

Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 2.1m

Galt GEOTECHNICS

DPSH11

Sounding : DPSH11
Site : WAG240411-01 BALLAJU
Date : 20/09/2024 00:00
Company : Groundbreaking Inves
User : Chris Harkin
Supervisor : MS
UTM area : 50J
UTM E,N : 396296 | 6477650
Altitude : 35.0 m
Tracking :

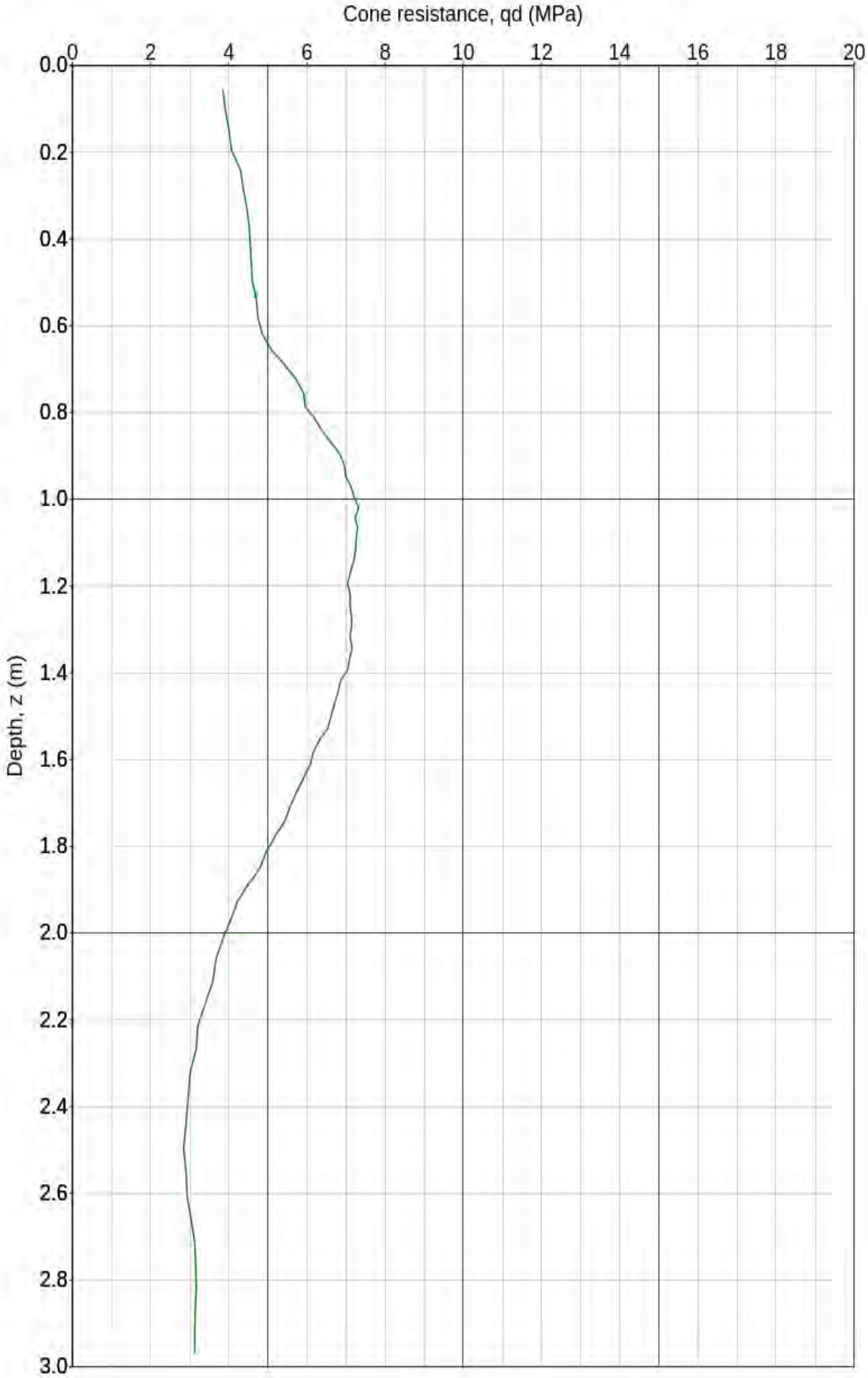
Test

Target depth : 3.0 m
Pre-drilling depth :
Stop condition : Temporary
Reached depth : 3.02 m
Water table : Not found
Stable level :
Unstable level :

Characteristics

Device type : Grizzly
Hammering mode : 63.5 kg
Cone section : 20 cm²

GRIZZLY®



Processing

Smoothing step : 100 mm
Regularization step : 1 mm
Clipping : No

Observation

Target Depth 3m. Dry @ 1.6m

Appendix E: Infiltration Test Results

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	WAG240411-01
Client:	Land Group (WA)
Project:	Residential Subdivision
Location:	Lakefarm Retreat
Calc by:	WF
Test No	IT01
Test Depth:	0.550 m

Spreadsheet author:	ORW	17-Oct-09

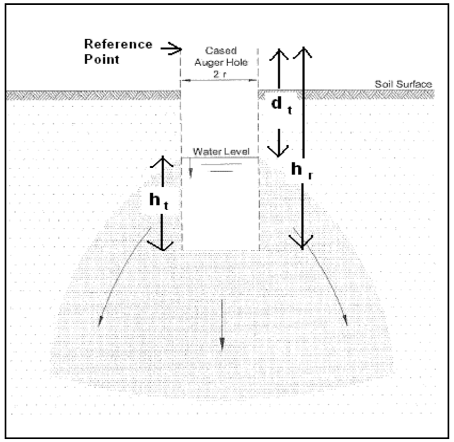
$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	0.67	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m



Test 1

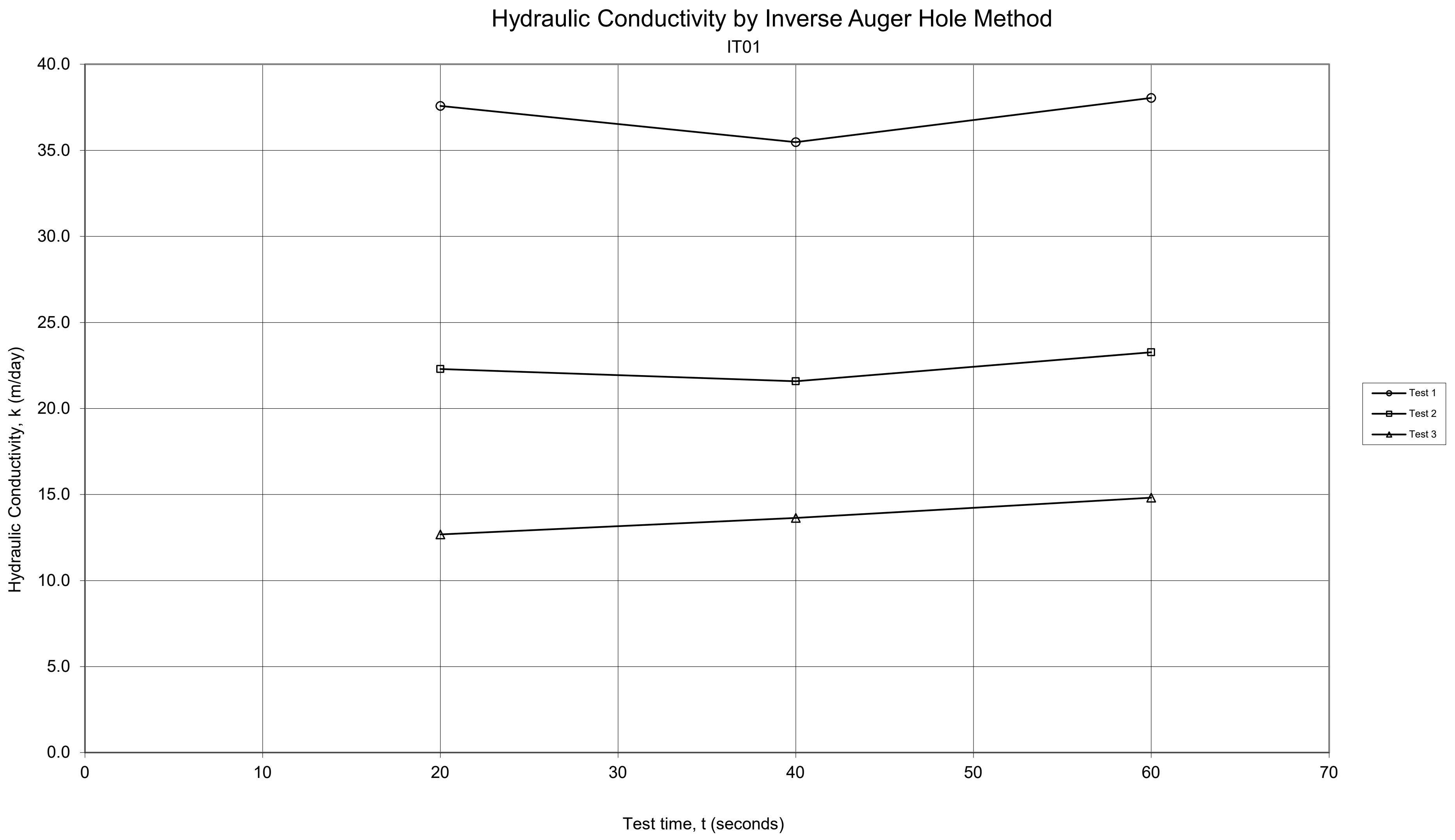
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.49	0.18	☒	☒
20	0.555	0.115	4.4E-04	37.6
40	0.595	0.075	4.1E-04	35.5
60	0.63	0.04	4.4E-04	38.0
		AVERAGE	4.3E-04	37.0

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.595	0.075	☒	☒
20	0.615	0.055	2.6E-04	22.3
40	0.63	0.04	2.5E-04	21.6
60	0.645	0.025	2.7E-04	23.3
		AVERAGE	2.6E-04	22.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.57	0.1	☒	☒
20	0.585	0.085	1.5E-04	12.7
40	0.6	0.07	1.6E-04	13.6
60	0.615	0.055	1.7E-04	14.8
		AVERAGE	1.6E-04	13.7



https://galtgeo.sharepoint.com/sites/WAG240411/Shared Documents/01 LandGroup SI/08 Analysis/Permeability Inverse Auger Hole Method - edited

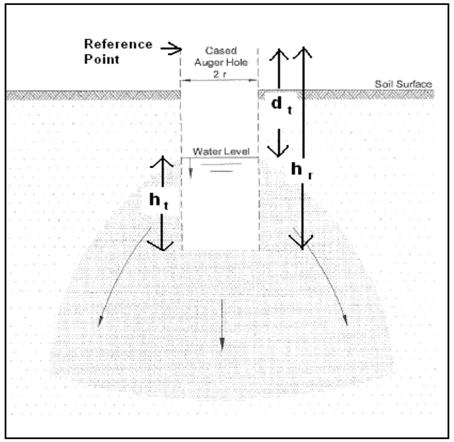
Hydraulic Conductivity Calculation - Inverse Auger Hole Method

Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09	
Job No:	WAG240411-01		
Client:	Land Group (WA)		
Project:	Residential Subdivision		
Location:	Lakefarm Retreat		
Calc by:	WF		
Test No	IT01		
Test Depth:	1.685	m	

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1.745	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

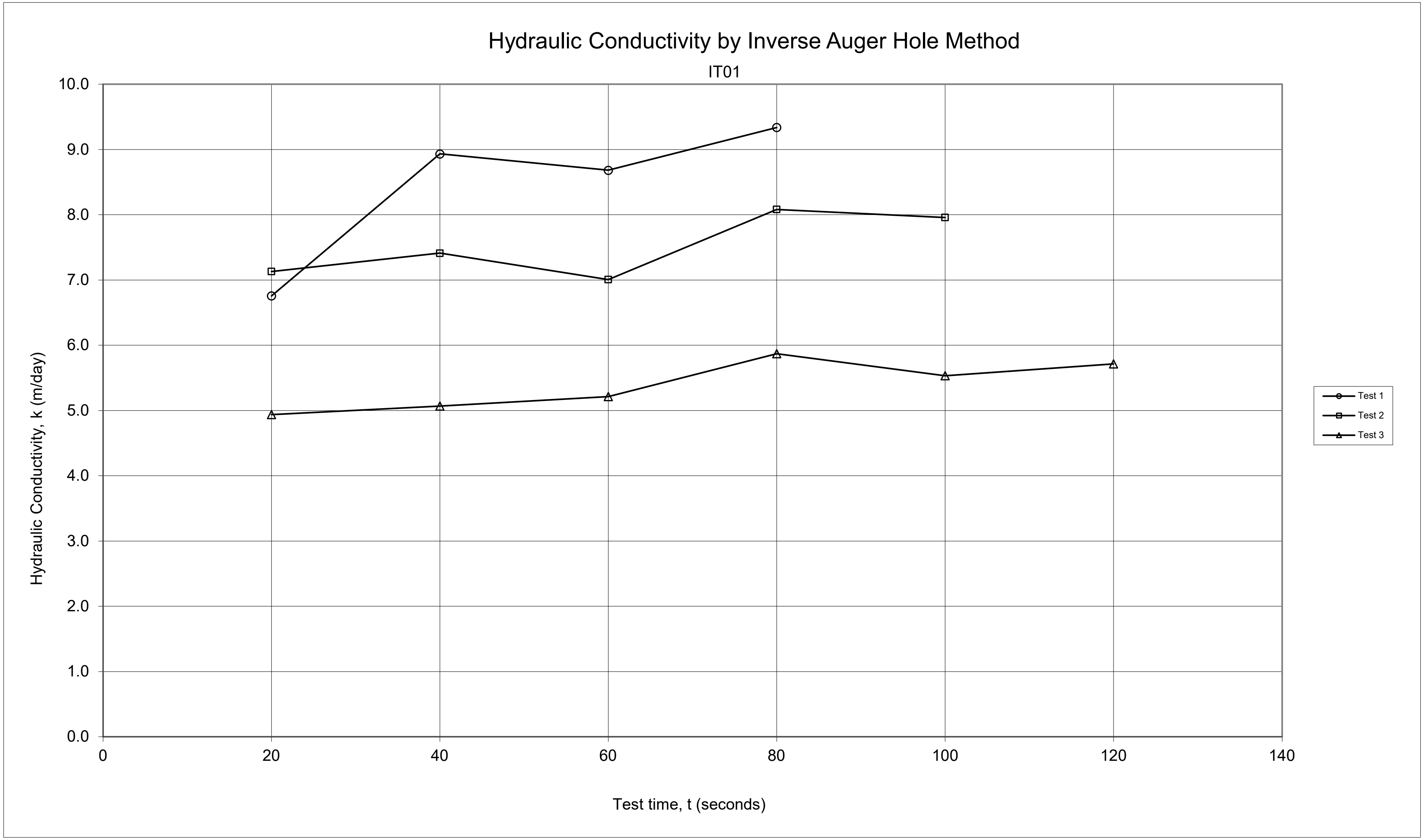
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.708	0.037	☒	☒
20	1.712	0.033	7.8E-05	6.8
40	1.718	0.027	1.0E-04	8.9
60	1.722	0.023	1.0E-04	8.7
80	1.727	0.018	1.1E-04	9.3
		AVERAGE	9.8E-05	8.4

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.711	0.034	☒	☒
20	1.715	0.03	8.3E-05	7.1
40	1.719	0.026	8.6E-05	7.4
60	1.722	0.023	8.1E-05	7.0
80	1.727	0.018	9.4E-05	8.1
100	1.73	0.015	9.2E-05	8.0
		AVERAGE	8.7E-05	7.5

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.707	0.038	☒	☒
20	1.71	0.035	5.7E-05	4.9
40	1.713	0.032	5.9E-05	5.1
60	1.716	0.029	6.0E-05	5.2
80	1.72	0.025	6.8E-05	5.9
100	1.722	0.023	6.4E-05	5.5
120	1.725	0.02	6.6E-05	5.7
		AVERAGE	6.2E-05	5.4



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Hydraulic Conductivity Calculation - Inverse Auger Hole Method

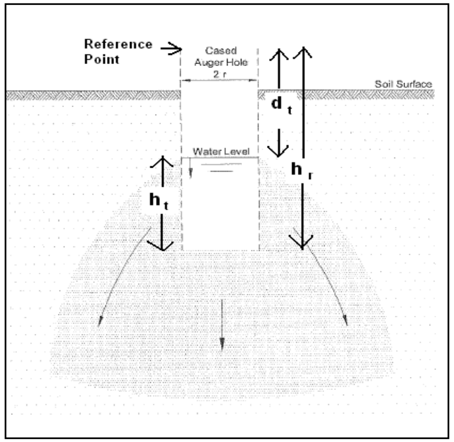
Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09

Job No:	WAG240411-01
Client:	Land Group (WA)
Project:	Residential Subdivision
Location:	Lakefarm Retreat
Calc by:	WF
Test No	IT02
Test Depth:	0.630 m

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	0.66	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

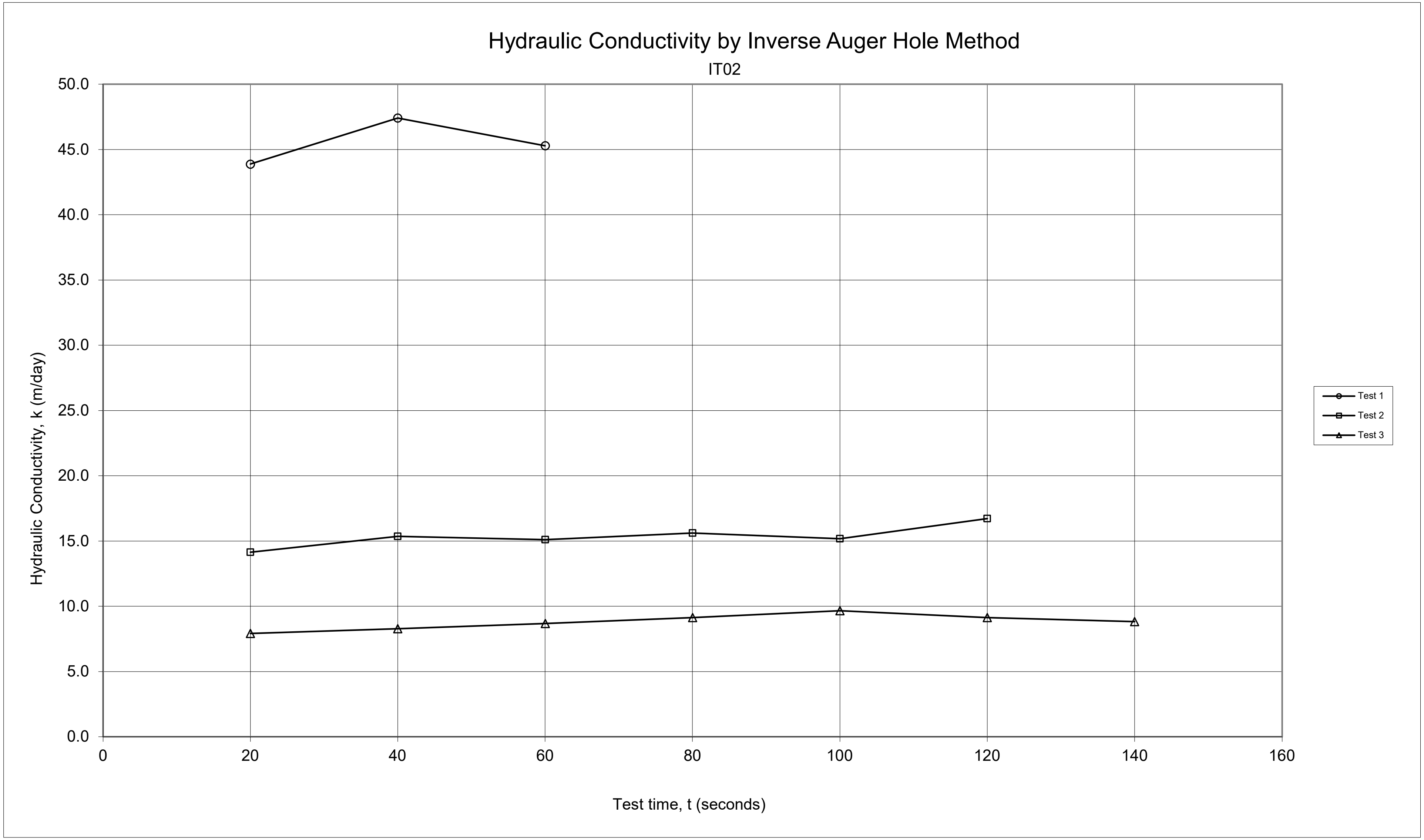
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.49	0.17	☒	☒
20	0.56	0.1	5.1E-04	43.9
40	0.61	0.05	5.5E-04	47.4
60	0.635	0.025	5.2E-04	45.3
		AVERAGE	5.3E-04	45.5

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.535	0.125	☒	☒
20	0.555	0.105	1.6E-04	14.1
40	0.575	0.085	1.8E-04	15.4
60	0.59	0.07	1.7E-04	15.1
80	0.605	0.055	1.8E-04	15.6
100	0.615	0.045	1.8E-04	15.2
120	0.63	0.03	1.9E-04	16.7
		AVERAGE	1.8E-04	15.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.555	0.105	☒	☒
20	0.565	0.095	9.2E-05	7.9
40	0.575	0.085	9.6E-05	8.3
60	0.585	0.075	1.0E-04	8.7
80	0.595	0.065	1.1E-04	9.1
100	0.605	0.055	1.1E-04	9.7
120	0.61	0.05	1.1E-04	9.1
140	0.615	0.045	1.0E-04	8.8
		AVERAGE	1.0E-04	8.8



Hydraulic Conductivity by Inverse Auger Hole Method

IT02

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Hydraulic Conductivity Calculation - Inverse Auger Hole Method

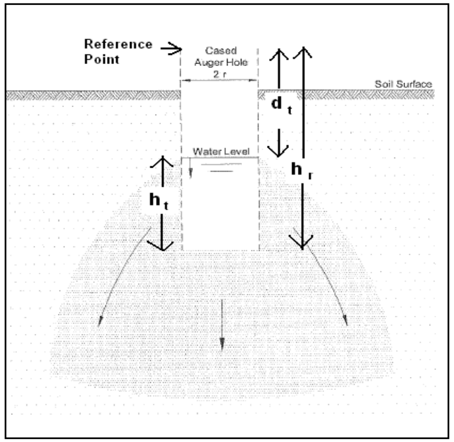
Galt Geotechnics

Job No:	WAG240411-01
Client:	Land Group (WA)
Project:	Residential Subdivision
Location:	Lakefarm Retreat
Calc by:	WF
Test No	IT02
Test Depth:	1.565 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0+\frac{1}{2}r)-\log_{10}(h_t+\frac{1}{2}r)}{t-t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1.645	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

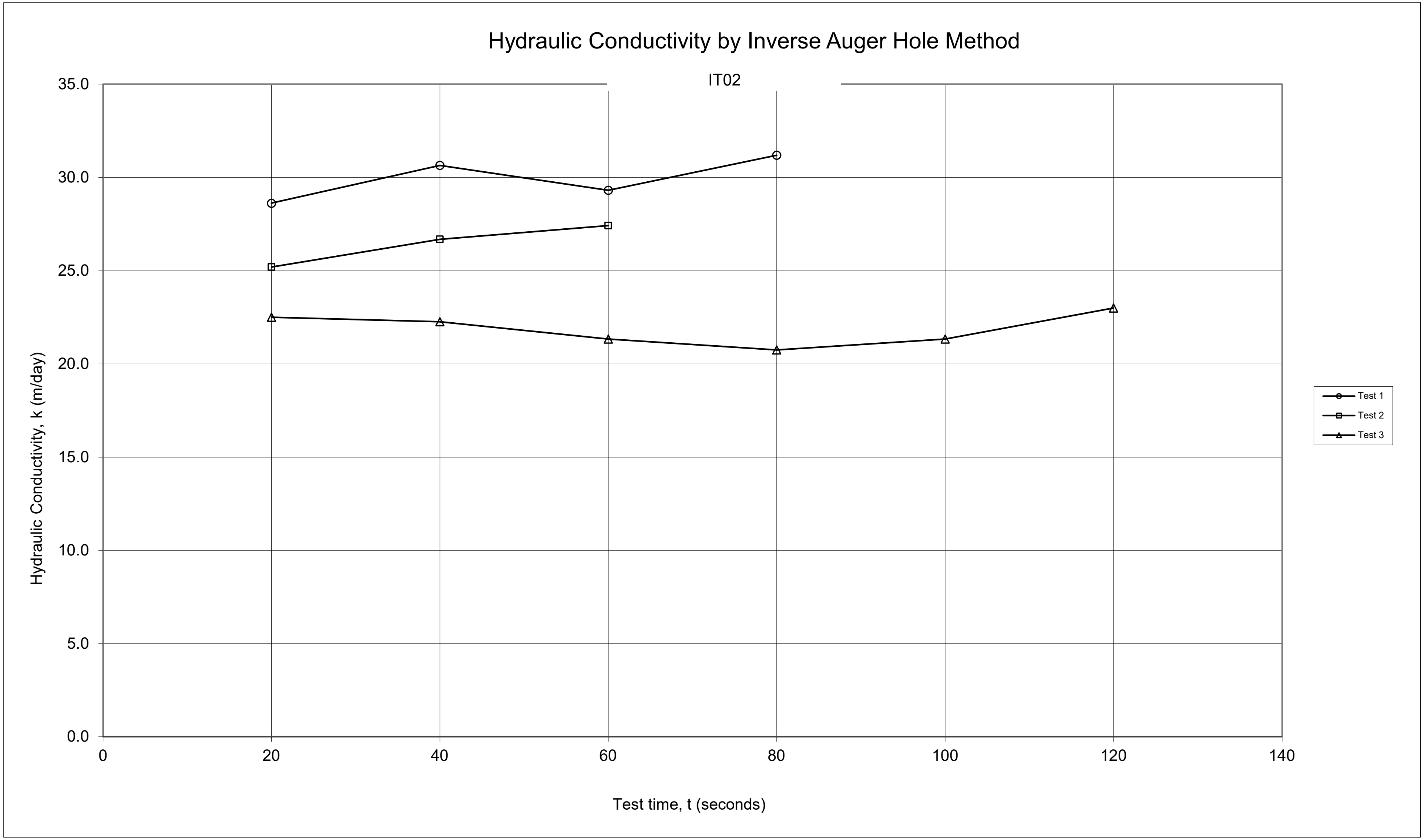
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.55	0.095	☒	☒
20	1.58	0.065	3.3E-04	28.6
40	1.605	0.04	3.5E-04	30.6
60	1.62	0.025	3.4E-04	29.3
80	1.635	0.01	3.6E-04	31.2
		AVERAGE	3.5E-04	29.9

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.58	0.065	☒	☒
20	1.6	0.045	2.9E-04	25.2
40	1.617	0.028	3.1E-04	26.7
60	1.63	0.015	3.2E-04	27.4
		AVERAGE	3.1E-04	26.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.45	0.195	☒	☒
20	1.495	0.15	2.6E-04	22.5
40	1.53	0.115	2.6E-04	22.3
60	1.555	0.09	2.5E-04	21.3
80	1.575	0.07	2.4E-04	20.8
100	1.595	0.05	2.5E-04	21.3
120	1.615	0.03	2.7E-04	23.0
		AVERAGE	2.5E-04	21.9



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Hydraulic Conductivity Calculation - Inverse Auger Hole Method

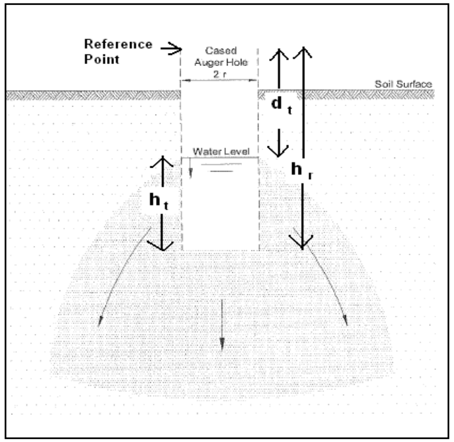
Galt Geotechnics

Spreadsheet author: ORW 17-Oct-09

Job No: WAG240411-01
Client: Land Group (WA)
Project: Residential Subdivision
Location: Lakefarm Retreat
Calc by: WF

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Test No: IT03
Test Depth: 0.84 m

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	0.87	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

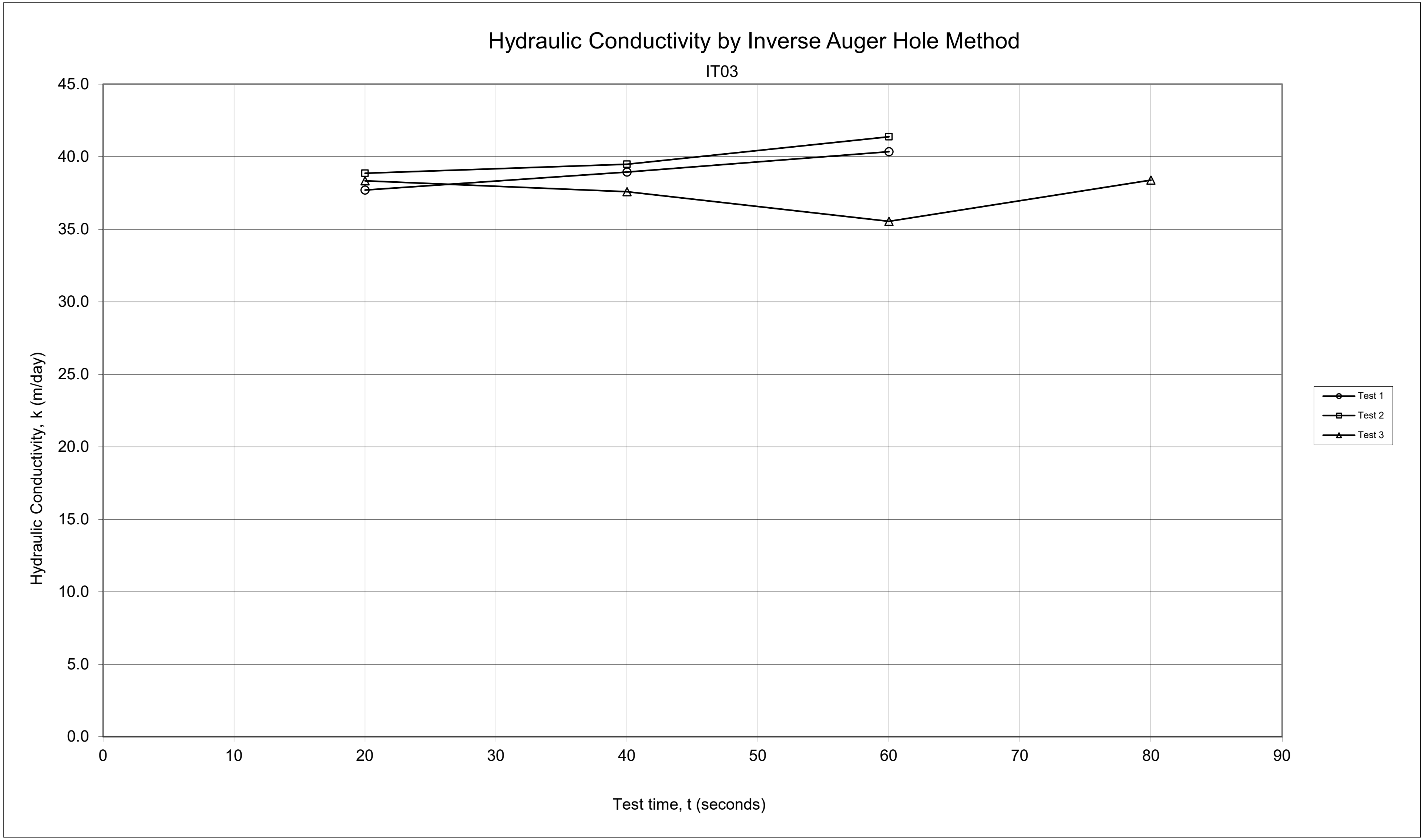
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.675	0.195	☒	☒
20	0.745	0.125	4.4E-04	37.7
40	0.795	0.075	4.5E-04	39.0
60	0.83	0.04	4.7E-04	40.4
		AVERAGE	4.5E-04	39.0

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.65	0.22	☒	☒
20	0.73	0.14	4.5E-04	38.9
40	0.785	0.085	4.6E-04	39.5
60	0.825	0.045	4.8E-04	41.4
		AVERAGE	4.6E-04	39.9

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.54	0.33	☒	☒
20	0.655	0.215	4.4E-04	38.3
40	0.73	0.14	4.4E-04	37.6
60	0.775	0.095	4.1E-04	35.6
80	0.82	0.05	4.4E-04	38.4
		AVERAGE	4.3E-04	37.5



Hydraulic Conductivity by Inverse Auger Hole Method

IT03

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Hydraulic Conductivity Calculation - Inverse Auger Hole Method

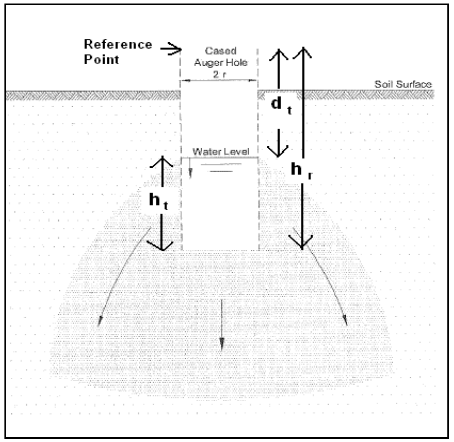
Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09	

Job No:	WAG240411-01
Client:	Land Group (WA)
Project:	Residential Subdivision
Location:	Lakefarm Retreat
Calc by:	WF
Test No	IT04
Test Depth:	0.82 m

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	0.87	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

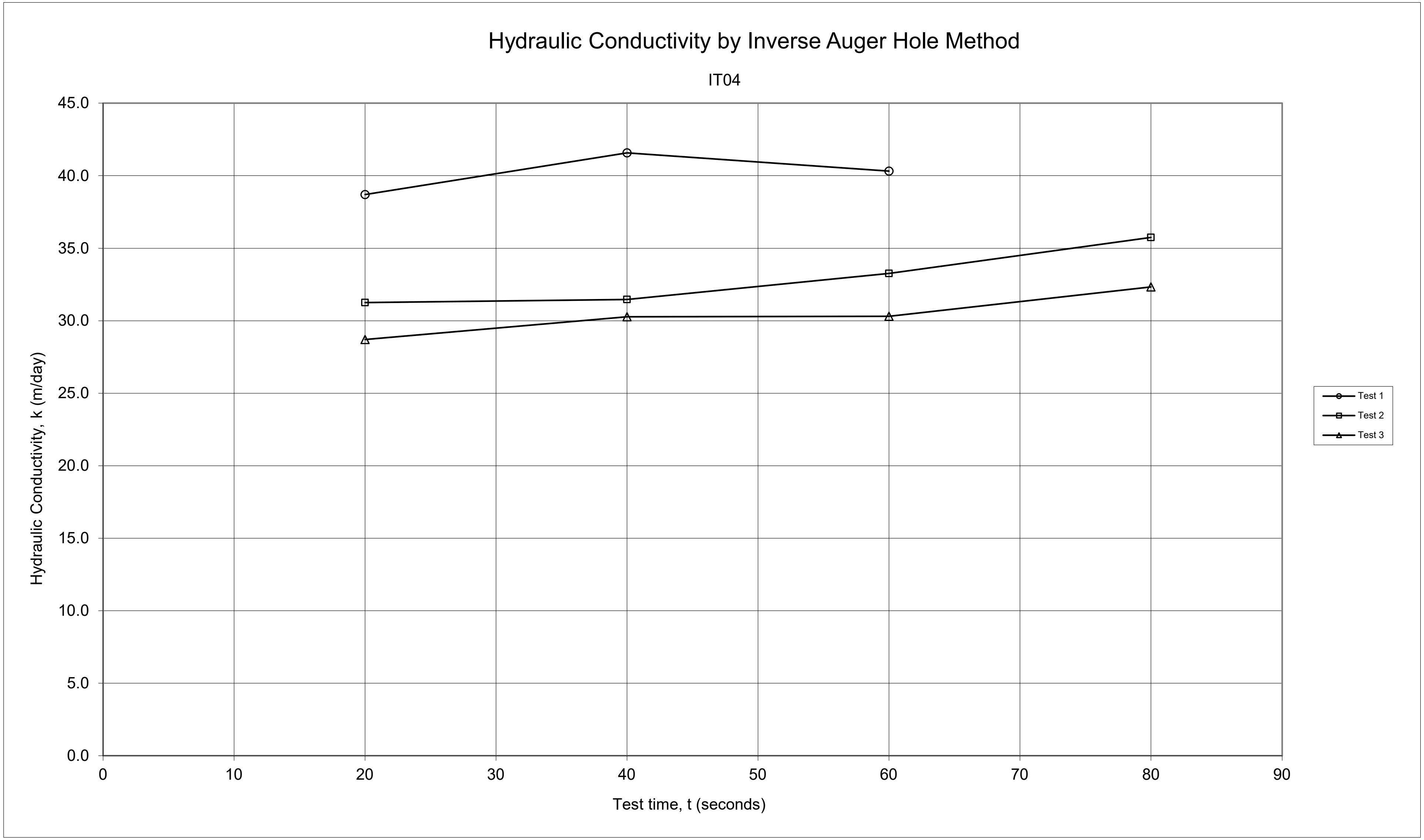
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.71	0.16	☒	☒
20	0.77	0.1	4.5E-04	38.7
40	0.815	0.055	4.8E-04	41.6
60	0.84	0.03	4.7E-04	40.3
		AVERAGE	4.7E-04	40.2

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.62	0.25	☒	☒
20	0.695	0.175	3.6E-04	31.3
40	0.75	0.12	3.6E-04	31.5
60	0.795	0.075	3.8E-04	33.3
80	0.83	0.04	4.1E-04	35.7
		AVERAGE	3.8E-04	32.9

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.58	0.29	☒	☒
20	0.66	0.21	3.3E-04	28.7
40	0.725	0.145	3.5E-04	30.3
60	0.77	0.1	3.5E-04	30.3
80	0.81	0.06	3.7E-04	32.3
		AVERAGE	3.5E-04	30.4


Hydraulic Conductivity by Inverse Auger Hole Method
IT04
Hydraulic Conductivity, k (m/day)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
10
20
30
40
50
60
70
80
90
Test time, t (seconds)
Test 1
Test 2
Test 3

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

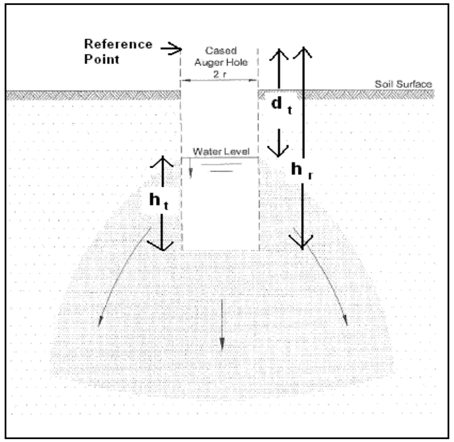
Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09	

Job No:	WAG240411-01
Client:	Land Group (WA)
Project:	Residential Subdivision
Location:	Lakefarm Retreat
Calc by:	WF
Test No	IT05
Test Depth:	0.48 m

$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	0.6	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

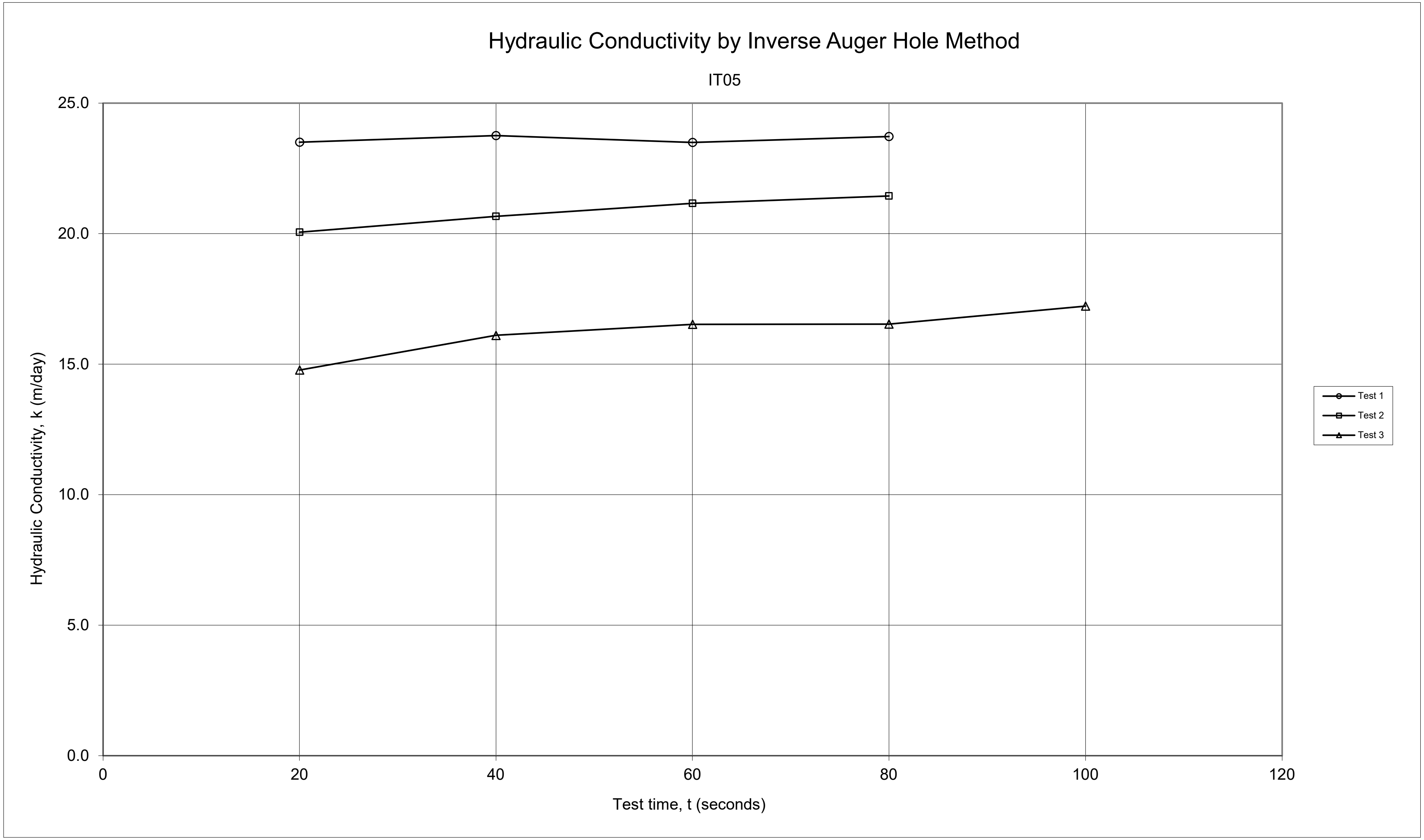
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.39	0.21	☒	☒
20	0.44	0.16	2.7E-04	23.5
40	0.48	0.12	2.8E-04	23.8
60	0.51	0.09	2.7E-04	23.5
80	0.535	0.065	2.7E-04	23.7
		AVERAGE	2.7E-04	23.6

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.435	0.165	☒	☒
20	0.47	0.13	2.3E-04	20.1
40	0.5	0.1	2.4E-04	20.7
60	0.525	0.075	2.4E-04	21.2
80	0.545	0.055	2.5E-04	21.4
		AVERAGE	2.4E-04	20.8

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.41	0.19	☒	☒
20	0.44	0.16	1.7E-04	14.8
40	0.47	0.13	1.9E-04	16.1
60	0.495	0.105	1.9E-04	16.5
80	0.515	0.085	1.9E-04	16.5
100	0.535	0.065	2.0E-04	17.2
		AVERAGE	1.9E-04	16.2



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Hydraulic Conductivity Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	WAG240411-01
Client:	Land Group (WA)
Project:	Residential Subdivision
Location:	Lakefarm Retreat
Calc by:	WF
Test No	IT05
Test Depth:	1.62 m

Spreadsheet author:	ORW	17-Oct-09

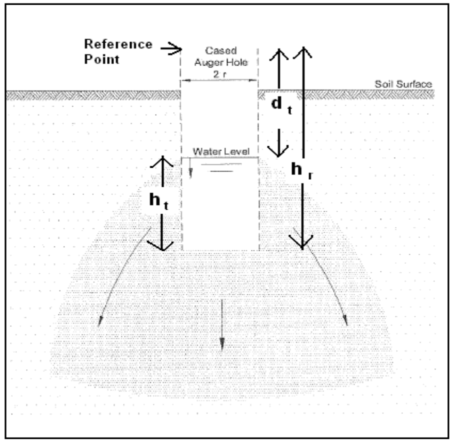
$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1.695	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m



Test 1

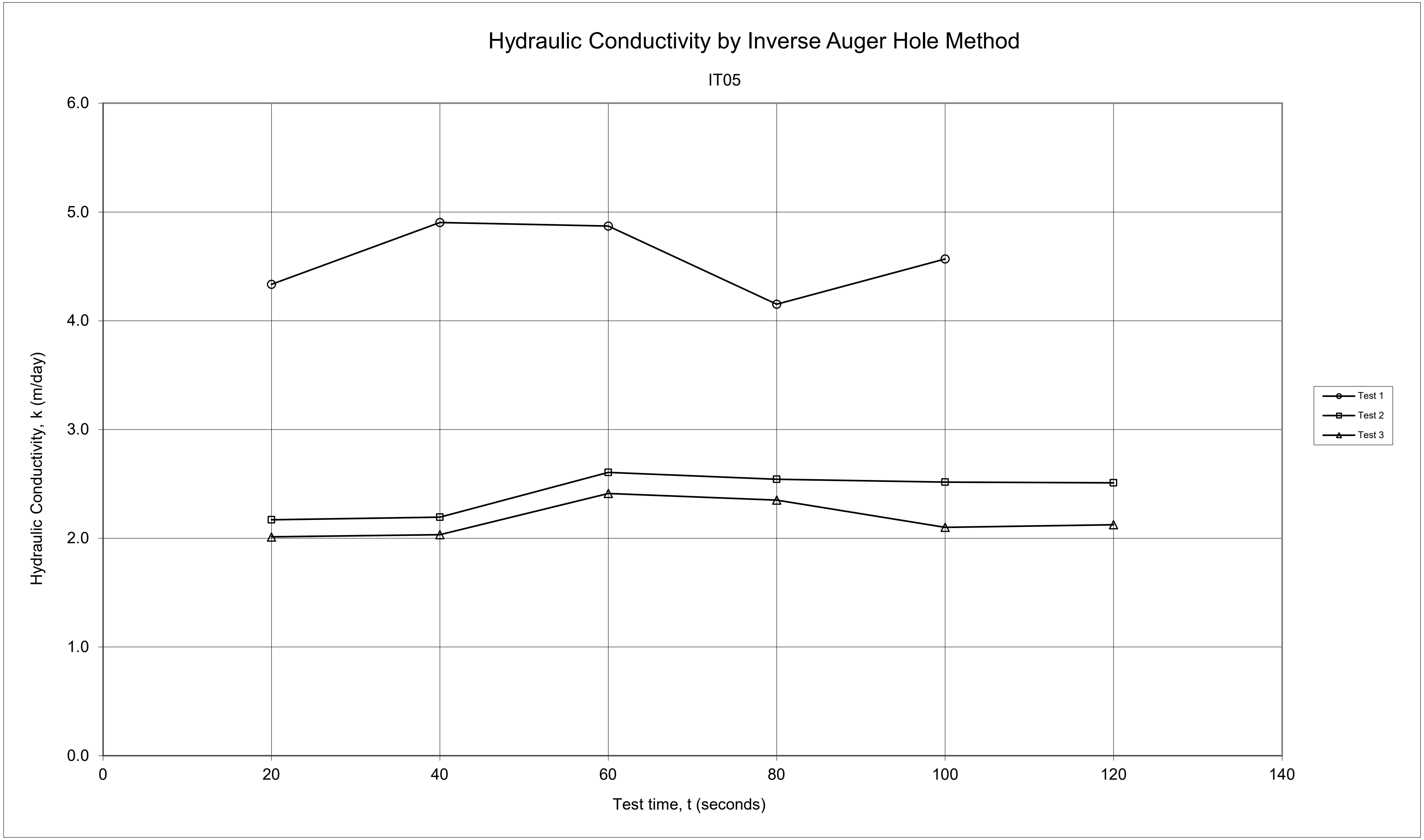
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.603	0.092	☒	☒
20	1.608	0.087	5.0E-05	4.3
40	1.614	0.081	5.7E-05	4.9
60	1.619	0.076	5.6E-05	4.9
80	1.621	0.074	4.8E-05	4.2
100	1.627	0.068	5.3E-05	4.6
		AVERAGE	5.3E-05	4.6

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.627	0.068	☒	☒
20	1.629	0.066	2.5E-05	2.2
40	1.631	0.064	2.5E-05	2.2
60	1.634	0.061	3.0E-05	2.6
80	1.636	0.059	2.9E-05	2.5
100	1.638	0.057	2.9E-05	2.5
120	1.64	0.055	2.9E-05	2.5
		AVERAGE	2.8E-05	2.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.62	0.075	☒	☒
20	1.622	0.073	2.3E-05	2.0
40	1.624	0.071	2.4E-05	2.0
60	1.627	0.068	2.8E-05	2.4
80	1.629	0.066	2.7E-05	2.4
100	1.63	0.065	2.4E-05	2.1
120	1.632	0.063	2.5E-05	2.1
		AVERAGE	2.5E-05	2.2



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Hydraulic Conductivity Calculation - Inverse Auger Hole Method

Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09	

Job No: WAG240411-01
Client: Land Group (WA)
Project: Residential Subdivision
Location: Lakefarm Retreat
Calc by: WF

Test No IT06
Test Depth: 0.81 m

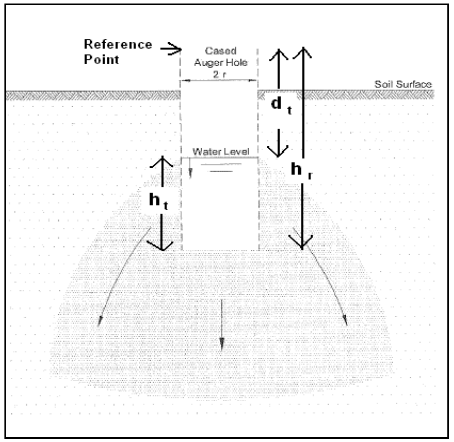
$$K = 1.15r\frac{\log_{10}(h_0+\frac{1}{2}r)-\log_{10}(h_t+\frac{1}{2}r)}{t-t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	**Description**	**Value**	**Units**
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	0.86	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m



Test 1

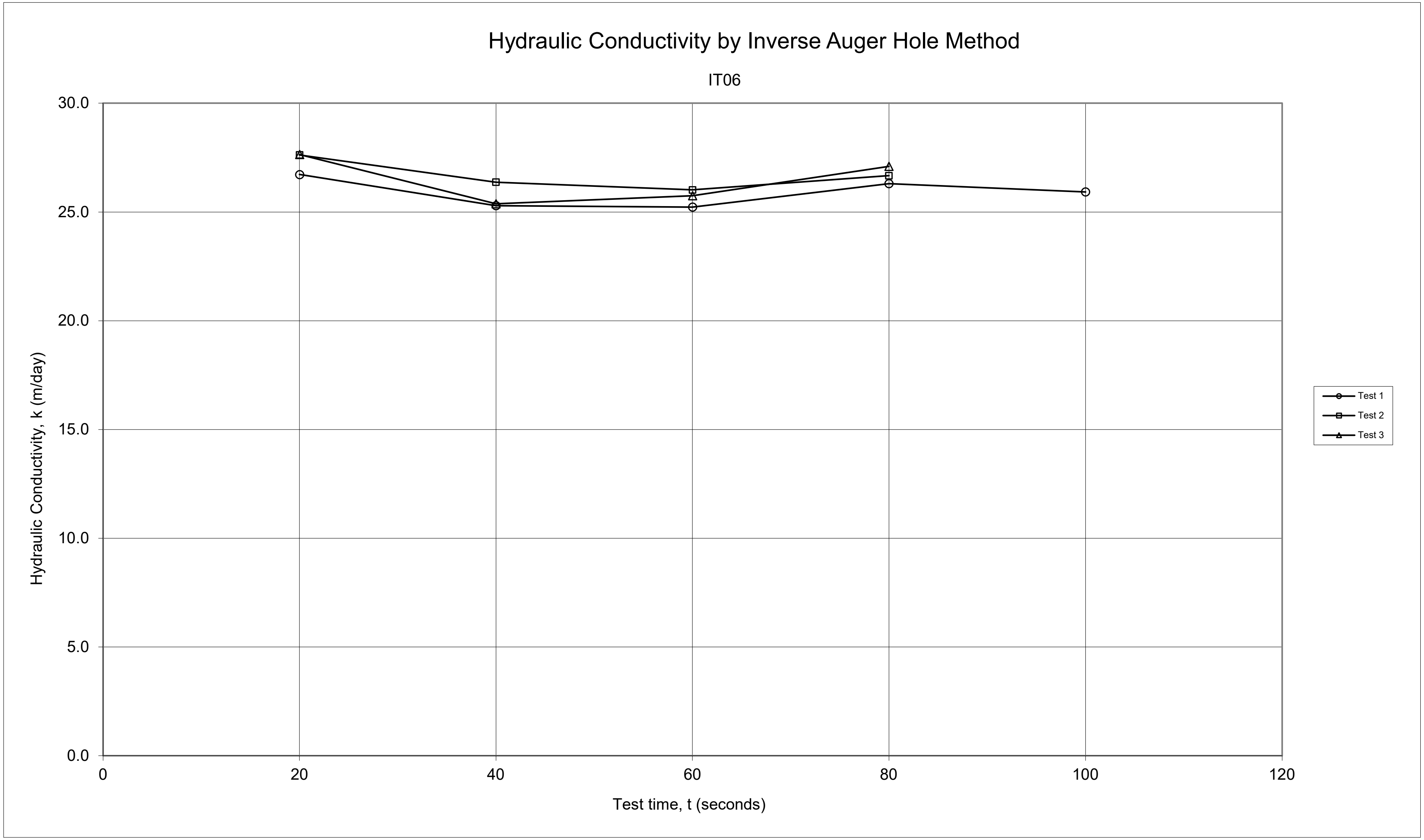
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.55	0.31	☒	☒
20	0.63	0.23	3.1E-04	26.7
40	0.685	0.175	2.9E-04	25.3
60	0.73	0.13	2.9E-04	25.2
80	0.77	0.09	3.0E-04	26.3
100	0.795	0.065	3.0E-04	25.9
		AVERAGE	3.0E-04	25.9

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.62	0.24	☒	☒
20	0.685	0.175	3.2E-04	27.6
40	0.73	0.13	3.1E-04	26.4
60	0.765	0.095	3.0E-04	26.0
80	0.795	0.065	3.1E-04	26.7
		AVERAGE	3.1E-04	26.7

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.6	0.26	☒	☒
20	0.67	0.19	3.2E-04	27.6
40	0.715	0.145	2.9E-04	25.4
60	0.755	0.105	3.0E-04	25.7
80	0.79	0.07	3.1E-04	27.1
		AVERAGE	3.1E-04	26.5



https://galtgeo.sharepoint.com/sites/WAG240411/Shared Documents/01 LandGroup SI/08 Analysis/Permeability Inverse Auger Hole Method - edited

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

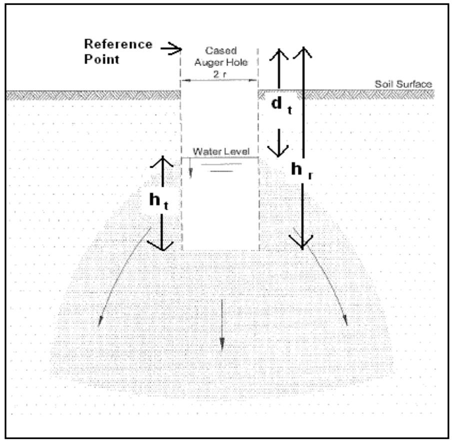
Job No:	WAG240411-01
Client:	Land Group (WA)
Project:	Residential Subdivision
Location:	Lakefarm Retreat
Calc by:	WF
Test No	IT07
Test Depth:	0.52 m

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	0.62	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m



Test 1

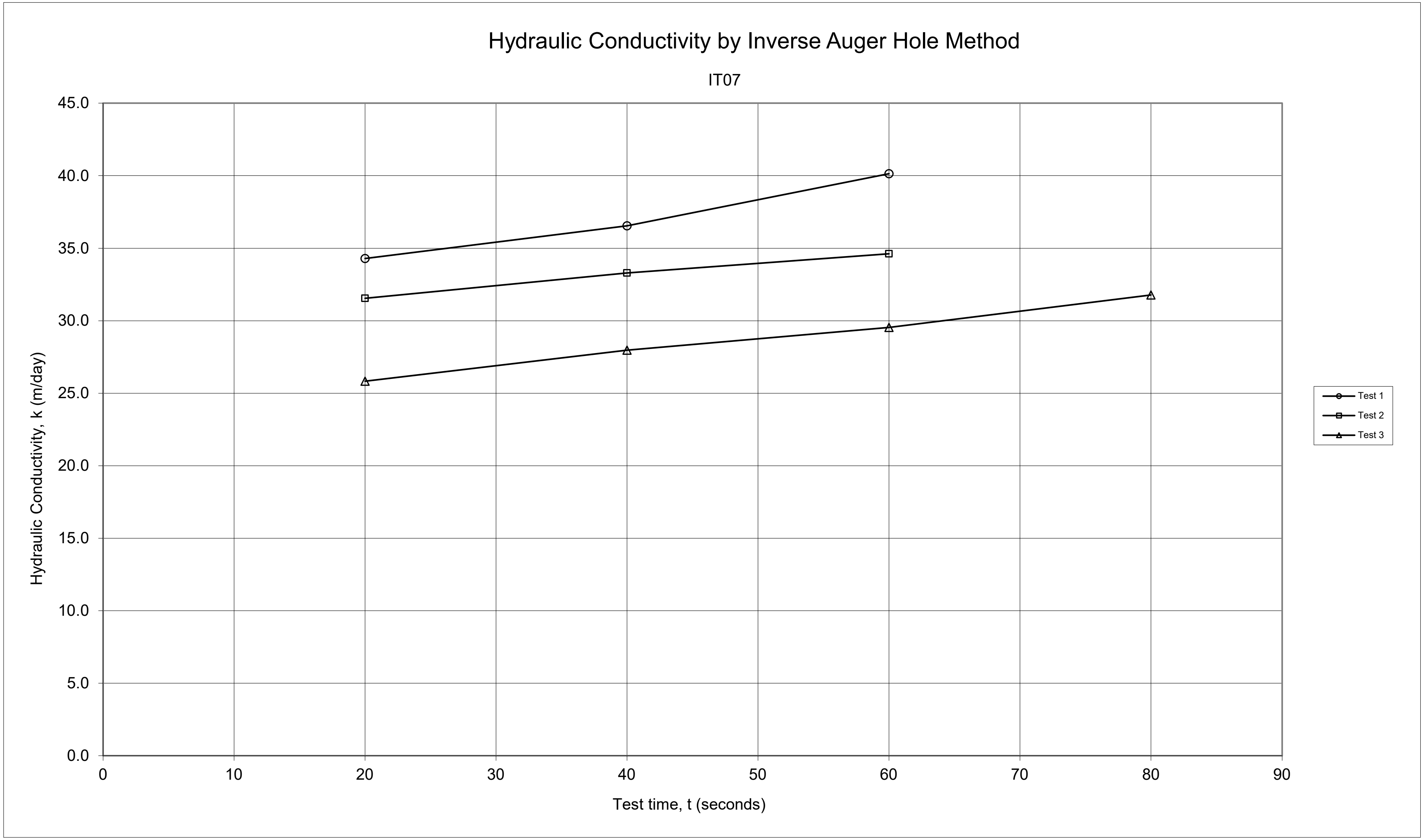
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.34	0.28	☒	☒
20	0.43	0.19	4.0E-04	34.3
40	0.5	0.12	4.2E-04	36.5
60	0.555	0.065	4.6E-04	40.1
		AVERAGE	4.3E-04	37.0

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.3	0.32	☒	☒
20	0.395	0.225	3.7E-04	31.5
40	0.47	0.15	3.9E-04	33.3
60	0.525	0.095	4.0E-04	34.6
		AVERAGE	3.8E-04	33.2

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.3	0.32	☒	☒
20	0.38	0.24	3.0E-04	25.8
40	0.45	0.17	3.2E-04	28.0
60	0.505	0.115	3.4E-04	29.5
80	0.55	0.07	3.7E-04	31.8
		AVERAGE	3.3E-04	28.8



https://galtgeo.sharepoint.com/sites/WAG240411/Shared Documents/01 LandGroup SI/08 Analysis/Permeability Inverse Auger Hole Method - edited

Hydraulic Conductivity Calculation - Inverse Auger Hole Method

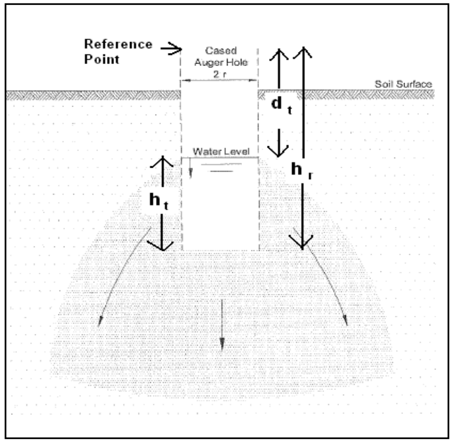
Galt Geotechnics

Job No:	WAG240411-01
Client:	Land Group (WA)
Project:	Residential Subdivision
Location:	Lakefarm Retreat
Calc by:	WF
Test No	IT07
Test Depth:	1.76 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0+\frac{1}{2}r)-\log_{10}(h_t+\frac{1}{2}r)}{t-t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

🟦	Required input
🟩	Calculated field
🟧	Comment field
☒	Field not used
🟨	Fixed field

Parameter	Description	Value	Units
K	Hydraulic Conductivity	☒	m/s
r	radius of test hole	0.045	m
t	time since start of measurement	☒	s
h_r	reference point height above base	1.78	m
d_t	depth from reference point to water at time t	☒	m
h_t	Water column height at time t	☒	m
h_0	h_t at t=0	☒	m

Test 1

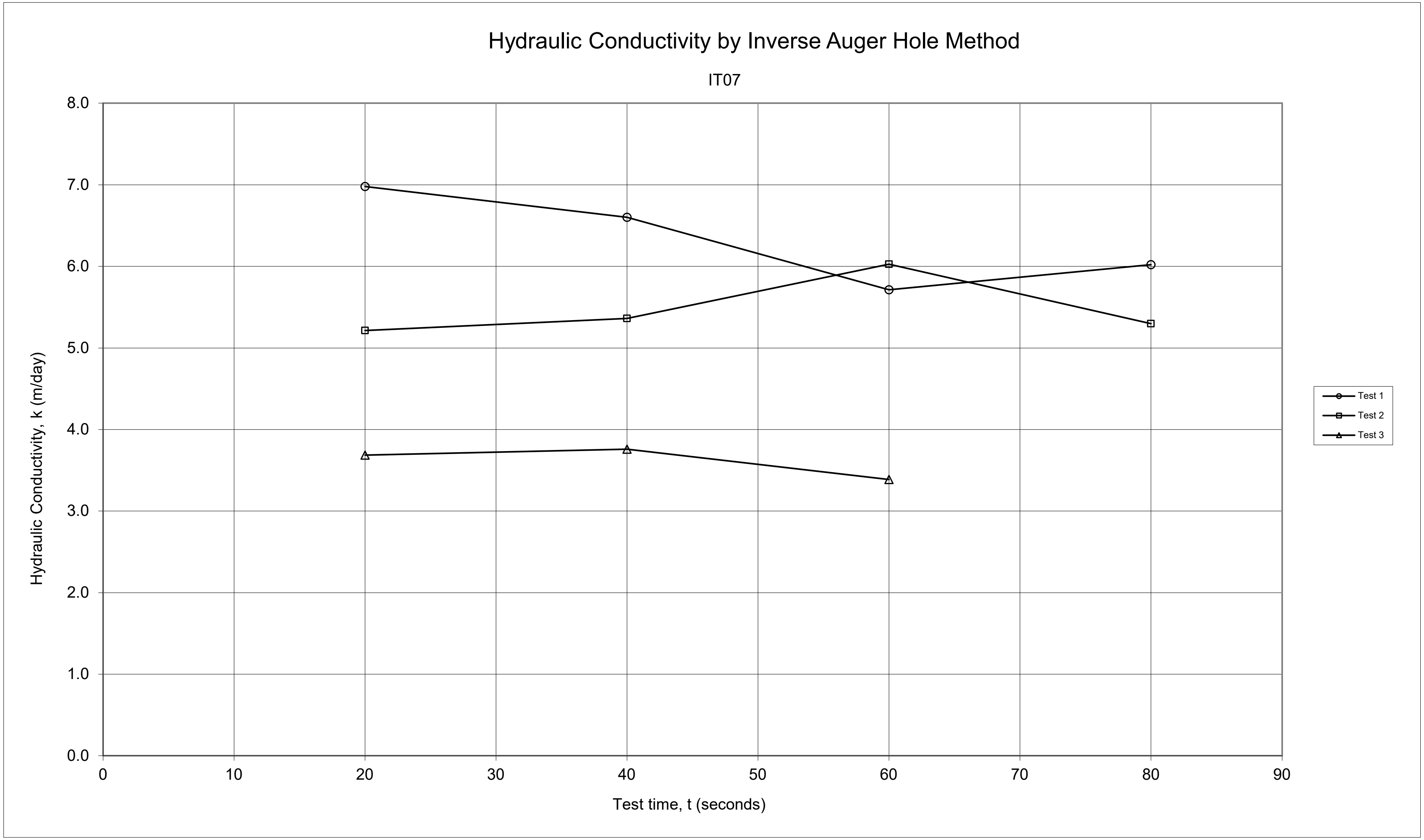
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.716	0.064	☒	☒
20	1.722	0.058	8.1E-05	7.0
40	1.727	0.053	7.6E-05	6.6
60	1.73	0.05	6.6E-05	5.7
80	1.735	0.045	7.0E-05	6.0
		AVERAGE	7.3E-05	6.3

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.726	0.054	☒	☒
20	1.73	0.05	6.0E-05	5.2
40	1.734	0.046	6.2E-05	5.4
60	1.739	0.041	7.0E-05	6.0
80	1.741	0.039	6.1E-05	5.3
		AVERAGE	6.3E-05	5.5

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	1.722	0.058	☒	☒
20	1.725	0.055	4.3E-05	3.7
40	1.728	0.052	4.4E-05	3.8
60	1.73	0.05	3.9E-05	3.4
		AVERAGE	4.2E-05	3.6



Hydraulic Conductivity by Inverse Auger Hole Method

IT07

Appendix F: Laboratory Test Results

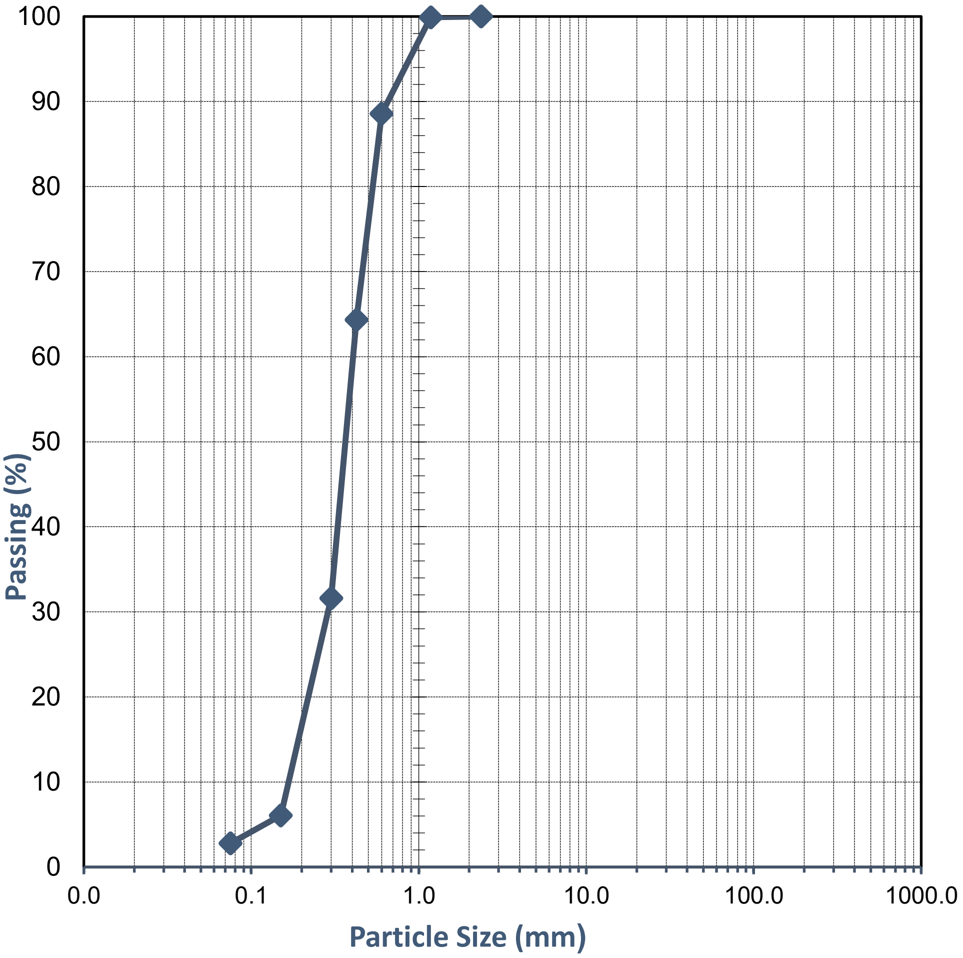
TEST REPORT - AS 1289.3.6.1

Client:	Land Group (WA) - Groves St Pty Ltd	*Ticket No.*	S14514
Client Address:	-	*Report No.*	WG24.14393_1_PSD
Project:	Propoed Residential Subdivision	*Sample No.*	WG24.14393
Location:	Lake Farm Retreat	*Date Sampled:*	Not Specified
Sample Identification:	BH02 (0.1-1.0m)	*Date Tested:*	25/09 - 26/09/2024

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	89
0.425	64
0.300	32
0.150	6
0.075	3



Comments:

Approved Signatory: Conellf

Name: Cody O'Neill
Date: 26/September/2024

Accreditation No. 20599
Accredited for compliance
with ISO/IEC 17025 - Testing

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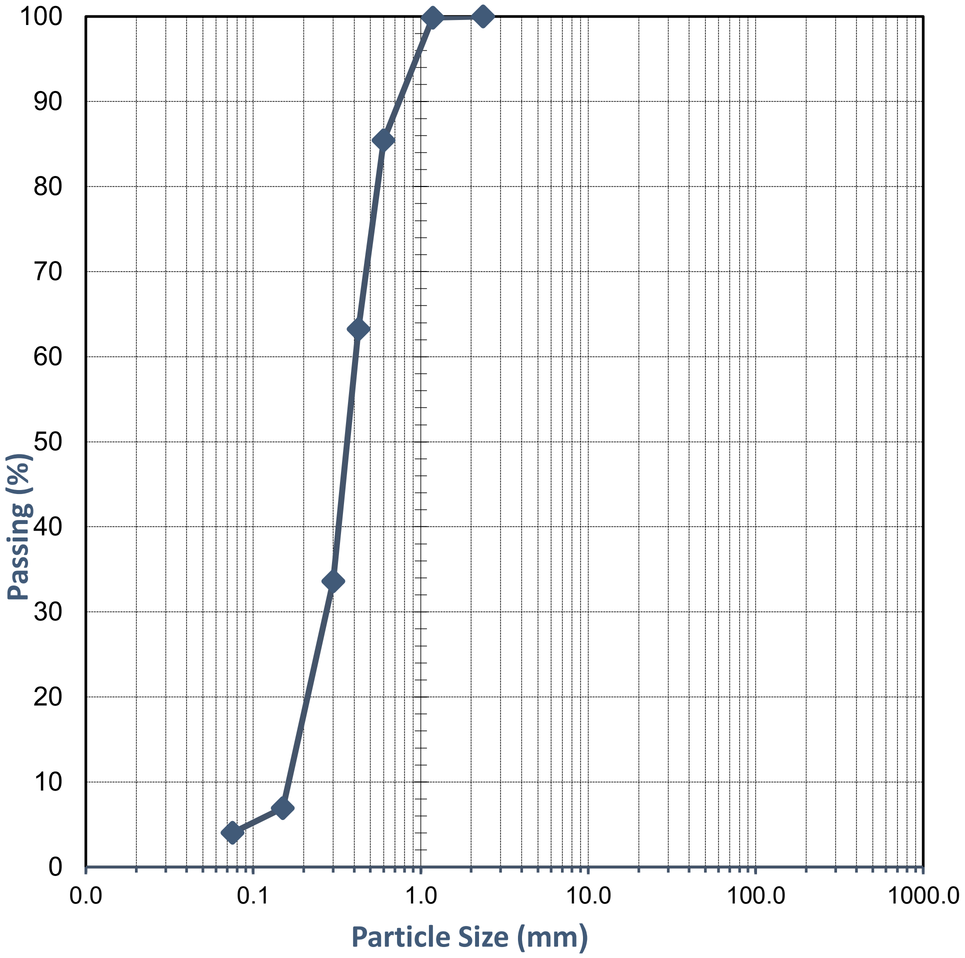
TEST REPORT - AS 1289.3.6.1

Client:	Land Group (WA) - Groves St Pty Ltd	*Ticket No.*	S14514
Client Address:	-	*Report No.*	WG24.14394_1_PSD
Project:	Propoed Residential Subdivision	*Sample No.*	WG24.14394
Location:	Lake Farm Retreat	*Date Sampled:*	Not Specified
Sample Identification:	BH02 (1.0-2.0m)	*Date Tested:*	25/09 - 26/09/2024

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	85
0.425	63
0.300	34
0.150	7
0.075	4



Comments:

Approved Signatory:

Name: Matthew Lichon
Date: 26/September/2024

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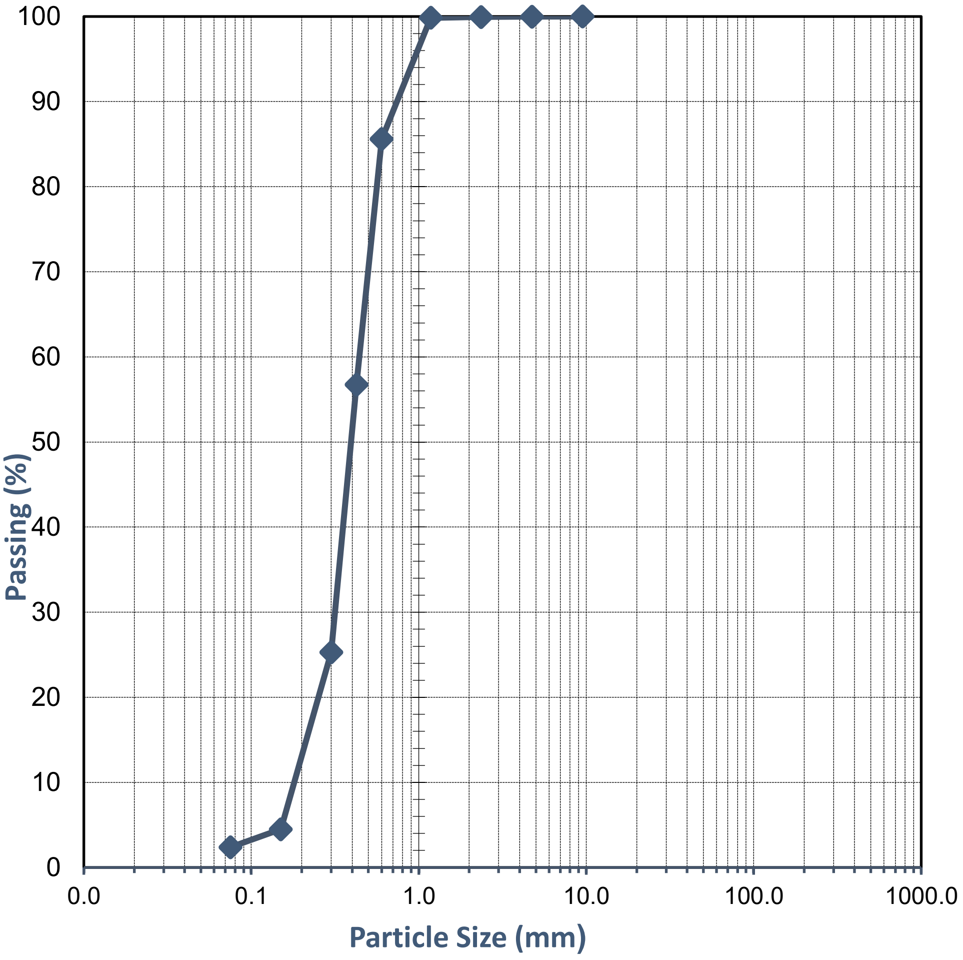
TEST REPORT - AS 1289.3.6.1

Client:	Land Group (WA) - Groves St Pty Ltd	*Ticket No.*	S14514
Client Address:	-	*Report No.*	WG24.14395_1_PSD
Project:	Propoed Residential Subdivision	*Sample No.*	WG24.14395
Location:	Lake Farm Retreat	*Date Sampled:*	Not Specified
Sample Identification:	BH06 (0.1-1.0m)	*Date Tested:*	25/09 - 26/09/2024

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	100
0.600	86
0.425	57
0.300	25
0.150	4
0.075	2



Comments:

Approved Signatory: Conell

Name: Cody O'Neill
Date: 26/September/2024

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WESTERN GEOTECHNICAL
& Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

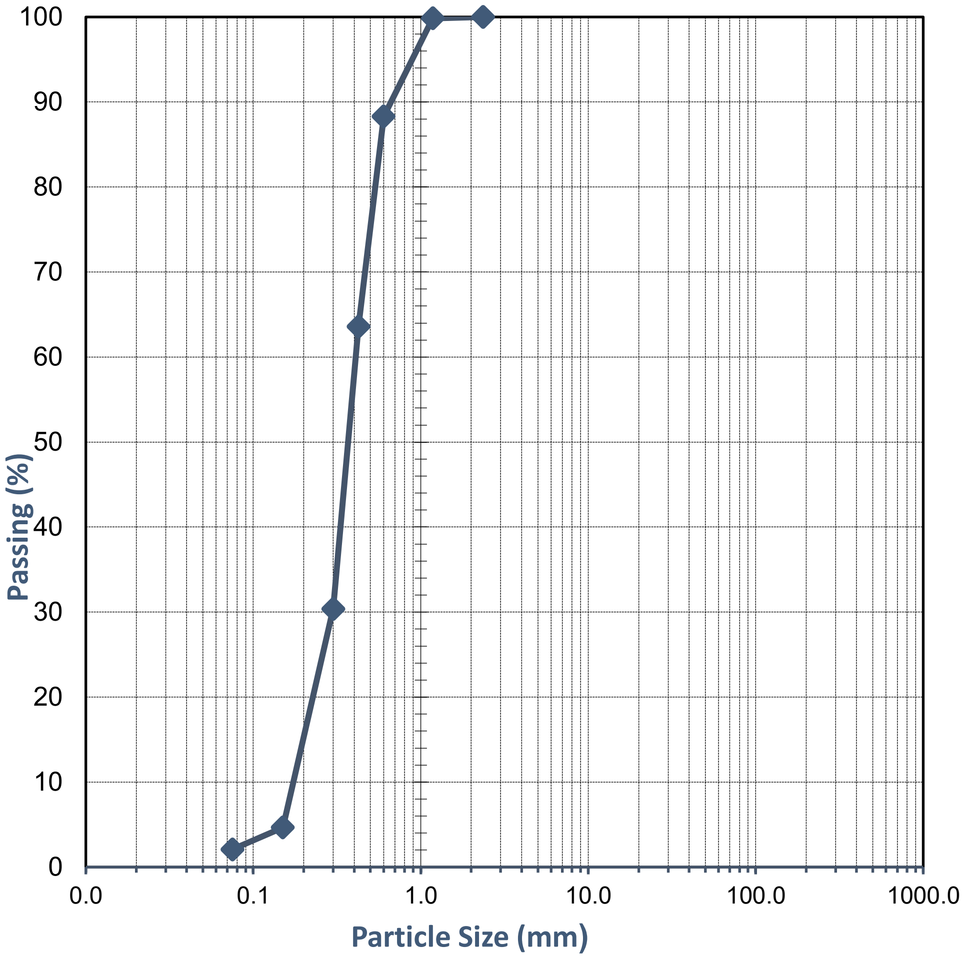
TEST REPORT - AS 1289.3.6.1

Client:	Land Group (WA) - Groves St Pty Ltd	*Ticket No.*	S14514
Client Address:	-	*Report No.*	WG24.14396_1_PSD
Project:	Propoed Residential Subdivision	*Sample No.*	WG24.14396
Location:	Lake Farm Retreat	*Date Sampled:*	Not Specified
Sample Identification:	BH06 (1.0-2.0m)	*Date Tested:*	25/09 - 26/09/2024

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	88
0.425	64
0.300	30
0.150	5
0.075	2



Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 26/September/2024

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TEST REPORT - AS 1289.4.1.1

Client:	Land Group (WA) - Groves St Pty Ltd	*Ticket No.*	C165
Client Address:	-	*Report No.*	WC24.407-408_1_OMC
Project:	Propoed Residential Subdivision	*Sample No.*	WC24.407-408
Location:	Lake Farm Retreat	*Date Sampled:*	Not Specified
Sample Identification:	Various - See Below	*Date Tested:*	30/09 - 01/10/2024

TEST RESULTS - Organic Matter Content of Soil - Normal Method

Sampling Method: **Sampled by Client, Tested as Received**

Sample Number	Sample Identification	Material Description	Organic Matter (%)
WC24.407	BH02 (0.1-1.0m)	Sand	0.2
WC24.408	BH06 (0.1-1.0m)	Sand	0.3

Comments:

Approved Signatory:

Name: Natasha Bielawski
Date: 02/October/2024

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Appendix G: Field and Laboratory ASS Results

Acid Sulfate Soil Testing Results

Field Observations							Laboratrory Results
Sample ID			pH_f	pH_{fox}	pH_f - pH_{fox}	Reaction Rate	Net Acidity
Location	Depth (m)	Elevation (m AHD)	pH units	pH units	pH units	LMHXV	%S
			4	4	1	NV	0.03
BH01	0.00		. . .	. . .	. . .	. . .	. . .
	0.25		5.4	4.5	0.9	L	. . .
	0.50		5.5	4.6	0.9	L	. . .
	0.75		5.5	4.6	0.9	L	. . .
	1.00		5.5	4.5	1.0	L	. . .
	1.25		5.4	4.6	0.8	L	. . .
	1.50		5.5	4.5	1.0	L	0.02
	1.75		5.3	4.5	0.8	L	. . .
	2.00		5.2	4.4	0.8	L	. . .
	2.25		5.3	4.4	0.9	L	. . .
	2.50		5.4	4.5	0.9	L	. . .
	2.75		5.2	4.4	0.8	L	. . .
	3.00		4.9	4.1	0.8	L	. . .
BH02	0.00		. . .	. . .	. . .	. . .	. . .
	0.25		6.6	5.4	1.2	L	. . .
	0.50		6.5	5.1	1.4	L	. . .
	0.75		6.5	5.0	1.5	L	. . .
	1.00		6.6	4.9	1.7	L	. . .
	1.25		6.5	5.1	1.4	L	. . .
	1.50		6.7	5.0	1.7	L	. . .
	1.75		6.7	5.2	1.5	L	. . .
	2.00		6.7	5.2	1.5	L	<0.02
	2.25		6.3	5.0	1.3	L	. . .
	2.50		6.0	4.7	1.3	L	. . .
	2.75		6.0	4.9	1.1	L	. . .
	3.00		5.9	4.8	1.1	L	. . .
BH03	0.00		. . .	. . .	. . .	. . .	. . .
	0.25		5.0	4.0	1.0	L	. . .
	0.50		5.1	4.1	1.0	L	. . .
	0.75		5.0	4.3	0.7	L	. . .
	1.00		4.9	4.3	0.6	L	. . .
	1.25		5.1	4.1	1.0	L	. . .
	1.50		5.2	4.2	1.0	L	. . .
	1.75		5.3	4.4	0.9	L	. . .
	2.00		5.5	4.5	1.0	L	. . .
	2.25		5.4	4.6	0.8	L	. . .
	2.50		5.5	4.5	1.0	L	<0.02
	2.75		5.5	4.6	0.9	L	. . .
	3.00		5.5	4.6	0.9	L	. . .
BH04	0.00		. . .	. . .	. . .	. . .	. . .
	0.25		5.3	4.1	1.2	L	. . .
	0.50		5.4	4.5	0.9	L	. . .
	0.75		5.5	4.4	1.1	L	. . .
	1.00		5.4	4.5	0.9	L	. . .
	1.25		5.5	4.5	1.0	L	. . .
	1.50		5.5	4.4	1.1	L	. . .
	1.75		5.4	4.4	1.0	L	. . .
	2.00		5.3	4.3	1.0	L	. . .
	2.25		5.3	4.4	0.9	L	. . .
	2.50		5.2	4.3	0.9	L	. . .
	2.75		5.3	4.4	0.9	L	. . .
	3.00		5.4	4.5	0.9	L	<0.02

Acid Sulfate Soil Testing Results

Field Observations							Laboratrory Results
Sample ID			pH_f	pH_{fox}	pH_f - pH_{fox}	Reaction Rate	Net Acidity
Location	Depth (m)	Elevation (m AHD)	pH units	pH units	pH units	LMHXV	%S
			4	4	1	NV	0.03
BH05	0.00		...	...	...	...	...
	0.25		5.5	4.6	0.9	L	...
	0.50		5.6	4.6	1.0	L	...
	0.75		5.5	4.7	0.8	L	...
	1.00		5.4	4.8	0.6	L	<0.02
	1.25		5.4	4.8	0.6	L	...
	1.50		5.5	5.0	0.5	L	...
	1.75		5.4	5.0	0.4	L	...
	2.00		5.9	5.0	0.9	L	...
	2.25		5.8	5.1	0.7	L	...
	2.50		5.9	5.1	0.8	L	...
	2.75		5.7	4.9	0.8	L	...
	3.00		5.8	4.7	1.1	L	...
BH06	0.00		...	...	...	...	...
	0.25		5.5	4.5	1.0	L	...
	0.50		5.5	4.6	0.9	L	...
	0.75		5.7	4.7	1.0	L	...
	1.00		5.8	4.8	1.0	L	...
	1.25		5.9	5.0	0.9	L	...
	1.50		6.0	5.1	0.9	L	<0.02
	1.75		6.2	5.3	0.9	L	...
	2.00		6.3	5.2	1.1	L	...
	2.25		6.2	5.2	1.0	L	...
	2.50		6.3	5.2	1.1	L	...
	2.75		6.2	5.0	1.2	L	...
	3.00		6.1	4.9	1.2	L	...
BH07	0.00		...	...	...	...	...
	0.25		6.1	5.1	1.0	L	...
	0.50		6.0	5.0	1.0	L	...
	0.75		6.0	5.1	0.9	L	...
	1.00		6.0	5.0	1.0	L	...
	1.25		6.1	5.0	1.1	L	...
	1.50		6.2	5.0	1.2	L	...
	1.75		6.2	5.1	1.1	L	...
	2.00		6.1	5.2	0.9	L	<0.02
	2.25		6.2	5.2	1.0	L	...
	2.50		6.3	5.0	1.3	L	...
	2.75		6.3	5.1	1.2	L	...
	3.00		6.0	5.1	0.9	L	...
BH08	0.00		...	...	...	...	...
	0.25		7.0	5.4	1.6	L	...
	0.50		6.9	5.5	1.4	L	...
	0.75		7.0	5.4	1.6	L	...
	1.00		7.3	5.3	2.0	L	...
	1.25		7.2	5.2	2.0	L	...
	1.50		7.0	5.3	1.7	L	...
	1.75		6.9	5.2	1.7	L	...
	2.00		6.9	5.1	1.8	L	...
	2.25		6.4	4.9	1.5	L	...
	2.50		6.2	4.9	1.3	L	<0.02
	2.75		6.3	5.1	1.2	L	...
	3.00		6.4	5.4	1.0	L	...

Acid Sulfate Soil Testing Results

Field Observations							Laboratrory Results
Sample ID			pH_f	pH_{fox}	pH_f - pH_{fox}	Reaction Rate	Net Acidity
Location	Depth (m)	Elevation (m AHD)	pH units	pH units	pH units	LMHXV	%S
			4	4	1	NV	0.03
BH09	0.00		...	...	...	...	...
	0.25		6.5	5.2	1.3	L	...
	0.50		6.4	5.1	1.3	L	...
	0.75		6.3	5.2	1.1	L	...
	1.00		6.4	5.4	1.0	L	...
	1.25		6.5	5.5	1.0	L	...
	1.50		6.7	5.4	1.3	L	...
	1.75		6.6	5.3	1.3	L	...
	2.00		6.6	5.1	1.5	L	...
	2.25		6.3	5.0	1.3	L	...
	2.50		5.9	4.7	1.2	L	...
	2.75		5.7	4.6	1.1	L	...
	3.00		5.4	4.6	0.8	L	<0.02
BH10	0.00		...	...	...	...	...
	0.25		6.6	5.6	1.0	L	...
	0.50		6.7	5.5	1.2	L	...
	0.75		6.6	5.3	1.3	L	...
	1.00		6.6	5.2	1.4	L	...
	1.25		6.3	5.1	1.2	L	...
	1.50		6.1	5.0	1.1	L	...
	1.75		6.2	5.2	1.0	L	...
	2.00		6.3	5.3	1.0	L	...
	2.25		6.0	5.0	1.0	L	...
	2.50		5.4	4.9	0.5	L	<0.02
	2.75		5.2	4.7	0.5	L	...
	3.00		5.3	4.5	0.8	L	...
BH11	0.00		...	...	...	...	...
	0.25		6.1	5.1	1.0	L	...
	0.50		6.0	5.0	1.0	L	...
	0.75		6.1	5.2	0.9	L	...
	1.00		6.2	5.5	0.7	L	...
	1.25		6.0	5.2	0.8	L	...
	1.50		6.0	5.1	0.9	L	...
	1.75		5.9	5.0	0.9	L	...
	2.00		5.8	4.9	0.9	L	...
	2.25		5.7	4.9	0.8	L	...
	2.50		5.7	4.8	0.9	L	...
	2.75		5.8	4.7	1.1	L	...
	3.00		5.7	4.7	1.0	L	<0.02

Appendix H: Environmental Laboratory Certificates of Analysis

Galt Environment P/L
50 Edward Street
Osborne Park
WA 6017

Attention: **- ALL SRA/Results**

Report **1142779-S**
Project name LAKEFARM RTT BALLAJURA
Project ID WAG240411
Received Date Sep 24, 2024

Client Sample ID			**BH01/1.5**	**BH02/2.0**	**BH03/2.5**	**BH04/3.0**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**L24-Se0064012**	**L24-Se0064013**	**L24-Se0064014**	**L24-Se0064015**
Date Sampled			**Sep 19, 2024**	**Sep 19, 2024**	**Sep 19, 2024**	**Sep 19, 2024**
Test/Reference	LOR	Unit				
Extraneous Material						
<2mm Fraction	0.005	g	50	82	54	71
>2mm Fraction	0.005	g	< 0.005	< 0.005	< 0.005	< 0.005
Analysed Material	0.1	%	100	100	100	100
Extraneous Material	0.1	%	< 0.1	< 0.1	< 0.1	< 0.1
Net Acidity (Excluding ANC)						
s-CRS Suite - Net Acidity - NASSG (Excluding ANC)	0.02	% S	0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Excluding ANC)	10	mol H+/t	13	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Excluding ANC)	1	kg CaCO3/t	< 1	< 1	< 1	< 1
Actual Acidity (NLM-3.2)						
pH-KCL (NLM-3.1)	0.1	pH Units	5.1	6.7	5.3	5.7
Titratable Actual Acidity (NLM-3.2)	2	mol H+/t	13	< 2	4.0	3.0
Titratable Actual Acidity (NLM-3.2)	0.003	% pyrite S	0.020	< 0.003	0.010	< 0.003
Potential Acidity - Chromium Reducible Sulfur						
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)[S04]	0.005	% S	< 0.005	< 0.005	< 0.005	< 0.005
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	3	mol H+/t	< 3	< 3	< 3	< 3
Extractable Sulfur						
Sulfur - KCl Extractable	0.005	% S	N/A	N/A	N/A	N/A
HCl Extractable Sulfur	0.005	% S	N/A	N/A	N/A	N/A
Retained Acidity (S-NAS)						
Net Acid soluble sulfur (SNAS) NLM-4.1	0.005	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (s-SNAS) NLM-4.1[S02]	0.005	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (a-SNAS) NLM-4.1	2	mol H+/t	N/A	N/A	N/A	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0	2.0
Acid Neutralising Capacity (ANCbt)						
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	0.01	% CaCO3	N/A	0.28	N/A	N/A
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)[S03]	0.02	% S	N/A	0.09	N/A	N/A
Acid Neutralising Capacity - (a-ANCbt) (NLM-5.2)	2	mol H+/t	N/A	55	N/A	N/A
ANC Fineness Factor		factor	1.5	1.5	1.5	1.5
Net Acidity (Including ANC)						
s-CRS Suite - Net Acidity - NASSG (including ANC)	0.02	% S	0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Including ANC)	10	mol H+/t	13	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Including ANC)[S01]	1	kg CaCO3/t	< 1	< 1	< 1	< 1
Sample Properties						
% Moisture	1	%	4.1	1.0	7.8	15

Client Sample ID			**BH05/1.0**	**BH06/1.5**	**BH07/2.0**	**BH08/2.5**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**L24-Se0064016**	**L24-Se0064017**	**L24-Se0064018**	**L24-Se0064019**
Date Sampled			**Sep 19, 2024**	**Sep 19, 2024**	**Sep 19, 2024**	**Sep 19, 2024**
Test/Reference	LOR	Unit				
Extraneous Material						
<2mm Fraction	0.005	g	75	69	66	70
>2mm Fraction	0.005	g	< 0.005	< 0.005	< 0.005	< 0.005
Analysed Material	0.1	%	100	100	100	100
Extraneous Material	0.1	%	< 0.1	< 0.1	< 0.1	< 0.1
Net Acidity (Excluding ANC)						
s-CRS Suite - Net Acidity - NASSG (Excluding ANC)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Excluding ANC)	10	mol H+/t	< 10	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Excluding ANC)	1	kg CaCO3/t	< 1	< 1	< 1	< 1
Actual Acidity (NLM-3.2)						
pH-KCL (NLM-3.1)	0.1	pH Units	5.5	5.3	5.3	5.3
Titratable Actual Acidity (NLM-3.2)	2	mol H+/t	3.0	3.0	7.0	6.0
Titratable Actual Acidity (NLM-3.2)	0.003	% pyrite S	< 0.003	0.010	0.010	0.010
Potential Acidity - Chromium Reducible Sulfur						
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)[S04]	0.005	% S	< 0.005	< 0.005	< 0.005	< 0.005
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	3	mol H+/t	< 3	< 3	< 3	< 3
Extractable Sulfur						
Sulfur - KCl Extractable	0.005	% S	N/A	N/A	N/A	N/A
HCl Extractable Sulfur	0.005	% S	N/A	N/A	N/A	N/A
Retained Acidity (S-NAS)						
Net Acid soluble sulfur (SNAS) NLM-4.1	0.005	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (s-SNAS) NLM-4.1[S02]	0.005	% S	N/A	N/A	N/A	N/A
Net Acid soluble sulfur (a-SNAS) NLM-4.1	2	mol H+/t	N/A	N/A	N/A	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0	2.0
Acid Neutralising Capacity (ANCbt)						
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	0.01	% CaCO3	N/A	N/A	N/A	N/A
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)[S03]	0.02	% S	N/A	N/A	N/A	N/A
Acid Neutralising Capacity - (a-ANCbt) (NLM-5.2)	2	mol H+/t	N/A	N/A	N/A	N/A
ANC Fineness Factor		factor	1.5	1.5	1.5	1.5
Net Acidity (Including ANC)						
s-CRS Suite - Net Acidity - NASSG (including ANC)	0.02	% S	< 0.02	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Including ANC)	10	mol H+/t	< 10	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Including ANC)[S01]	1	kg CaCO3/t	< 1	< 1	< 1	< 1
Sample Properties						
% Moisture	1	%	2.6	6.3	4.3	3.8

Client Sample ID			**BH09/3.0**	**BH10/2.5**	**BH11/3.5**
Sample Matrix			**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**L24-Se0064020**	**L24-Se0064021**	**L24-Se0064022**
Date Sampled			**Sep 19, 2024**	**Sep 19, 2024**	**Sep 19, 2024**
Test/Reference	LOR	Unit			
Extraneous Material					
<2mm Fraction	0.005	g	72	50	140
>2mm Fraction	0.005	g	< 0.005	< 0.005	< 0.005
Analysed Material	0.1	%	100	100	100
Extraneous Material	0.1	%	< 0.1	< 0.1	< 0.1

Client Sample ID			**BH09/3.0**	**BH10/2.5**	**BH11/3.5**
Sample Matrix			**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**L24-Se0064020**	**L24-Se0064021**	**L24-Se0064022**
Date Sampled			**Sep 19, 2024**	**Sep 19, 2024**	**Sep 19, 2024**
Test/Reference	LOR	Unit			
Net Acidity (Excluding ANC)					
s-CRS Suite - Net Acidity - NASSG (Excluding ANC)	0.02	% S	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Excluding ANC)	10	mol H+/t	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Excluding ANC)	1	kg CaCO3/t	< 1	< 1	< 1
Actual Acidity (NLM-3.2)					
pH-KCL (NLM-3.1)	0.1	pH Units	5.6	5.4	5.6
Titratable Actual Acidity (NLM-3.2)	2	mol H+/t	3.0	5.0	5.0
Titratable Actual Acidity (NLM-3.2)	0.003	% pyrite S	< 0.003	0.010	0.010
Potential Acidity - Chromium Reducible Sulfur					
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)^{S04}	0.005	% S	< 0.005	< 0.005	0.006
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	3	mol H+/t	< 3	< 3	4.0
Extractable Sulfur					
Sulfur - KCl Extractable	0.005	% S	N/A	N/A	N/A
HCl Extractable Sulfur	0.005	% S	N/A	N/A	N/A
Retained Acidity (S-NAS)					
Net Acid soluble sulfur (SNAS) NLM-4.1	0.005	% S	N/A	N/A	N/A
Net Acid soluble sulfur (s-SNAS) NLM-4.1^{S02}	0.005	% S	N/A	N/A	N/A
Net Acid soluble sulfur (a-SNAS) NLM-4.1	2	mol H+/t	N/A	N/A	N/A
HCl Extractable Sulfur Correction Factor	1	factor	2.0	2.0	2.0
Acid Neutralising Capacity (ANCbt)					
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	0.01	% CaCO3	N/A	N/A	N/A
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)^{S03}	0.02	% S	N/A	N/A	N/A
Acid Neutralising Capacity - (a-ANCbt) (NLM-5.2)	2	mol H+/t	N/A	N/A	N/A
ANC Fineness Factor		factor	1.5	1.5	1.5
Net Acidity (Including ANC)					
s-CRS Suite - Net Acidity - NASSG (including ANC)	0.02	% S	< 0.02	< 0.02	< 0.02
CRS Suite - Net Acidity - NASSG (Including ANC)	10	mol H+/t	< 10	< 10	< 10
CRS Suite - Liming Rate - NASSG (Including ANC)^{S01}	1	kg CaCO3/t	< 1	< 1	< 1
Sample Properties					
% Moisture	1	%	15	10	14

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Extraneous Material - Method: LTM-GEN-7050/7070	Brisbane	Sep 27, 2024	6 Week
Chromium Suite - NASSG (Excluding ANC) - Method: LTM-GEN-7070 Chromium Reducible Sulfur Suite	Brisbane	Sep 27, 2024	6 Week
% Moisture - Method: LTM-GEN-7080 Moisture	Brisbane	Sep 25, 2024	14 Days

eurofins

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Osborne Park
WA 6017

Project Name: LAKEFARM RTT BALLAJURA
Project ID: WAG240411

Order No.: WAG240411
Report #: 1142779
Phone: 08 6272 0200
Fax: 08 9285 8444

Received: Sep 24, 2024 4:15 PM
Due: Oct 1, 2024
Priority: 5 Day
Contact Name: - ALL SRA/Results

Eurofins Analytical Services Manager : Natalie Hill

Sample Detail						Moisture Set	Chromium Suite - NASSG (Excluding ANC)
Brisbane Laboratory - NATA # 1261 Site # 20794 & 2780						X	X
External Laboratory							
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**		
1	BH01/1.5	Sep 19, 2024		Soil	L24-Se0064012	X	X
2	BH02/2.0	Sep 19, 2024		Soil	L24-Se0064013	X	X
3	BH03/2.5	Sep 19, 2024		Soil	L24-Se0064014	X	X
4	BH04/3.0	Sep 19, 2024		Soil	L24-Se0064015	X	X
5	BH05/1.0	Sep 19, 2024		Soil	L24-Se0064016	X	X
6	BH06/1.5	Sep 19, 2024		Soil	L24-Se0064017	X	X
7	BH07/2.0	Sep 19, 2024		Soil	L24-Se0064018	X	X
8	BH08/2.5	Sep 19, 2024		Soil	L24-Se0064019	X	X
9	BH09/3.0	Sep 19, 2024		Soil	L24-Se0064020	X	X
10	BH10/2.5	Sep 19, 2024		Soil	L24-Se0064021	X	X
11	BH11/3.5	Sep 19, 2024		Soil	L24-Se0064022	X	X
Test Counts						11	11

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follow guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013. They are included in this QC report where applicable. Additional QC data may be available on request.
2. Unless otherwise stated, all soil/sediment/solid results are reported on a dry weight basis.
3. Unless otherwise stated, all biota/food results are reported on a wet weight basis on the edible portion.
4. For CEC results where the sample's origin is unknown or environmentally contaminated, the results should be used advisedly.
5. Actual LORs are matrix dependent. Quoted LORs may be raised where sample extracts are diluted due to interferences.
6. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds where annotated.
7. SVOC analysis on waters is performed on homogenised, unfiltered samples unless noted otherwise.
8. Samples were analysed on an 'as received' basis.
9. Information identified in this report with blue colour indicates data provided by customers that may have an impact on the results.
10. This report replaces any interim results previously issued.

Holding Times

Please refer to the 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours before sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and despite any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the sampling date; therefore, compliance with these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether, the holding time is seven days; however, for all other VOCs, such as BTEX or C6-10 TRH, the holding time is 14 days.

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ppm:** parts per million
µg/L: micrograms per litre	**ppb:** parts per billion	**%:** Percentage
org/100 mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100 mL:** Most Probable Number of organisms per 100 millilitres
CFU: Colony Forming Unit	**Colour:** Pt-Co Units (CU)	

Terms

APHA	American Public Health Association
CEC	Cation Exchange Capacity
COC	Chain of Custody
CP	Client Parent - QC was performed on samples pertaining to this report
CRM	Certified Reference Material (ISO17034) - reported as percent recovery.
Dry	Where moisture has been determined on a solid sample, the result is expressed on a dry weight basis.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
LOR	Limit of Reporting.
LCS	Laboratory Control Sample - reported as percent recovery.
Method Blank	In the case of solid samples, these are performed on laboratory-certified clean sands and in the case of water samples, these are performed on de-ionised water.
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC represents the sequence or batch that client samples were analysed within.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
SRA	Sample Receipt Advice
Surr - Surrogate	The addition of a similar compound to the analyte target is reported as percentage recovery. See below for acceptance criteria.
TBTO	Tributyltin oxide (*bis*-tributyltin oxide) - individual tributyltin compounds cannot be identified separately in the environment; however, free tributyltin was measured, and its values were converted stoichiometrically into tributyltin oxide for comparison with regulatory limits.
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	Toxic Equivalency Quotient or Total Equivalence
QSM	US Department of Defense Quality Systems Manual Version 6.0
US EPA	United States Environmental Protection Agency
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should only be used as a guide and may be different when site-specific Sampling Analysis and Quality Plan (SAQP) have been implemented.

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is ≤30%; however, the following acceptance guidelines are equally applicable:

Results <10 times the LOR:	No Limit
Results between 10-20 times the LOR:	RPD must lie between 0-50%
Results >20 times the LOR:	RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range, not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% for Speciated Phenols & 50-150% for PFAS. SVOCs recoveries 20 – 150%, VOC recoveries 50 – 150%

PFAS field samples containing surrogate recoveries above the QC limit designated in QSM 6.0, where no positive PFAS results have been reported or reviewed, and no data was affected.

QC Data General Comments

1. Where a result is reported as less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown are not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery, the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results, a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data; thus, it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
LCS - % Recovery							
Actual Acidity (NLM-3.2)							
pH-KCL (NLM-3.1)	%	99			80-120	Pass	
Titratable Actual Acidity (NLM-3.2)	%	104			80-120	Pass	
LCS - % Recovery							
Potential Acidity - Chromium Reducible Sulfur							
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)	%	89			80-120	Pass	
CRM - % Recovery							
Actual Acidity (NLM-3.2)							
pH-KCL (NLM-3.1)	%	101			80-120	Pass	
CRM - % Recovery							
Acid Neutralising Capacity (ANCbt)							
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	%	100			80-120	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Net Acidity (Excluding ANC)				Result 1	Result 2	RPD			
s-CRS Suite - Net Acidity - NASSG (Excluding ANC)	L24-Se0064012	CP	% S	0.02	N/A	N/A	30%	Pass	
CRS Suite - Net Acidity - NASSG (Excluding ANC)	L24-Se0064012	CP	mol H+/t	13	N/A	N/A	20%	Pass	
CRS Suite - Liming Rate - NASSG (Excluding ANC)	L24-Se0064012	CP	kg CaCO3/t	< 1	N/A	N/A	30%	Pass	
Duplicate									
Actual Acidity (NLM-3.2)				Result 1	Result 2	RPD			
pH-KCL (NLM-3.1)	L24-Se0064012	CP	pH Units	5.1	5.0	2.0	20%	Pass	
Titratable Actual Acidity (NLM-3.2)	L24-Se0064012	CP	mol H+/t	13	14	8.0	20%	Pass	
Titratable Actual Acidity (NLM-3.2)	L24-Se0064012	CP	% pyrite S	0.020	0.020	8.0	30%	Pass	
Duplicate									
Potential Acidity - Chromium Reducible Sulfur				Result 1	Result 2	RPD			
Chromium Reducible Sulfur (s-SCr) (NLM-2.1)	L24-Se0064012	CP	% S	< 0.005	< 0.005	<1	20%	Pass	
Chromium Reducible Sulfur (a-SCr) (NLM-2.1)	L24-Se0064012	CP	mol H+/t	< 3	< 3	<1	30%	Pass	
Duplicate									
Extractable Sulfur				Result 1	Result 2	RPD			
Sulfur - KCl Extractable	L24-Se0064012	CP	% S	N/A	N/A	N/A	30%	Pass	
HCl Extractable Sulfur	L24-Se0064012	CP	% S	N/A	N/A	N/A	20%	Pass	
Duplicate									
Retained Acidity (S-NAS)				Result 1	Result 2	RPD			
Net Acid soluble sulfur (SNAS) NLM-4.1	L24-Se0064012	CP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur (s-SNAS) NLM-4.1	L24-Se0064012	CP	% S	N/A	N/A	N/A	30%	Pass	
Net Acid soluble sulfur (a-SNAS) NLM-4.1	L24-Se0064012	CP	mol H+/t	N/A	N/A	N/A	30%	Pass	
Duplicate									
Acid Neutralising Capacity (ANCbt)				Result 1	Result 2	RPD			
Acid Neutralising Capacity - (ANCbt) (NLM-5.2)	L24-Se0064012	CP	% CaCO3	N/A	N/A	N/A	20%	Pass	
Acid Neutralising Capacity - (s-ANCbt) (NLM-5.2)	L24-Se0064012	CP	% S	N/A	N/A	N/A	30%	Pass	
ANC Fineness Factor	L24-Se0064012	CP	factor	1.5	1.5	<1	30%	Pass	

Duplicate									
Net Acidity (Including ANC)				Result 1	Result 2	RPD			
s-CRS Suite - Net Acidity - NASSG (including ANC)	L24-Se0064012	CP	% S	0.02	0.02	8.0	30%	Pass	
CRS Suite - Net Acidity - NASSG (Including ANC)	L24-Se0064012	CP	mol H+/t	13	14	8.0	30%	Pass	
CRS Suite - Liming Rate - NASSG (Including ANC)	L24-Se0064012	CP	kg CaCO3/t	< 1	1.0	8.0	30%	Pass	
Duplicate									
Sample Properties				Result 1	Result 2	RPD			
% Moisture	L24-Se0064017	CP	%	6.3	6.4	1.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	N/A
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
S01	Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil' multiply 'reported results' x 'wet bulk density of soil in t/m3'
S02	Retained Acidity is Reported when the pHKCl is less than pH 4.5
S03	Acid Neutralising Capacity is only required if the pHKCl if greater than or equal to pH 6.5
S04	Acid Sulfate Soil Samples have a 24 hour holding time unless frozen or dried within that period

Authorised by:

Natalie Hill	Analytical Services Manager
Jonathon Angell	Senior Analyst-Sample Properties
Jonathon Angell	Senior Analyst-SPOCAS

Glenn Jackson
Managing Director

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Standard Geotechnical Definitions, Recommendations, Requirements and Limitations

GDR1 ABOUT THIS APPENDIX

These technical notes are to be read with the attached report. These notes contain important information regarding the study in the attached report, and the report cannot be considered in isolation without full reading of these notes.

Where there are conflicts between this appendix and the report text, the report text takes precedence.

Unless noted otherwise, geotechnical investigations are conducted in accordance with AS1726-2017, “Geotechnical site investigations”.

Unless noted otherwise, the report does not include any assessment (or implied assessment) of karst risk.

GDR2 DEFINITIONS

The following definitions apply:

- **Approved Fill** – fill that has been assessed and approved by the geotechnical engineer or civil designer for a particular purpose.
- **Bulk Fill** – Controlled fill intended to support future infrastructure, but potentially lacking some engineering properties required for upper fill layers or adjacent to structures, where fill with specific properties may be required. Contrast with Select Fill.
- **Civil Design** – the engineering design of the earthworks including surface water and erosion control and subsurface drainage control (where required) to achieve an earthworked, drained site which is capable of supporting the proposed development (including target site classification to AS2870, where relevant). This design is separate to this geotechnical investigation and is a required element of a site development.
- **Clay** – A component of a soil with particles smaller than 0.002 mm in size.
- **Cohesionless (Non-cohesive) Soil** – A soil mass that has does not hold together at low applied stress levels. The strength of the soil depends solely on friction between particles.
- **Cohesive Soil** – A soil mass that has holds together and can adhere to itself.
- **Collapsible Soil** – a soil with high void ratio that is typically strong when dry but loses strength and consolidates under constant stress when wetted, usually due to loss of soil matric suction or dissolving of a chemical cementing agent.
- **Compaction –** The process of increasing the soil density, typically be mechanical means.
- **Competent Person** – A person who has, through a combination of training, education and experience, acquired knowledge and skills enabling that person to correctly perform a specified task.
- **Consistency** – The stiffness of a cohesive soil, at specific moisture contents, to resist mechanical stress or manipulation (remoulding).
- **Controlled (or engineered) Fill** – Any fill for which engineering properties are controlled during placement. Also referred to as structural fill.
- **Dense –** with respect to sandy soils, at a relatively high density index or dry density ratio, exhibiting better engineering parameters with respect to strength and stiffness than the same material at a lower density index.
- **Density** – A measure of the mass of material per unit volume.
- **Eccentric Load** – a load incorporating either a varying vertical load and/or a horizontal load such that the peak vertical stress exceeds the average vertical stress.
- **Fill** – Any material that has been placed by anthropogenic processes.
- **Fines** – A component of a soil with particles smaller than 0.075 mm in size.
- **Groundwater** – Water located beneath the earth’s surface in pore spaces, fractures and voids in soil or rock.
- **Gravel** – A component of a soil with particles between 2.36 mm and 63 mm in size.

- **Heavily Loaded** – in reference to mobile plant, particularly intended for equipment where ground bearing pressures exceed 50 kPa and/or equipment has a high centre of gravity and could be prone to toppling. In reference to buildings/structures, where footing pressures exceed 100 kPa and/or footing dimensions exceed 1 m wide.
- **Hydraulic Conductivity** – ratio of volume flux to hydraulic gradient – a quantitative measure of soil's ability to transmit water when subjected to a hydraulic gradient. k_{sat} – saturated hydraulic conductivity, intended for dewatering assessment, subsoil drainage design and other engineering assessments where saturated soils are relevant. k_{unsat} – unsaturated hydraulic conductivity, intended for design of stormwater disposal elements such as soakwells and infiltration basins, where the base of disposal elements is above the groundwater level.
- **In situ** – In the place and condition in which it exists naturally. May also refer to fill that is present at any site prior to an investigation taking place.
- **Limestone** – A sedimentary carbonate rock. The use of the term does not infer a specific strength, carbonate content or grain size. Refer to GDR4.1 for further detail.
- **Loose** – with respect to sand soils, at a relatively low density index or dry density ratio, typically indicating poorer engineering parameters with respect to strength and stiffness than the same material at a higher density index.
- **Material** – Matter that meets the definitions of 'soil', 'rock', other engineered matter (i.e., concrete, bricks etc.) or non-engineered matter (organics, contaminated refuse, deleterious material).
- **May** – Indicates that the statement is an option.
- **Must** – Indicates that the statement is mandatory.
- **Natural** – In the context of soil or rock, material which is present as a result of natural geological processes and has not been subject to anthropogenic engineering processes (such as filling, excavation, replacement, etc).
- **Organic** – In the context of soil, material derived from living matter, primarily plants.
- **Overconsolidated** – a soil that has been subjected to a greater vertical stress than its current state.
- **Permeable Soil** – soil that meets the civil design permeability requirements to allow relatively rapid flow of water through the soil matrix.
- **Rock** – Any aggregate of minerals and/or materials that cannot be disaggregated by hand in air or water without prior soaking.
- **Sand** – a component of soil with particle size between 0.075 mm and 2.36 mm.
- **Select Fill** – a controlled fill which has been chosen for particular engineering characteristics (such as strength, CBR, grading, permeability, etc), commonly for use as a higher-grade capping layer or adjacent to structures. Contrast with Bulk Fill.
- **Shall** – Indicates that the statement is mandatory.
- **Should** – Indicates that the statement is a recommendation.
- **Silt** – A component of a soil with particles between 0.075 mm and 0.002 mm in size.
- **Soil** – Particulate materials that occur in the ground and can be disaggregated or remoulded by hand in air or water without prior soaking.
- **Sand** – A component of a soil with particle between 0.075 mm and 2.36 mm in size.
- **Uncontrolled Fill** – Any material that has been deposited by anthropogenic process, which does not meet the definition of 'controlled fill'.

GDR3 GEOTECHNICAL TEST METHODS AND INTERPRETATION

GDR3.1 Test Pit Excavation

Test pit excavations are formed using mechanical excavation equipment (typically an excavator) or hand dug, with the objective of inspecting (or profiling) the soil exposed in the excavation.

Typical limitations on test pit excavations are:

- Limited depth of excavation – typically governed by reach of the excavator arm.
- Cannot be excavated below groundwater in cohesionless soils, due to collapse and water ingress.
- Cannot be excavated through very stiff / very dense soils (i.e., desiccated clays or cemented soils) or most rock.
- Cannot typically obtain rock samples that are suitable for strength testing.

Test pits are usually mechanically excavated with a toothed bucket (intended for excavation in clay or weak rock) or a flat-edged bucket (typically for sands).

When hand-dug test pits are excavated, it is usually for recovery of near-surface soils or inspection of shallow in-ground elements.

We note that where test pits are excavated on a site, they are only ever loosely backfilled during our studies. They must always be located during site preparation works, over-excavated to their full depth and plan extents and re-filled with approved fill in compacted layers.

GDR3.2 Cone Penetration Tests (CPTs)

Cone penetration testing (CPT) is done by Galt or specialist contractors and typically to AS1289.6.5.1. The test involves pushing an instrumented cone into the soil with a hydraulically operated pushing frame. The test measures tip resistance and sleeve friction on the cone, which are then plotted with depth.

We interpret soil types and associated geotechnical soil parameters from CPT data using the following:

Technical Interpretations and International Guides

- Robertson P.K., Campanella R.G., Gillespie D. and Grieg J. (1986). “Use of piezometer cone data”. Proceedings of the ASCE Speciality Conference In Situ ’86: Use of In Situ Tests in Geotechnical Engineering, Blacksburg, pp 1263-80, American Society of Civil Engineers (ASCE).
- Robertson, P.K., Cabal K.L. (2016) “Guide to Cone Penetration Testing for Geotechnical Engineering 6th Edition 2015”. Gregg Drilling & Testing, Inc., California.
- Baldi G., Bellotti R., Ghionna V.H., Jamiolkowski M., Lo Presti D. C. (1989) “Modulus of sands from CPTs and DMTs”. Proc. 12th Int. Conf. on SMFE, Rio de Janeiro, Vol 1, p165-170, Balkema, Rotterdam.

Local (Perth and Western Australia) Research, Interpretation and Guides

- Fahey, M., Lehane, B., Stewart, D. (2003) “Soil stiffness for shallow foundation design in the Perth CBD”. Australian Geomechanics Vol. 8 No. 3.
- Main Roads Western Australia (MRWA) (2009) “Structures Engineering Design Manual”. Document 3912/03, Perth.
- Lehane B. (2017). “CPT-Based Design of Foundations”, E.H. Davis Memorial Lecture, Australian Geomechanics, Vol 54. No. 4’ and
- Galt’s in-house correlations between CPT data and other geotechnical testing.

GDR3.3 Borehole Drilling

Boreholes are drilled for sampling of the soil and rock, with a small disturbance footprint. Typical techniques are:

- Auger drilling (hand auger or machine auger) – for recovery of soil at relatively shallow depths only. Cannot penetrate cemented soils or rock.
- Push probe drilling – for recovery of soil at relatively shallow depths and below groundwater. Cannot penetrate cemented soils or rock.
- Air core drilling – for recovery of soil, cemented soil and rock (typically up to high strength rock). Not suited to drilling of very high strength rock.
- Diamond coring (or rotary coring) – for recovery of cemented soil, rock and some soil types (typically not sand). Suited to all strengths of rock.

If used, standard penetration tests (SPTs) are done in accordance with AS1289.6.3.1. Correlations for consistency and density are based on:

- Standards Australia (2016), “HB160-2006, Soils Testing”.

GDR3.4 Dynamic Cone Penetrometer (DCP)

The DCP is a hand-held tool for assessing penetration resistance of a soil. This comprises a 16 mm rod equipped with a 20 mm cone, hammered into the ground using a falling 9 kg weight on a 510 mm slide hammer on the top of the rod. This is done in accordance with AS1289.6.3.2 and the blow counts to hammer in the rod are measured in 100 mm penetration increments. Where provided, correlations for consistency and density are based on:

- Standards Australia (2016), “HB160-2006, Soils Testing”.

GDR3.5 Perth Sand Penetrometer (PSP)

The PSP is a variation on a DCP and uses a 9 kg weight on a 600 mm slide hammer to hammer in a 16 mm rod with a blunt (square-faced) end. Testing is done in accordance with AS1289.6.3.3, with the following typical variations:

- Testing is often done to a greater depth than the 450 mm covered in the standard.
- Blow counts are sometimes recorded in 150 mm intervals (compared to 300 mm intervals used in the standard) to provide better resolution on the tests.

Where provided, correlations for density are based on:

- Standards Australia (2016), “HB160-2006, Soils Testing”.

GDR3.6 Dynamic Probing Super Heavy (DPSH)

The DPSH test involves driving a solid cone (20 cm^2) into the ground using a 63.5 kg hammer falling 760 mm. Testing is done in accordance with EN ISO 22476-2 – Geotechnical engineering – Field testing – Part 2: Dynamic probing – DPSH-B.

Results may be presented as either:

- N10 (No. of blows required for every 100 mm penetration);
- N30 (No. of blows required for every 300 mm penetration); or
- q_d (dynamic tip resistance, analogous to CPT q_c).

GDR3.7 Inverse Auger Hole Infiltration Test (Falling Head, Unsaturated Soil)

Infiltration tests are carried out using the ‘inverse auger hole’ method described by:

- Cocks, G (2007), “Disposal of Stormwater Runoff by Soakage in Perth Western Australia”, Journal and News of the Australian Geomechanics Society, Volume 42 No. 3, pp 101-114

This test is an unsaturated falling head test, in that it is carried out above the groundwater table and is intended to mimic the behaviour of soak wells and similar drainage elements (i.e. soakage basins), which discharge stormwater into an unsaturated medium.

The hole is wetted only for a short period prior to the testing.

The test is usually repeated three times, with the intention that the second and third tests provide similar results (within about 10%-20%). Tests are done over a short duration, typically 2 minutes to 10 minutes. The focus of the testing is generally when the head is low (200 mm or lower), such that the relevant lateral zone is as saturated as the zone directly below the borehole.

The hydraulic conductivity derived from this test is not to be used for applications where saturated hydraulic conductivity is relevant, e.g.:

- Subsoil drainage design; and
- Dewatering estimations.

Based on Galt's in-house research, this method does not completely saturate the soil in any reasonable test length, and thus may not be suitable for assessment of soils at sites where the critical drainage condition is a fully saturated soil (i.e., in areas with high groundwater tables). Our research on sand sites indicates that the test does correlate well with actual soak well performance, in unsaturated sand zones without impermeable zones.

GDR3.8 Guelph Permeameter Test (Constant Head, Quasi-Saturated Soil)

The Guelph permeameter test, conducted in accordance with the constant head test method outlined in Appendix G of AS1547, is a constant-head test in nominally "saturated" soil (in that the test is conducted until a "steady state" is reached). However, we note that this test can only be done above the groundwater table and as such, is in an unsaturated zone. Therefore, the hydraulic conductivity derived from this test should be used with caution and evaluated against other test methods (such as saturated, constant-head permeability testing from laboratory samples, or in situ saturated hydraulic conductivity testing below the groundwater table).

GDR4 GEOLOGICAL UNITS

GDR4.1 Limestone

The term 'Limestone' is used to describe a carbonate rock. Tamala Limestone is the common limestone in Western Australia, and typically comprises cemented quartz and shell fragments cemented together by calcium carbonate.

Limestone can vary significantly across short distances in composition, strength and cementation. Tamala limestones in Western Australia also have known possible geological features including:

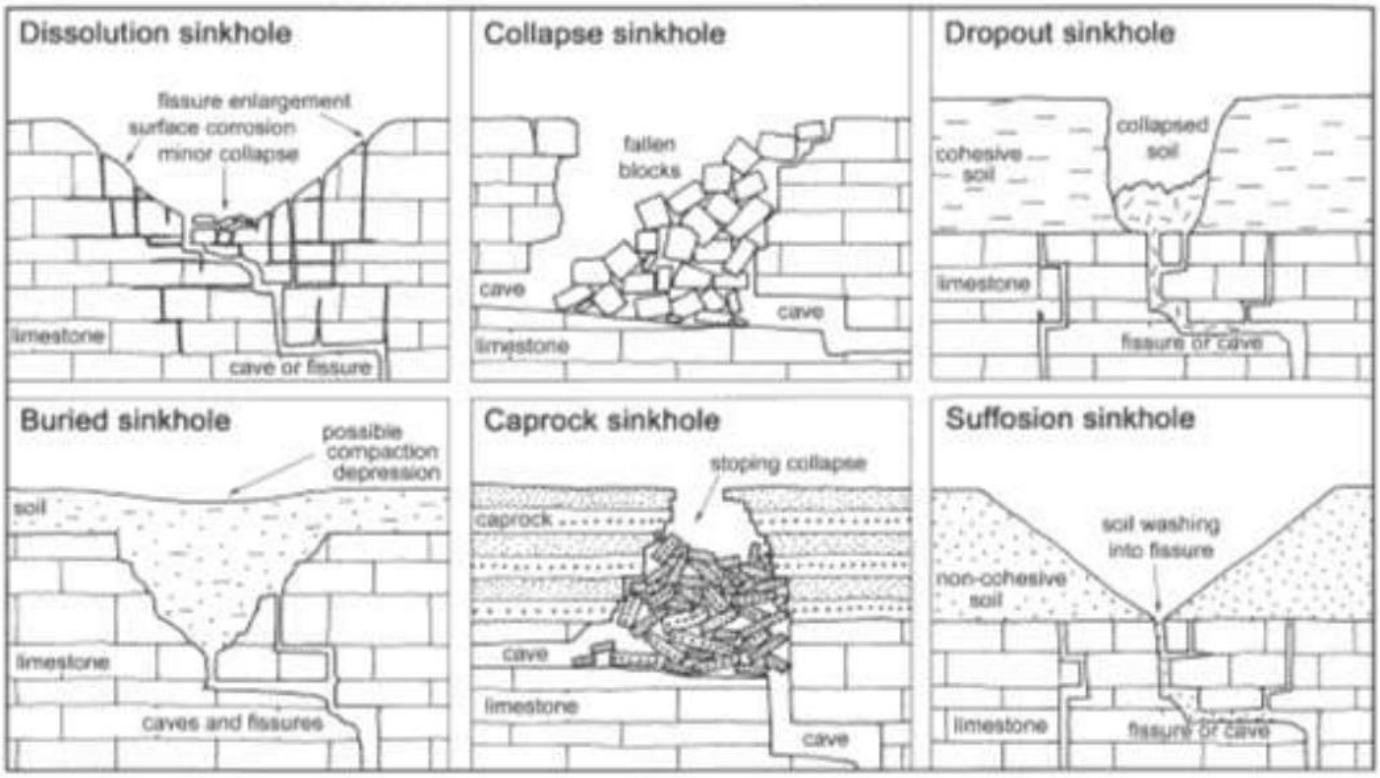
- Caprock/calcrete – The formation of a very hard duricrust, usually due to sun exposure. Caprock may be up to 3 m thick, but typically around 1.5 m thick. Caprock is very difficult to excavate and may require the use of hydraulic rock breakers or rock saws to excavate.
- Solution features/tubes – Often initially formed due to the presence of Eucalypt and Jarrah roots during limestone formation, and often increasing in depth and size due to ongoing weathering. May be up to 500 mm in diameter. These are typically filled with very loose, unconsolidated sand.
- Pinnacles – Pinnacles are usually the limestone that is left around surrounding solution features. Often can comprise very hard limestone/caprock that can be substantially higher than surrounding areas. Pinnacles may have also been formed by surrounding erosion (i.e., wind/water).
- Karst/caves – Karst is caused by the dissolution of limestone, typically where there is interaction in low-lying areas with water and limestone. Karst manifests itself as loose near-surface sand with cavities (caves) in the underlying limestone. This can lead to sinkholes and collapse of overlying structures.

Inline images showing typical pinnacle/solution features and Karstic features follow. These are taken from:

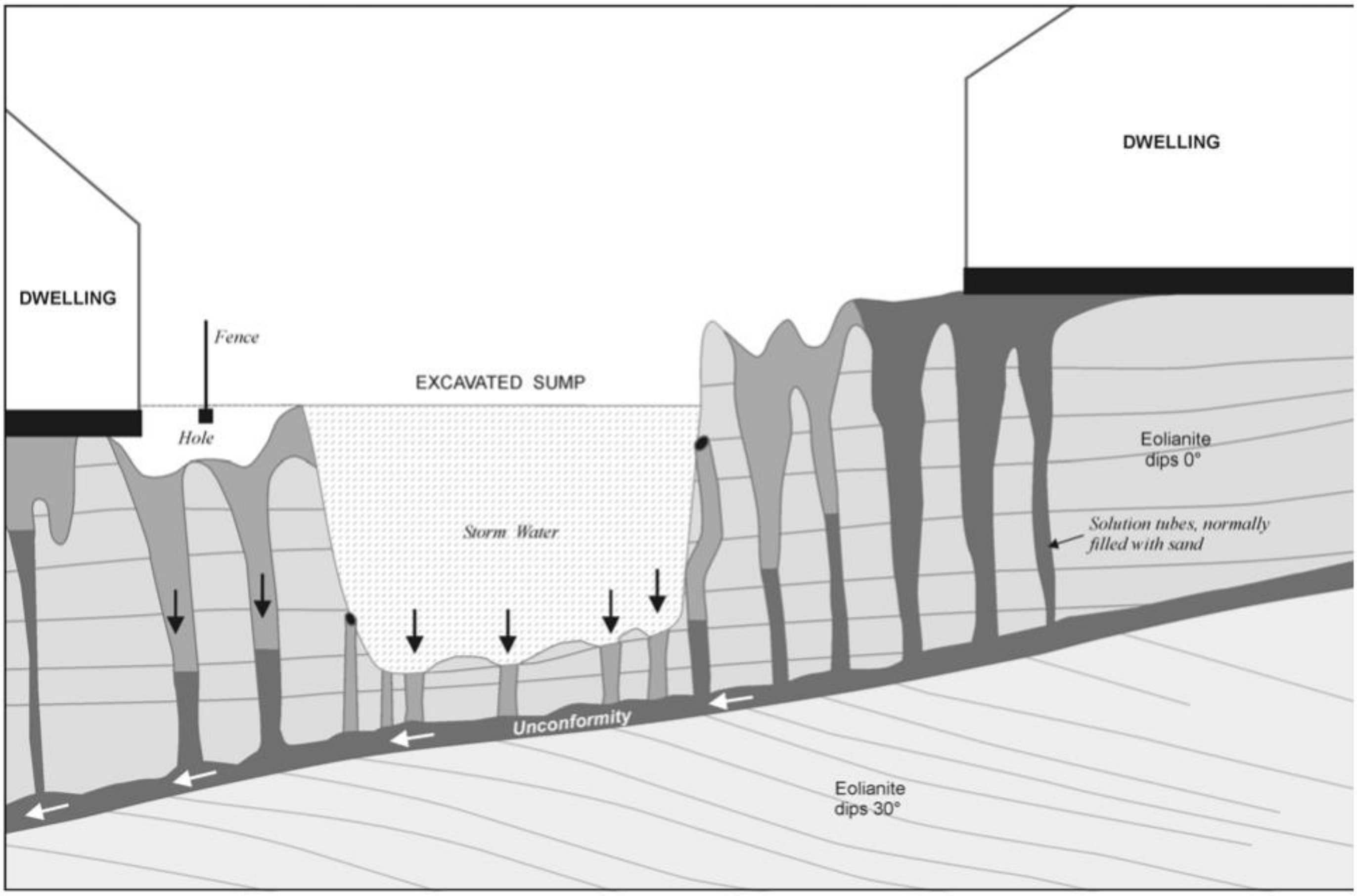
- Gordon, R. (2003). "Coastal Limestones". Australian Geomechanics Vol.38 No. 4, The Engineering Geology of Perth.

- Waltham, A. & Fookes, P. (2003). "Engineering Classification of Karst Ground Conditions: Quarterly Journal of Engineering Geology and Hydrogeology, Vol 36.

Inline Image GDR 1 - Karstic Sinkhole Features from Waltham and Fookes (2003)



Inline Image GDR 2: Pinnacle/Solution Features from Gordon (2003)



GDR4.2 Pindan Sands and Collapsible Soils

In the Western Australian context, Pindan sands are sandy soils present predominantly across the Pilbara and Kimberley regions. Pindan sands are typically:

- Red brown in colour.
- Between 10% and 40% fines.
- Of aeolian origin, usually resulting in unconsolidated in situ conditions (nuclear density gauge testing often indicates these soils have in situ density ratios of 80%-85% of modified maximum dry density).
- Very strong when dry due to high soil suctions in the fine fraction, which create strong bonds between the sand particles.

As the grains are usually held in place by the dry fine fraction, this can lead to:

- very high settlements (i.e., “collapse”) as the grain-to-grain bonds are weakened as matric suction decreases on soaking; and
- loss of vertical and horizontal strength/stiffness as the grain-to-grain bonds weaken.

The risks associate with Pindan sands are usually quantified in terms of the collapse potential/magnitude of possible collapse events.

Other similar soils are present in Western Australia that may exhibit similar collapse potential and may not strictly be Pindan sands (i.e., have other grain-to-grain bonding mechanisms).

GDR5 SITE CLASSIFICATION

Site classification refers to the assessment of a site in reference to AS2870-2011, “Residential slabs and footings”. The method for assessing the site class is outlined in Section 2 of AS2870-2011, which indicates that this may be done by:

- assessing the characteristic surface movement, due to seasonal moisture changes in the soil profile;
- assessing the performance of existing foundations; or
- assessment of the soil profile (where there are deleterious inclusions, landfill, putrescible waste etc.).

The site classifications based on the expected characteristic surface movement are summarised in Table GDR 1.

Table GDR 1: Summary of Site Classifications (AS2870-2011)

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock site with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm
H1	Highly reactive sites, which may experience high ground movements from moisture change	40 – 60 mm
H2	Highly reactive sites, which may experience very high ground movements from moisture change	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movements from moisture change	>75 mm
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	Not Defined

The calculated characteristic surface movement is predominantly based on:

- the reactivity (i.e., the shrink-swell potential) of the soil (and any proposed fill);

- the design depth of soil suction change, which is the maximum expected depth of soil suction change due to seasonal soil moisture changes; and
- the depth to any bedrock and groundwater table.

The design depth of soil suction change for Western Australia has been refined using the Thornthwaite Moisture Index (TMI). We have carried out assessment using the depths as detailed in:

- Hu Y, Saraceni P, Cocks G, Zhou M (2016). "TMI assessment and climate zones in Western Australia". Australian Geomechanics Journal, Vol.51 No.3.
- Hu Y, Raj A, Cocks G, Verheyde F (2019). "Re-assessment of TMI based climate zones in metropolitan Perth, WA". ANZ Geomechanics Conference 2019, Perth Australia.

The design depth of soil suction change for Northern Territory is based on the research presented in:

- Jackson, S (2022), "Thornthwaite moisture index and climate zones in the Northern Territory", Australian Geomechanics Journal, Vol. 57 No. 3.

We highlight that AS2870-2011 does not make any reference to the fines content of a soil when assessing the site classification.

Where a site classification is provided in our reports, it is always predicated on the requirement that the recommended site preparation procedures are carried out.

We also highlight that the footing performance and shrink-swell movements of a site can be impacted by the planting or removal of trees. This should be considered where appropriate, and we refer to the CSIRO BTF 18-2011 "Foundation Maintenance and Footing Performance: A Homeowner's Guide" for further information.

AS 2870 is limited to single and double storey residential buildings with normal shallow footings with a maximum bearing pressure of 100 kPa and is not applicable where development types other than this are proposed.

GDR6 SITE PREPARATION

GDR6.1 General

The intent of the site preparation guidelines provided in the above report are to ensure that the earthworks can be constructed to meet specific requirements, i.e., minimum compaction, fill requirements, removal of unsuitable material etc. The site preparation guidelines are not exhaustive, and on-site conditions may dictate that other preparation measures may be required to meet geotechnical requirements.

GDR6.2 Site Preparation

Site preparation measures outlined in this section relate to bulk earthworks at the site in preparation for the construction of buildings, pavements and other structures.

The preparation of a site in accordance with outlined measures below or those presented in the report text does not imply that the site is suitable for heavily loaded plant or eccentric loads. This is especially applicable for working platforms for mobile plant including cranes, crawlers or the like. The site surface may still not be trafficable for mobile plant. Individual working platform assessments must be done if heavily loaded mobile plant are proposed.

GDR6.2.1 Common Measures

The common measures outlined below are to prepare standard sites in advance of proof compaction, bulk excavation and filling. These measures are applicable to most sites, however the applicability of these measures is stated in the main report.

Table GDR 2: Common Measures

Measure	Commentary
Demolish and remove structures and pavements	Demolish existing structures and pavements, including removal of all buried services and footings and dispose off-site.
Remove demolition debris and other deleterious material	Remove any demolition debris and other deleterious material from site including old footings, slabs, soak wells, buried services, paving and building rubble.
Strip uncontrolled fill (where present)	Strip any uncontrolled fill from the site (where encountered) and, if suitable, stockpile it for potential re-use as non-structural fill. If contaminated, dispose off-site. Refer to the report text for discussions on the presence of detected uncontrolled fill and its composition. It is important to realise that undetected uncontrolled fill may be present between test locations and the absence of its identification in our report does not preclude its presence. If uncontrolled fill is detected during site works, please contact us for inspection and to provide recommendations.
Remove trees	All tree roots must be removed, this may result in significant excavation in places. Where tree roots and stumps are removed, the disturbed soil must be over-excavated and replaced with controlled, compacted fill. Backfilling of over-excavations is discussed in the following sections .
Strip and stockpile topsoil.	Strip and stockpile topsoil from unpaved areas of the site for potential re-use in non-structural applications. The topsoil strip is only necessary to remove roots and we recommend a topsoil strip as necessary to remove all roots from the soil.
Carry out bulk excavation	Excavate to the required level. Stockpile suitable excavated material for potential re-use as fill (the re-use of spoil as fill , if appropriate, is discussed in the report text) and remove unsuitable or excess material off-site.
Batter edges of excavation	Excavations should be battered to a temporary slope as given in the report text where applicable and not in close proximity to adjacent structures etc. If required, construct temporary/permanent retaining walls where batters cannot be accommodated.

By following these measures, the site should have been prepared to a point where topsoil and vegetation has been removed to expose either natural soil or controlled fill. Over-excavation to the required levels may then be required for some projects. Once complete, the site is now ready for proof compaction and filling.

GDR6.2.2 Sand Sites

The preparation measures outlined below are provided for sand sites meeting the following criteria:

- Site underlain by sand.
- No collapsible soils present.
- No deep loose sand.
- Compaction of a loose upper horizon to maximum 1 m depth.
- No shallow groundwater (<1 m deep).
- No limestone or other rock present at shallow depth.
- “Common Measures” outlined in Section GDR6.2.1 have been completed (as required).

The applicability of these measures is stated in the main report. These measures must be carried out for all areas where structures, footings, pavements and any other settlement-sensitive infrastructure is proposed.

Unless specified otherwise in the report, the **Approved Fill** to be used is outlined in Section GDR8 (**Permeable Sand** where permeable fill is required, else **General Sand**). The specific selection is subject to the requirements of the civil designer.

Table GDR 3: Sand Site Measures

Measure	Commentary
Moisture condition and proof compact.	Moisture condition and compact the exposed sandy ground to achieve the density specified in Section GDR7.1 (“sand”) to a depth of at least 900 mm.
Test proof compaction	Check that the density specified in Section GDR7.1 (“sand”) has been achieved to a depth of at least 900 mm. We note that the applicability of the use of the PSP for compaction control is discussed in the report. Unless specifically approved for use on the subject site, the contractor must **not** assume that the use of the PSP is appropriate.
Treat areas of loose or unsuitable material	Any areas of loose sand or unsuitable material (including over-excavated areas of former trees and root balls) must be removed and replaced with **Approved Fill** as outlined in the report or as noted above. The report will explain the suitability of site-derived materials for re-use as approved fill.
Carry out bulk filling	Where fill is required to build up levels, use **Approved Fill**, placed and compacted in layers of no greater than 300 mm loose thickness. Test compaction to achieve the density specified in Section GDR7.1.

In following this method, shallow/surficial loose sand will be compacted, and the site will be filled (where required) in preparation for supporting footings, ground slabs, pavements and the like.

GDR6.2.3 Deep Loose Sand Sites

The preparation measures outlined below are provided for sand sites meeting the following criteria:

- Site underlain by sand.
- Collapsible soils or deep loose sand present (if applicable, this is discussed in the report).
- Over-excavation, compaction and replacement of loose sand required.
- No shallow groundwater (<1 m deep).
- No limestone or other rock present at shallow depth.
- “Common Measures” outlined in Section GDR6.2.1 have been completed.

The greatest depth of compaction that can be achieved with standard compaction equipment (vibrating roller, etc) is around 1 m (for sands). As such, it is necessary to cut down the site level to a point where this compaction can be done to the lowest level needed to be improved.

The applicability of these measures is stated in the main report. These measures must be carried out for all areas where structures, footings and any other settlement-sensitive infrastructure are proposed. Not typically required for pavement subgrades, however, this is discussed in the report if required.

Unless specified otherwise in the report, the **Approved Fill** to be used is outlined in Section GDR8 (**Permeable Sand** where permeable fill is required, else **General Sand**). The specific selection is subject to the requirements of the civil designer.

Table GDR 4: Deep Loose Sand Site Measures

Measure	Commentary
Over-excavate to the required depth.	Over-excavate sand soil to the depth stated in the report and, if appropriate (discussed in report) retain it for re-use as fill. Over-excavation is likely to be done in stages depending on the site area available for earthworks. Excavations must be battered to a temporary slope as given in the report text where applicable and not in close proximity to adjacent structures etc. If required, construct temporary/permanent retaining walls where batters cannot be accommodated.
Moisture condition and proof compact.	Moisture condition and compact the exposed sandy ground to achieve the density specified in Section GDR7.1 (“sand”) to a depth of at least 900 mm.
Test proof compaction	Check that the density specified in Section GDR7.1 (“sand”) has been achieved to a depth of at least 900 mm. We note that the applicability of the use of the PSP for compaction control is discussed in the report. Unless specifically approved for use on the subject site, the contractor must **not** assume that the use of the PSP is appropriate.
Treat areas of loose or unsuitable material	Any areas of loose sand or unsuitable material (including over-excavated areas of former trees and root balls) must be removed and replaced with compacted **Approved Fill** as outlined in the report or as noted above. The report will explain the suitability of site-derived materials for re-use as approved fill.

Measure	Commentary
Carry out bulk filling	Where fill is required to build up levels (including restoration of the site surface level to the original level), use **Approved Fill**, placed and compacted in layers of no greater than 300 mm loose thickness. Test compaction as specified in Section GDR7.1.

In following this method, deep, loose sand will be compacted to a sufficient depth to reduce settlement impacts and the site will be filled (where required) in preparation for supporting footings, ground slabs, pavements and the like.

GDR6.2.4 Clayey Sites

The preparation measures outlined below are provided for sand sites meeting the following criteria:

- Site underlain by cohesive soils (typically >12% fines, i.e., clayey enough for the fines proportion of the soil to dominate behaviour).
- No collapsible soils present.
- No deep soft soils or organic soils.
- Over consolidated clayey soils present which will not be subject to significant primary or secondary consolidation (settlements expected to be within the limit of typical seasonal movements occasioned by moisture content changes, which would be captured in assignment of an AS2870 site classification).
- No shallow groundwater (<1 m deep)
- No rock present at shallow depth.
- “Common Measures” outlined in Section GDR6.2.1 have been completed.

The applicability of these measures is stated in the main report. These measures must be carried out for all areas where structures, footings, pavement subgrades and any other settlement-sensitive infrastructure is proposed.

Unless specified otherwise in the report, the **Approved Fill** to be used is **Clay** as outlined in Section GDR8.

Table GDR 5: Clay Site Measures

Measure	Commentary
Moisture condition and proof compact.	Moisture condition and compact the exposed clayey ground to achieve the density specified in Section GDR7.1 (“fine grained soils”) to a depth of at least 300 mm.
Test proof compaction	Check that the density specified in Section GDR7.1 (“fine grained soils”) has been achieved to a depth of at least 300 mm. The use of a penetrometer for compaction control of cohesive soils is not an appropriate substitute for in situ NDG testing.
Treat areas of loose or unsuitable material	Any areas of soft clayey soils or unsuitable material (including over-excavated areas of former trees and root balls) must be removed and replaced with compacted **Approved Fill**. The report will explain the suitability of site-derived materials for re-use as approved fill.
Carry out bulk filling	Where excavations are done into clayey soils (e.g. to treat soft zones, remove root balls and the like), they must not be backfilled filled with sand fill (even where a sand topping layer is proposed). Where fill is required (including backfilling of excavations to remove trees), only use **Approved Fill**, moisture conditioned, placed and compacted in layers of no greater than 300 mm loose thickness. Test moisture and compaction as specified in Section GDR7.1.
Grade completed clayey surface	Surface water control is essential for clayey sites. This also applies to control of infiltrated water into sand topping layers or the like. The surface of clayey ground must be graded at a minimum of 1% crossfall to drain. This is a general recommendation and an appropriate civil design must be done to account for surface and subsoil drainage.
Install sand topping layer	Where a sand topping layer is proposed, this should be done as outlined in Section GDR6.2.5.

These measures do not take into account the objectives of the civil design for the site, particularly with regard to surface water drainage and groundwater control (including clay grading, subsoil drainage, thickness and composition of a sand topping layer and the like). This must be taken into account by the civil designer. General commentary on drainage control measures is presented in Section GDR14.

GDR6.2.5 Sand Topping Layer

Where a sand topping layer is required:

Unless specified otherwise in the report, the **Approved Fill** to be used is outlined in Section GDR8 (**Permeable Sand** where permeable fill is required, else **General Sand**). The specific selection is subject to the requirements of the civil designer.

Table GDR 6: Sand Topping Layer Measures

Measure	Commentary
Prepare Substrate	Prepare the clayey or other substrate as separately outlined prior to installing the topping layer.
Build up sand topping layer	Build up level to the required level with **Approved Fill**, placed and compacted in layers of no greater than 300 mm loose thickness to achieve the density specified in Section GDR7.1.

For the purposes of achieving the allowable bearing pressures and site classification discussed in the report, it is not necessary to have the bases of slabs and footings in the sand topping layer, i.e. if required, they may extend through the sand topping layer into clayey soil below.

GDR6.2.6 Limestone Sites

The preparation measures outlined below are provided for sites underlain by limestone (refer to Section GDR4.1), meeting the following criteria:

- Site underlain by sand overlying limestone.
- Compaction of a loose upper horizon to maximum 1 m depth, with localised deeper treatments between pinnacles if required.
- No shallow groundwater (<1 m deep)
- “Common Measures” outlined in Section GDR6.2.1 have been completed.

The site preparation measures outlined below are aimed at improvement of the site in preparation for construction of the structures including on-ground slabs, shallow footings, retaining walls and pavements.

Unless specified otherwise in the report, the **Approved Fill** may comprise one of the following as specified in Section GDR8 (the specific selection is subject to the requirements of the civil designer):

- **Permeable Sand** where permeable fill is required
- **General Sand** where permeable fill is not required
- **Mixed Sand/Limestone Fill** where permeable fill is not required

The re-use of any limestone for fill is subject to the requirements of the civil design and discussions in the report text. The use of **Mixed Sand/Limestone Fill** is discussed in Section GDR6.2.7. The preparation measures outlined in Table GDR 7 assume sand fill.

Table GDR 7: Standard Limestone Site Measures (Bulk Earthworks)

Measure	Commentary
Treat zones of loose sand	Where deep loose sand is present (particularly, but not exclusively, between limestone pinnacles), over-excavate to the depth as noted in the report . Sand should be retained for re-use as fill if recommended in the report. Limestone debris and pinnacles should be separated and only re-used if recommended in the report.
Moisture condition and proof compact.	Moisture condition and compact the exposed sandy ground to achieve the density specified in Section GDR7.1 ("sand") to a depth of at least 900 mm. Proof compaction of intact limestone is not required.
Test proof compaction	Check that the density specified in Section GDR7.1 ("sand") has been achieved to a depth of at least 900 mm. We note that the applicability of the use of the PSP for compaction control is discussed in the report. Unless specifically approved for use on the subject site, the contractor must not assume that the use of the PSP is appropriate. If refusal to the test method is encountered within the target test depth on limestone and the results to the refusal depth are acceptable, it is not necessary to repeat compaction testing at that location. Compaction control of intact limestone is not required.
Treat areas of loose or unsuitable material	Any areas of loose sand or unsuitable material (including over-excavated areas of former trees and root balls) must be removed and replaced with compacted **Approved Fill** as outlined in the report or as noted above. The report will explain the suitability of site-derived materials for re-use as approved fill.
Carry out bulk filling	Where fill is required to build up levels, use **Approved Fill**, placed and compacted in layers of no greater than 300 mm loose thickness. Test compaction to achieve the density specified in Section GDR7.1.

These measures do not take into account the specifics of the civil design, including the requirement (if any) for excavatable and/or free draining layers to achieve construction and drainage objectives. The civil design must take precedence and is not specifically considered in this advice.

Soakwells can perform poorly in limestone and specific advice may apply to the installation of soakwells in limestone areas. If not discussed in our report, please contact us for further advice.

Without further consultation with the structural designer, footings for any one structure must not be founded on a mixture of sand and intact limestone. This is due to potential differential settlements between limestone zones (relatively stiff) and soil zones (relatively soft). Where this is the case, the measures outlined in Table GDR 8 must be followed, only with guidance from the structural designer and Galt.

Table GDR 8: Standard Limestone Site Measures (Footing and Slab Preparation)

Measure	Commentary
Excavate and compact for slabs, subgrades, pad or strip footings	Excavate for pad and strip footings. Where a mix of soil and limestone is present below any one structure, one of the following must be done (to be agreed with structural designer and us): ▪ **Over-excavate limestone and replace with compacted soil:** Typically where the foundation largely comprises soil and a relatively small amount of limestone is present. Where footings and slabs are founded partly on soil and partly on limestone, over-excavate the limestone by at least 300 mm below the base of footing or slab and replace the excavated material with compacted **Approved Fill**. ▪ **Remove soil from over limestone and replace with concrete**: Typically where the foundation largely comprises limestone and a relatively small amount of soil is present. Localised zones of sand and mixed sand/limestone rubble must be removed and replaced with lean-mix concrete, e.g. 10 MPa blinding concrete. ▪ **Design the structure to accommodate differential foundation movements:** For example, include construction joints or use a more heavily reinforced footing (subject to the structural designer's requirements).
Test compaction of footing bases, slabs or subgrades.	Compact the exposed bases to achieve the density specified in Section GDR7.1 ("sand"), to a depth of at least 900 mm, or to the depth where limestone is intersected. If refusal to the test method is encountered within the target test depth on limestone and the results to the refusal depth are acceptable, it is not necessary to repeat compaction testing at that location. Compaction control of intact limestone is not required. Remove, replace and compact as required with approved fill any zone not achieving the density specified in Section GDR7.1 ("sand")

GDR6.2.7 Mixed Sand/Limestone Filling

On sites where deemed appropriate by the Civil Design, **Approved Fill** may comprise limestone rubble fill (**Mixed Sand/Limestone**, as specified in Section GDR8).

The preparation measures outlined below are provided for sites meeting the following criteria:

- No shallow groundwater (<1 m deep)
- "Common Measures" outlined in Section GDR GDR6.2.1 have been completed.
- Substrate preparation for the relevant site type has been done in preparation for further filling (as relevant for sand, limestone or clayey sites discussed in the preceding sections).

The site preparation measures outlined below are required prior to construction of structures including on-ground slabs, shallow footings, retaining walls and pavements.

Table GDR 9: Mixed Sand/Limestone Fill Measures

Measure	Commentary
Develop a method specification for the filling	A performance specification is not appropriate for compaction control in **Mixed Sand/Limestone** fill, due to oversize limestone particles and the limitations of test methods. Therefore, a method specification is required. Development of a method specification is discussed in Section GDR7.5. A tentative method specification for **Mixed Sand/Limestone** Fill preparation is also provided.
Carry out bulk filling	Where fill is required to build up levels, use **Approved Fill**, placed and compacted in accordance with the developed method specification.
Maintain Construction Records	As performance testing cannot be done, quality assurance records are limited. Therefore, the parameters mentioned in Section GDR7.5.1 must be kept in a comprehensive record of the earthworks done to the developed method specification. The use of the PSP is possible only to check for loose sand zones between limestone particles. High PSP blow counts, where limestone particles are intersected, are meaningless in terms of assessing density of the prepared fill. The primary means of validation of the earthworks is conformance with the developed method specification.
Install sand topping layer	Where a sand topping layer is proposed, this should be done as outlined in Section GDR6.2.5.

These measures do not take into account the specifics of the civil design, including the requirement (if any) for excavatable and/or free draining layers to achieve construction and drainage objectives. The civil design must take precedence and is not specifically considered in this advice.

Soakwells can perform poorly in limestone fill and specific advice may apply to the installation of soakwells in limestone fill areas. If not discussed in our report, please contact us for further advice.

GDR6.3 Guidance on Sites with Cohesive Soils

Cohesive soils (most commonly, "clayey" soils) require careful moisture conditioning to facilitate compaction. We recommend that the moisture content of the material is between optimum moisture content (OMC) and 2% wet of OMC at the time of placement and compaction. We note that compaction to the densities specified in Section GDR7.1 can be difficult to achieve for clayey material when not appropriately moisture conditioned.

Vibratory padfoot rollers are preferred for compacting cohesive fill to promote proper kneading and interlocking of subsequent layers.

Clayey soils will drain poorly when inundated following rain events and result in saturated conditions that may inhibit compaction of the soil. In general, it is preferable to avoid trying to re-work clayey sites within several days of any substantial rainfall.

We recommend that the surfaces of clayey sites are sealed by compaction (i.e., final compaction should be with a smooth drum roller) and graded to drain (to avoid low spots where water can pond and cause softening) prior to any rain events. Stripping back of softened materials to expose competent natural or compacted clayey soil is required before continuing earthworks.

If difficulties are experienced during compaction due to water, further advice should be sought from a geotechnical engineer.

GDR6.4 Preparation and Testing of Shallow Footings

It is preferable to dig all footing excavations carefully with a flat-edged bucket to minimise the disturbance of underlying foundation soil.

Where the footing base is disturbed, or compaction is required, this must be done using appropriate compaction equipment particular to the task (as evaluated by the contractor) – typically a 'jumping jack', self-propelled plate compactor or an excavator-mounted plate compactor.

All footing bases must be tested to achieve the density requirements of Section GDR7.1. PSP testing of sand foundations is only applicable where the use of the PSP is specifically approved in the report, otherwise all testing is to be done using the NDG.

Sand Topping Layer - Where a sand topping layer is present over a different soil (i.e., clay, limestone etc.), testing of the density of the sand topping layer is only necessary within the thickness of the sand topping layer. Testing does not need to extend into the underlying compacted substrate, which is separately subjected to compaction control.

Mixed Sand/Limestone Fill – Where mixed sand/limestone fill has been installed to a method specification, no compaction control testing is required, however re-compaction of the base must be done as noted above.

In situ limestone – where in situ limestone (weakly or more cemented limestone, with no sand zones or voids) is present at a footing base and no over-excavation has been done (refer to Section GDR6.2.6 regarding over-excavation of footing bases in limestone), then no compaction control testing is required.

Where loose or soft material is encountered, one of the following actions must be taken:

- Over-excavate the loose / soft layer to expose a suitable layer that does meet the required density (Section GDR7.1) and either:
    - Place and compact Approved Fill (relevant to the appropriate preparation measures outlined in Section GDR6.2) to achieve the required density (Section GDR7.1); or
    - Pouring blinding concrete (f'_c>15 MPa at 28 days) from the competent layer up to the underside of the footing.

All foundations must be assessed by a competent person prior to blinding.

Measures must be taken to minimise moisture changes in clayey foundation soils at the base of footing excavations. Concrete footings are to be poured soon after excavation to minimise the potential for excessive moisture change. The use of a concrete blinding layer following foundation preparation should be considered.

GDR7 COMPACTION AND MOISTURE CONDITIONING

GDR7.1 Requirements

Any soil within the significant founding zone of structures (buildings, slabs, pavements, etc.) must be suitably moisture conditioned and compacted. These soils must be compacted to the requirements as outlined below.

Table GDR 10: Compaction and Moisture Requirements

Soil Description	Soil Particle Limits	Moisture Requirement	Density Requirement (DDR)	Possible QA/QC Test Methods
Sand	<5% fines <5% gravel *Maximum particle size 9.5 mm*	MOMC ±2%	95% MMDD	PSP NDG
Gravel	<5% fines >50% gravel *Maximum particle size 19.0 mm*	MOMC ±2%	95% MMDD	NDG
Clayey/Silty Gravel	5-35% fines >50% gravel *Maximum particle size 19.0 mm*	MOMC ±2%	95% MMDD	NDG
Sand with fines or gravel	5-35% fines; and/or 5-50% gravel *Maximum particle size 19.0 mm*	MOMC ±2%	95% MMDD	NDG Method Specification
Fine grained soils (Clayey or Silty)	>35% fines *Maximum particle size 19.0 mm*	MOMC ±2%; or SOMC ±2%^{2}	92% MMDD; or 95% SMDD	NDG Method Specification
Oversize/rubbly soil	Any soils with particles >19.0 mm	MOMC ±2%	95% MMDD (Or equivalent to)	Method Specification Detailed Assessment Based on Specific Material

NOTES:

1. *DDR – Dry Density Ratio*
   MMDD – Modified maximum dry density (AS1289.5.2.1)
   MOMC – Modified optimum moisture content (AS1289.5.2.1)
   SMDD – Standard maximum dry density (AS1289.5.1.1)
   SOMC – Standard optimum moisture content (AS1289.5.1.1)
   PSP – Perth Sand Penetrometer
   NDG – Nuclear Density Gauge
2. *Preferably OMC to OMC +2%, for ease of compaction and producing a homogenous fill*
3. *Test frequencies are specified in Section GDR7.6.*

The soil groups and definitions outlined above are generally based on AS1726-2017. Test methods are discussed in subsequent sections.

GDR7.2 Construction Recommendations

Over-excavation and replacement of loose material must be done where the minimum DDR cannot be achieved.

Fill must be placed in horizontal layers of not greater than 300 mm loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

Care will need to be taken if compacting in the vicinity of existing structures, such as the adjacent properties. This is particularly important if vibratory compaction is being carried out.

- Tynan (1973), “Ground Vibration and Damage Effects on Buildings”, Australia Road Research Board, Special Report No. 11.

Tynan (1973) provides guidance on the selection of compaction equipment for use adjacent to structures. The distance of influence (i.e., the definition of “vicinity”) will vary depending on the size of compaction plant proposed for use. Where there is concern regarding the impact on nearby structures, a dilapidation study should be done.

Care must be taken when compaction is undertaken when the site surface is within 1 m of the groundwater level, as compaction (particularly with vibration) can draw the water up to the surface. In this instance, consideration should be given to:

- Static rolling only;
- Using a pioneering layer (if possible); or
- Dewatering to keep the water at least 1 m below the surface being compacted.

GDR7.3 Nuclear Density Gauge

Where applicable, a nuclear density gauge (NDG) must be used in accordance with AS1289.5.8.1. NDG tests must be done to a depth of 300 mm or as otherwise indicated in the text of the attached report.

GDR7.4 Perth Sand Penetrometer

Where clean sand is used (<5% fines and <5% gravel), a Perth sand penetrometer (PSP) may be used for compaction control in accordance with AS1289.6.3.3. Refer to the report for recommended blow counts correlating to the specified density.

Where the fines or gravel contents of a sand soil exceed the maximum contents noted above, a PSP must not be used exclusively for compaction control. As a minimum, ongoing confirmation testing with an NDG is required. If not specified in our report, please contact us for further advice regarding test frequencies.

If difficulties are experienced recording the required blow counts, a site-specific PSP correlation should be carried out to determine the PSP blow count correlating to a DDR of 95% MMDD. In addition, a particle size distribution (PSD) test should be carried out to verify that the use of a PSP is suitable for the sands being tested. A site-specific PSP correlation must:

- be done on site;
- use the nuclear density gauge (NDG) to determine density at a minimum of 5 points with varying density to a depth of 300 mm below surface;
- include at least 1 point where the dry density ratio is in excess of 95% MMDD;
- use a calibrated PSP to determine the PSP blow count from 150 mm to 450 mm at each NDG test point; and
- be plotted on a chart of PSP blow count vs DDR.

Only where specifically stated as applicable in the report and where the use of the PSP is relevant as noted above, the following values may be taken as deemed to conform to a dry density ratio of 95% MMDD for the relevant sand type.

Table GDR 11: Deemed-to-comply Values for PSP Results in Perth Sands

Depth Interval (mm)	Bassendean	Tamala	Calcareous
0-150	SET	SET	SET
150-450	7	8	12
450-750	9	10	14
750-1050	11	12	16

NOTES:

1. *Blows per 300 mm interval*
2. *Bassendean Sand is typically a white - grey, low-fines quartz sand found on the eastern part of the Perth coastal plain*
3. *Tamala / Spearwood sand is typically yellow or orange, low-fines quartz sand found on the western part of the Perth coastal plain*
4. *Calcareous sands are typically white or yellow, calcareous sand found in low-lying areas on the western fringe of the Perth coastal plain*

5. Values derived from Galt experience on PSP correlations done on sites across Perth for the 150-450 mm interval.

GDR7.5 Method Specifications

GDR7.5.1 General

Where proposed, a method specification should be developed by a geotechnical engineer or similarly qualified person and ratified by us (including a site visit by us). The method specification should be confirmed by the construction of a trial pad or trial area and the compaction methodology should be checked against either:

- density, as assessed using a nuclear density gauge; or
- settlement, as assessed using a dGPS.

Specific advice should be requested for the development of a method specification, taking into consideration the material being compacted.

Method specification compliance should be maintained for all areas on a minimum 20 m grid, with the compliance to include:

- Roller used (weight, style, vibration);
- Water application rate (per lift);
- Layer thickness placed; and
- Number of passes with roller.

GDR7.5.2 Indicative Method Specification – Sand/Limestone Rubble Mix

Where mixed sand/limestone is used as structural fill, a performance specification is not appropriate due to the inaccuracies of standard test methods (NDG/PSP etc.) in this type of material. A method specification can be used instead. The following indicative method specification is provided for evaluation and trial but must be trialled and ratified by us prior to widespread employment on site. The following would be typically adopted:

- Maximum particle size: 250 mm
- Maximum loose layer thickness: 350 mm
- Minimum watering rate: 10 L/m^2/100 mm thickness of loose material (e.g. 35 L/m^2 for a 350 mm thick layer)
- Minimum 8 passes with a vibrating padfoot roller, minimum static weight 10 tonnes.
- The compacted fill must comprise closely packed particles without any significant voids between the larger particles.

GDR7.6 Testing Frequency

After compaction, verify that the required density has been achieved by testing at the base of excavation and through the full depth of any fill, and to a minimum depth of:

- 900 mm where a PSP is used; or
- 300 mm where a NDG is used.

The frequency of testing (when a method specification is not used) should be as follows:

Table GDR 12: Compaction Testing Frequency Requirements

Area	Minimum Testing Frequency	Minimum Tests Per Lot
Proof Compacted Area	1 test per 1,000 m^2 (30 m grid)	2
Structural Fill Outside of Building and Pavement Footprints	1 test per 500 m^3 2 tests per layer *Whichever is greater*	2
Structural Fill Within Building and Pavement Footprints	1 test per 500 m^3 4 tests per layer *Whichever is greater*	4
Spread/Pad Footings	1 test per 9 m^2 per footing	1
Strip Footings/Retaining Wall Foundations	Minimum 2 tests At 5 m centres *Whichever is greater*	2
On-ground slabs, pavements and rafts	Minimum 2 tests At 10 m centres 1 test per 100 m^2 *Whichever is greater*	2

NOTES:

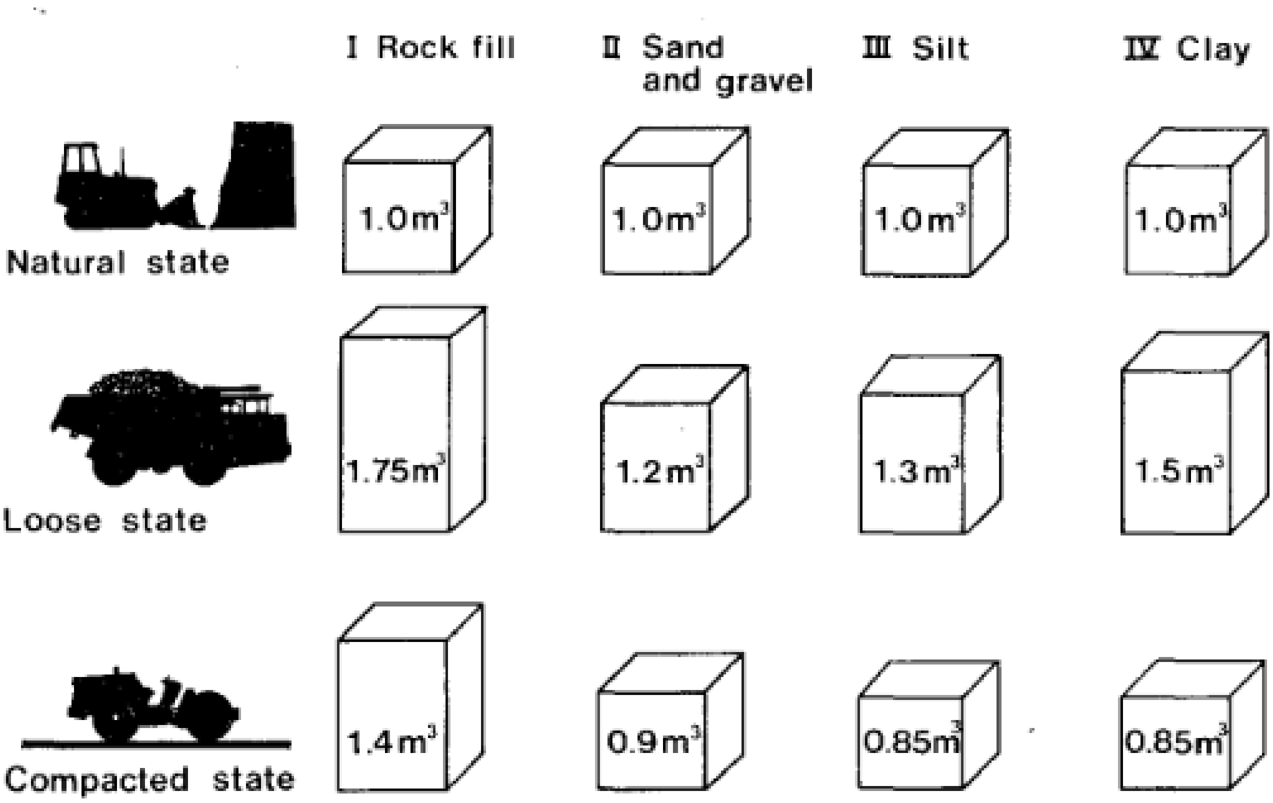
1. *A 'lot' is defined in the context of this section as a section of earthworks that is undertaken in one operation where the equipment, personnel, materials and methodology are consistent throughout the entire process. This would typically be limited to operations done in one day, but this is not mandatory.*
2. *There will frequently be multiple 'lots' in an earthworks process, therefore the number of tests must be adjusted according to the minimum number per lot in this table (where this is more than the frequency specified in 'testing requirements').*

GDR7.7 Bulking and Compaction Factors

All soils will "bulk" when excavated to stockpile, and "compact" when placed from stockpile to earthworks layers. Published bulk and compaction factors are presented below for conventional materials, taken from:

- Forssblad, L (1981), "Vibratory Soil and Rock Fill Compaction", Dynapac Maskin AB

Inline Image GDR 3: Volumes of Different Types of Fill Materials in Natural, Loose and Compacted State



These values are indicative only and will vary according to site specific conditions. The values provided here must not be used for commercial volume estimates or settling disputes regarding volumes.

GDR8 APPROVED FILL AND CONFORMANCE TESTING

Imported fill must comply with the material requirements as stated in AS 3798-2007, “Guidelines on Earthworks for Commercial and Residential Developments”.

Where doubt exists, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials.

The following table presents recommended material parameters for standard fill types. This does not take account of availability of materials either on site or in the local area. Refer to the report text for specific advice on fill at the subject site.

Table GDR 13: Standard Fill Recommendations

Soil Description	Application	Soil Particle Limits (%)[3]				k_{min}[1] (m/d)	OC[2] (%)	Atterberg Limits		CBR[6] (%)	Test Method[4]
		Fines	Sand	Gravel	Max.			LL (%)	PI (%)		
Permeable Sand	Permeable bulk fill Retaining wall backfill Permeable select fill	≤5	≥90	≤5	9.5	5	≤2	NP	NP	≥12	PSP NDG
General Sand	Bulk fill Select fill (permeability not required)	≤5	≥90	≤5	9.5	N/A	≤2	NP	NP	≥12	PSP NDG
Silty Sand	Bulk fill Select fill	≤35	≥55	≤10	9.5	N/A	≤2	<35	<11	≥12	NDG
Clayey Sand	Bulk fill Select fill	≤35	≥55	≤10	9.5	N/A	≤2	<40	N/A	≥12	NDG
Mixed Sand/Limestone	Bulk fill (permeability not required)	≤5	≥20	≤80	250	N/A	≤2	NP	NP	N/A	NDG Method
Blue Metal Gravel[8]	Retaining wall backfill Drainage trench backfill	≤3	≤5	≥90	37.5	5	≤1	NP	NP	N/A	NDG
Clay[7]	Reinstatement of localised excavations in clay Bulk fill	≥12	Varies	≤30	19	N/A	≤2	Varies			NDG

NOTES:

1. k_{min} – *minimum saturated hydraulic conductivity (AS1289.6.7.1, remoulded to minimum DDR 100% MMDD).*
2. *OC – organic content (Walkley-Black method recommended, AS1289.4.1.1 – not loss on ignition methods)*
3. *% by mass.*
4. *Test method indicates possible compaction control methods for this material.*
   PSP – Perth sand penetrometer (AS1289.6.3.3). Where a PSP is used, a site-specific correlation must be done unless otherwise noted in the report.
   NDG – Nuclear density gauge (AS1289.5.8.1)
   Method – method specification
5. *Atterberg Limits: LL – liquid limit PI – plasticity index NP – non-plastic*
6. *CBR: California bearing ratio (for sand - remoulded to DDR 95% MMDD @ OMC, 4.5 kg surcharge). CBR values may be changed depending on the design pavement requirements.*
7. *"Clay" fill type is included for broad reference only and to illustrate preferred applications, particle size limits and recommended test method. Specific discussion on the use of clayey fills is included in the report text if applicable. Atterberg limit and CBR testing of clayey fills may be required and advice must be sought from us if not stated in the report.*
8. *"Blue metal" gravel refers to single sized, crushed, washed igneous rock gravel used for drainage purposes.*
9. *In the absence of specific test frequencies by the civil designer, the testing shown in Table GDR 14 must be done (highlights in Table GDR 13 show where the test is required).*

Table GDR 14: Conformance Testing Frequency Requirements

Parameter	Frequency (m^3)	Minimum Tests per Source	AS1289 Reference
Particle size distribution	5,000	1	3.6.1
Hydraulic conductivity (permeability)	10,000	2	6.7.1
Organic content	5,000	1	4.1.1
Atterberg limits	5,000	1	3.1.1, 3.2.1, 3.3.1
CBR	10,000	2	6.1.1

NOTES:
1. *Frequency is for the nominal number of cubic metres of compacted fill.*
2. *Unless stated otherwise in the report text, the conformance testing must also be carried out on site-derived materials to confirm suitability.*

GDR9 SHALLOW FOUNDATIONS

GDR9.1 Design

Footings and slabs may be designed in accordance with the assigned site classification in accordance with AS2870-2011. We note that AS2870-2011 is limited to single and double storey residential and commercial developments and may not be strictly applicable.

Where the report provides tables for shallow footing design, custom footings may be designed by the structural engineer using the data provided therein.

GDR9.2 Interpretation of Provided Values

BEARING PRESSURES

All settlement and bearing pressures estimates are provided on the assumption that the site preparation requirements outlined in the report are completed below all structures plus a minimum distance of 1 m beyond the outside edge of any footing or slab. It is essential that the soil below all foundations is appropriately prepared as outlined and meets the relevant compaction requirements.

Allowable bearing pressures for footings of intermediate plan dimensions (to any tabulated) can be interpolated. Footings that have a plan dimension either smaller or larger than those presented in the report will need to be considered individually along with other embedment depths.

Allowable bearing pressures, where provided, are considered to be the upper limit for shallow footings to limit total and differential settlements. Footings carrying eccentric loading, such as below retaining walls, must be assessed separately.

SETTLEMENTS

The reporting of settlements to any precision level is not intended to imply a high accuracy of settlement prediction. Settlements as reported should be considered ‘order of magnitude’.

Estimated settlements represent vertical downwards movement due to loading and do not take into account potential additional movement associated with the characteristic surface movement of the soil (which must be taken in addition to these settlements from loading, refer Section GDR5). The site classification is discussed in the report.

The actual settlement of any proposed structure will depend upon a number of factors including the applied pressures, footing size and base preparation. The estimated settlement(s) provided in this report are for the working bearing pressures as indicated. Differential settlements are likely between footings of similar sizes, loads and elevations (as stated in the report text). A proportion of the settlement is expected to occur during construction (i.e., during initial loading.

The provided settlement estimates (unless otherwise stated) do not include interaction effects from footings founded near other footings (i.e., groups of footings). Interaction effects will need to be considered if the spacing between adjacent footings is smaller than the dimension of the footings (i.e., the centre-to-centre spacing between footings is less than twice the width of the footing). This could act to double provided settlements, dependent on the footing configuration. Where an assessment of footing groups is required, a more detailed numerical or finite-element modelling analysis would need to be undertaken.

CREEP AND CONSOLIDATION

Creep settlement is an irreversible component of long-term soil settlement caused by sustained vertical stress. Consolidation is a time-dependent irreversible compression in a soil layer caused by a reduction in pore pressure between soil particles. Both creep and consolidation can occur in natural materials as a result of earthworks or the placement of loads on to soil layers. The settlements as presented for short-term loading do not include consideration for creep and consolidation settlements unless specifically stated.

GDR9.3 Raft Foundations

Where moduli of subgrade reactions are provided for the design of raft foundations, we highlight that these are an estimate of the elastic reaction of the soil. The values are provided based on an expected load and loaded area size. Soils are typically non-linear in their response and will have different stiffnesses at different levels of strain and load repetitions. This is due to the physical interaction of soil particles under different levels of stress.

The possibility of a non-linear response must be considered by the designer of any raft foundation.

GDR10 PILED FOUNDATIONS

Piles must be designed and tested in accordance with AS2159-2009, “Piling – Design and Installation”. We use the following interpretation/design methods to provide pile design parameters:

- Franki Africa Pty Ltd (2008) “A Guide to Practical Geotechnical Engineering in South Africa”. 4th ed.
- AFNOR (2012) “NF P 94-262 – Justification des ouvrages géo-techniques, Normes d’application nationale de l’Eurocode 7”, Afnor, Paris, July 2012.
- Lehane, B. (2017) “CPT-Based Design of Foundations”. E.H Davis Memorial Lecture, Australian Geomechanics Vol 54. No. 4.
- Lehane, B. et al. (2020) “A New ‘Unified’ CPT-Based Axial Pile Capacity Design for Drivel Piles in Sand”. Proceedings of the Fourth International Symposium on Frontiers of Offshore Geotechnics.
- Doan., Lehane, B. (2021) “CPT-Based Design Method for Axial Capacities of Drilled Shafts and Cast-in-place Piles.” American Society of Civil Engineers (ASCE), Journal of Geotechnical and Geoenvironmental Engineering.

The pile designer must:

- consider the possible variation in subsurface conditions at each pile location;
- consider any pile group effects based on the final piling configuration;
- assume that the unit shaft resistance in tension is less than 80% of the unit shaft resistance in compression to account for Poisson’s effect in sand;
- ignore pile resistance in the surficial 0.5 m or 1 x pile diameter (whichever is greater), if relevant;

- consider the impact of weak layers underlying stiffer layers (or vice versa) on end bearing capacity; and
- reduce the pile capacity in tension to no greater than 0.8 of the pile capacity in compression.

The piling contractor must:

- make their own assessment on the suitability of their equipment to install any piles at the subject site; and
- carry out or appoint a suitably experienced contractor to test the piles in accordance with AS2159.

Where dynamic or static testing of the piles does not occur, we consider that a design geotechnical reduction factor (ϕg) of 0.4 is applicable for the pile design. If testing of the piles is proposed by the piling contractor, a higher ϕg could be adopted.

Unless otherwise stated, providing pile design parameters does not specifically indicate the driveability of any piles into soil units.

A separate driveability study may be required and must be considered by the pile designer and installer. The given pile design parameters must not be used for driveability assessments as these parameters are likely to be un-conservative.

GDR11 EARTH RETAINING STRUCTURES

GDR11.1 General

Retaining structures may be designed in accordance with AS4678 (2002) “Earth Retaining Structures”. Unless otherwise specifically stated, we recommend that all retaining walls are backfilled with free-draining soil (Permeable Sand or Blue Metal Gravel as defined in Section GDR8).

Where the cohesive soil is used as retaining wall backfill, a suitable, permanent drainage system must be placed behind the wall such that a build-up of pore pressure is prevented. A separator geotextile (Bidim A24, or similar, or heavier) must be used between the interface of any granular backfill and the cohesive soil.

Where drainage is not provided, the retaining wall must be designed to accommodate water pressure behind the wall (10 kPa per metre height).

GDR11.2 Earth Pressure Coefficients and Strength Parameters

Where earth pressure coefficients are provided for retaining walls, the wall designer must make an independent assessment of the parameters appropriate to the construction method to be used, including alternative values of wall friction. Unless otherwise stated, we have assumed a horizontal ground surface behind and in front of the retaining wall for provided parameters.

GDR11.2.1 Cohesionless Soils

Where cross-referenced for suitability in the report, the following parameters may be adopted for design of earth retaining structures in cohesionless soils (sand and gravel).

Table GDR 15: Retaining Wall Geotechnical Parameters (Cohesionless Soils)

Density	γ (kN/m^3)	ϕ' (°)	k_0	Wall Friction=0		Wall Friction=0.5ϕ		Wall Friction=0.67ϕ	
				k_a	k_p	k_a	k_p	k_a	k_p
Very Loose	17	30	0.44	0.33	3.00	0.29	4.81	0.28	5.74
Loose	17	32	0.42	0.31	3.25	0.27	5.55	0.26	6.83
Medium Dense	18	34	0.39	0.28	3.54	0.25	6.47	0.23	8.26
Dense	19	36	0.36	0.26	3.85	0.22	7.63	0.21	10.18
Very Dense (1)	19	38	0.34	0.24	4.20	0.21	9.11	0.20	12.85
Very Dense (2)	19	40	0.31	0.22	4.60	0.19	11.06	0.18	16.73

NOTES:

1. *Earth pressure coefficients are provided in this table for conditions of zero friction between the wall and the soil and with wall friction of 0.5Φ' or 0.67Φ'.*
2. *A horizontal ground surface behind and in front of the wall has been assumed.*
3. *The retaining wall designer should make an independent assessment of the parameters appropriate to the construction method to be used, including alternative values of wall friction.*
4. *γ – bulk unit weight*
   ϕ' – effective friction angle
   k_a – coefficient of active earth pressure (Coulomb – AS4678-2002, Appendix E)
   k_p – coefficient of passive earth pressure (Coulomb – AS4678-2002, Appendix E)
   k_0 – coefficient of at-rest earth pressure (Jaky)
5. *Maximum fines content 12% for applicability of this table for design purposes.*
6. *Unit weights based on Table D1 of AS4678-2002, for moist bulk weight.*
7. *Friction angle based on Equation D1 and Table D2 of AS4678-2002, based on rounded, moderately graded siliceous sand.*

GDR11.2.2 Cohesive Soils

Where cohesive soils (i.e. clayey or silty soils) are proposed for backfill, geotechnical design parameters may be provided in the form of effective strength and undrained strength parameters. We note that:

- Undrained strength parameters should be used for analysis of short-term stability, or stability under sudden loading of cohesive soils.
- The effective strength parameters should be used for analysis of free-draining soils and the long-term stability of cohesive soils.

Table GDR 16: Retaining Wall Geotechnical Design Parameters (Cohesive Soils – Undrained)

Consistency	γ_b (kN/m^3)	c_u (kPa)
Soft	17	12
Firm	18	25
Stiff	19	50
Very Stiff	20	100
Hard	20	200

NOTES:

1. *γ_b – bulk unit weight*
   c_u – undrained cohesion
   ϕ_u = 0° (undrained friction angle)
2. *Unit weights based on Table D1 of AS4678-2002*
3. *Undrained cohesion based on lower end of shear strengths as define in AS1726-2017, Table 11*

Table GDR 17: Retaining Wall Geotechnical Design Parameters (Cohesive Soils – Drained)

Fines Content	PI (%)	γ_b (kN/m^3)	ϕ' (°)	c' (kPa)[5]
12-35%	All	19	32	0
>35%	10	20	30	0 – 5
>35%	20	20	26	0 – 5
>35%	30	20	23	0 – 5
>35%	40	20	21	0 – 5

NOTES: **1.** *γ_b – bulk unit weight*
c' – drained cohesion
ϕ' – effective friction angle
PI – plasticity index

2. *Unit weights based on Table D1 of AS4678-2002, assuming generally stiff to hard overconsolidated soils.*

3. *For fines contents <35% (silty sand and clayey sand), strength parameters based on:*

- *Lehane, B. et al (2007) "A Laboratory Investigation of the Upper Horizons of the Perth/Guildford Formation in Perth CBD", Australian Geomechanics Vol 42. No. 3.*

4. *For fines content >35% (sandy clay), strength parameters based on:*

- *CIVL5503 course notes (2004), "Underground Construction", University of Western Australia*

5. *c' = 0 recommended for long-term design. Table D4 of AS4678 suggests c' up to 5 kPa for 'poor' fine grained soils and 10 kPa for 'average' fine-grained soils. The use of c' for design is subject to the designer's judgement but recommended by us only for temporary works.*

Per AS4678-2002 Appendix E, horizontal earth pressures for frictional-cohesive soils may be calculated in accordance with the Rankine-Bell design model (illustrated in Figure E2 of AS4678). The earth pressures are as follows (Z = depth, all other terms have the meanings given in the above tables):

- Active: $p_a = \gamma Z tan^2\left(45 - \frac{\emptyset}{2}\right) - 2ctan\left(45 - \frac{\emptyset}{2}\right)$
- Passive: $p_p = \gamma Z tan^2\left(45 + \frac{\emptyset}{2}\right) + 2ctan\left(45 + \frac{\emptyset}{2}\right)$

GDR11.3 Design and Construction Considerations

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

Retaining walls can move and rotate under imposed soil loading resulting in settlement behind the wall. This must be considered in the design and during construction of the retaining walls in order that adjacent infrastructure is not adversely affected.

It is important to note that some ground movement will occur behind any soil retaining system, including gravity retaining walls.

GDR12 EXCAVATIONS, BATTERS AND SLOPES

GDR12.1 Excavatability

Our assessment of the excavatability of rock is based on a combination of:

- Our experience on earthworks and construction projects across Australia; and
- Figure 10 of the revised graphical method of assessing excavatability of rock by:
- Pettifer, G.S. & Fookes, P.G., "A revision of the graphical method for assessing the excavatability of rock", Quarterly Journal of Engineering Geology, 27, pp145-164, 1994.

GDR12.2 Safety

All excavations must be carried out in accordance with:

- Commission for Occupational Safety and Health (2022). “Excavation: Code of Practice”, Department of Mines, Industry Regulation and Safety, 89pp, Perth.

Excavations in cohesionless soils are particularly prone to instability unless support is provided. Care must be exercised in such excavations and appropriate safety measures adopted where necessary, particularly in the vicinity of existing buildings, structures and infrastructure.

The toe of any batter must be at least 500 mm above groundwater (including perched groundwater).

Unless a specific slope stability assessment or retention design has been done, the toe of any excavation should not encroach within a line of 1V:3H to any nearby footings, pavements or other settlement-sensitive structures.

Surcharges (such as structures, plant and soil stockpiles) must not be placed at or close to the crest of unsupported excavations, without a specific slope stability assessment.

A geotechnical engineer must be consulted where there is any doubt regarding the stability or safety of unsupported excavations.

GDR12.3 Batters

Temporary batter slopes provided in the report are subject to the following conditions, unless otherwise stated:

- The maximum slope height is 2 m without specific advice and slope stability analysis.
- The groundwater level for the duration of the excavation must be at least 500 mm below the toe of the slope.
- No surcharges are present in the vicinity of the slope (i.e. must be outside a line of 1V:3H from the toe of the slope).

Unless noted specifically in the report, the following batters may be adopted (maximum height: 2 m):

Table GDR 18: Default Batter Angles

Situation	Material	Batter
Temporary	Cohesionless Soils (Sand/Gravel)	1V:2H
Temporary	Cohesive Soils – Soft	1V:2H
Temporary	Cohesive Soils – Firm, Stiff, Very Stiff or Hard	1V:1H
Temporary	Limestone – Variably Cemented	1V:1H
Temporary	Limestone – Well Cemented	1V:0.5H
Permanent	All Soils	1V:3H
Permanent	Limestone – Variably Cemented	1V:2H
Permanent	Limestone – Well Cemented	1V:1H

Where specified batters cannot be accommodated in the vicinity of existing footings, roads and services, temporary or permanent lateral support will be required.

Specific advice is required for batters higher than 2 m.

Erosion control must be considered for permanent slopes.

Rock slopes must be inspected, and all loose cobbles / boulders removed. Permanent rock slopes may require dentition works or possibly rock catch drains.

GDR12.4 Grouting

Permeation or jet grouting involves injecting a microfine cement into soil to form a grouted soil block (soilcrete) to support excavation and structures. Grouting is typically only effective where the soil has the capacity to "take" the grout and form a uniformly cemented soil mass. Permeation grouting is generally limited to relatively permeable, coarse-grained cohesionless soils (sands and gravels with <5% fines).

If grouting is proposed, we recommend the following:

- Grouting must be carried out by a suitably experienced contractor.
- Only microfine cement grout should be used (not GP or coarse cement blends) to ensure adequate penetration into the soil matrix.
- Grouting should be done on a grid of not greater than 300 m.
- Application rates must be discussed with the contractor.
- The grouted soil mass must have intimate contact with any structures it is intended to support.
- The contractor must satisfy themselves that the proposed grouting can be installed with their equipment and into the subsurface conditions encountered at the site, considering possible obstructions, groundwater, cemented layers, loose sands etc.
- Testing of the grouted soil mass must be done to ensure that the grout has adequately permeated through the soil matrix. This can be done by drilling into the soil mass to ensure the cementation is continuous.

Grouting is most effective on permeable, relatively loose natural sand. Where historical filling or other ground disturbances have occurred, the grouting process can be less effective due to the tendency of grout (or other liquids) to follow more permeable paths / zones through the disturbed soil.

GDR13 STORMWATER DISPOSAL AND DRAINAGE DESIGN

GDR13.1 Groundwater Separation – Controlled Groundwater

These recommendations ONLY apply to where regional controls on groundwater (primarily: subsoil drainage, but also surficial 'main drains') exist, i.e. only to areas where groundwater is actively controlled.

The following reference:

- IPWEA (2016), "Specification: Separation Distances for Groundwater Controlled Urban Development", Institute of Public Works Engineering Australasia

recommends the following separation distances from drainage infrastructure to groundwater:

- Underground infiltration systems: 0 mm from the 50% AEP (annual exceedance probability) phreatic surface.
- Surface infiltration systems (vegetated): 300 mm from the 50% AEP phreatic surface.

The above IPWEA reference also states that performance measures for underground infiltration systems are to have a: *demonstration of acceptable volumetric capacity when groundwater is elevated above base of system and that the groundwater recedes below the invert of the system during mosquito breeding seasons (grated or partially open systems).*

GDR13.2 Groundwater Separation – Uncontrolled Groundwater

These recommendations apply where regional controls on groundwater levels are not present. For infiltration into soakwells and soakage basins to be the full theoretical value, an adequate separation to groundwater must be achieved, because otherwise performance is hindered by inadequate separation to groundwater or partial submergence of the infiltrative element.

We recommend a minimum separation of 500 mm from the underside of infiltrative elements to maximum groundwater level.

- To average annual maximum groundwater level (AAMGL), where this has been defined for the site; or
- To historical maximum groundwater level, where this has been defined to the site.

GDR13.3 Design Hydraulic Conductivity Values

Where provided, the values of hydraulic conductivity (k) should be considered the maximum/upper limit design values. As discussed in Section GDR3.7, the inverse auger hole test is an unsaturated field test carried out above the groundwater table and, as such, presents the best-case conditions for drainage.

For soak wells in sand, we provide the design value taking into consideration the variability in materials and reduced permeability as a result of:

- Densification of sand during site preparation works; and
- Natural variation in sands.

Design k_{unsat} values provided for soak wells are only appropriate for the design of unsaturated soils where the base of disposal area is at least 500 mm above groundwater and 500 mm above any impermeable layer.

Where design values of k_{unsat} have been provided, clogging of the base of the soakwell / drainage basin has not been considered. Clogging will need to be controlled with maintenance over the life of the soakwell / drainage basin.

For the design of subsoil drains or modelling of saturated soil performance, a k_{sat} value must be given (in the report text) or assessed by laboratory testing (or a combination of field and laboratory testing). Unless specifically stated, k_{unsat} values presented in our report are for unsaturated conditions and intended for design of stormwater disposal elements above groundwater. If no k_{sat} value has been provided, do not use the provided k_{unsat} value for saturated drainage design. Please contact us for further advice.

For saturated or semi-saturated sands, the hydraulic conductivity must be assessed by testing of representative soil samples at a NATA accredited laboratory to determine:

- The modified maximum dry density (MMDD); and
- The constant-head permeability (AS1289.6.7.1) on a sample remoulded to at least 5% greater than the proposed specification density (i.e., sample should be remoulded to 100% MMDD if the earthworks specification requires a density ratio of 95% MMDD).

For saturated or semi-saturated clayey or silty soils, the hydraulic conductivity must be assessed by testing of representative soil samples at a NATA accredited laboratory to determine:

- The standard maximum dry density (SMDD); and
- The falling-head permeability (AS1289.6.7.2) on a sample remoulded to at least 3% greater than the proposed specification density (i.e., sample should be remoulded to 101% SMDD if the earthworks specification requires a density ratio of 98% SMDD).

GDR13.4 Soakwells

In uncontrolled groundwater environments, the base of any soakwell must be the higher of:

- At least 500 mm above the average annual maximum groundwater level (AAMGL).
- At least 500 mm above any low permeability/impermeable layers (clay, rock or otherwise).

In controlled groundwater environments (refer to Section GDR13.1), the base of any soakwell may be 0 mm above the controlled groundwater level at the location of the soakwell (as determined by the civil engineer).

Soak wells must be placed outside a line of 1V:2H extending below the edge of the nearest footing, subject to local council regulations. Discharge from soak wells has been known to promote densification of loose sandy soils, leading to settlements of footings and slabs. Soak wells should be carefully wrapped with geotextile to prevent migration of sand and fines into the soak well.

Where soak wells are proposed to dispose of water within a line of 1V:2H from any basement walls or similar, the walls must be waterproofed to prevent seepage or damp within the basement wall.

In potentially karstic terrain or areas of potentially collapsible soils, soakwells should typically be located 10 m from the nearest footing, slab or pavement.

GDR13.5 Design Groundwater Elevation

Where applicable, a recommended design groundwater elevation will be provided in the report and will be identified as such.

In the absence of a specific statement on design groundwater elevation, **do not assume** that:

- Absence of comments about groundwater indicates an absence of groundwater (in particular, sites that are dry in the dry season to the investigated depth may well become waterlogged in the rainy season).
- Where groundwater depths/levels are noted, that these are fixed (groundwater fluctuations occur over the course of the year and between wetter and drier years).

Where groundwater elevations are likely to be critical for a development (particularly where large-scale subdivision or large developments are proposed with substantial channelling of stormwater into on-site disposal by infiltration), a site-specific hydrology study is likely to be required to confirm design groundwater elevations.

GDR14 DRAINAGE CONTROL

In addition to the site preparation measures outlined for cohesive soils (refer Section GDR6.2.4), careful control of surface water and stormwater is essential to minimise the likelihood of cohesive soils decreasing in strength and affecting the installed infrastructure. These measures include:

- The ground surface of clayey soils should be graded to drain any seepage away from structures and prevent standing water over the cohesive soils. A grade of at least 1% is recommended.
- Pavements should be sealed to minimise water ingress.
- Stormwater disposal swales should be located at least 10 m away from buildings, retaining walls and pavements.
- Runoff from hardstandings and pavements must either be collected and discharged via pipes into discrete locations (via swales or soakage basins) at least 10 m away from structures and pavements or, alternatively, discharged over a wide area, but not allowed to collect and discharge into concentrated areas, particularly near structures and pavements.

- Spoon drains should be used to collect water at the crest of slopes to capture surface runoff and direct it away from running directly down slopes or seeping into the ground behind slopes.

These measures are general in nature only and do not take into account the civil design objectives, which must be addressed separately by the civil designer.

GDR15 DEWATERING

Dewatering may be required for excavations and construction below groundwater or perched groundwater tables. Common dewatering methods are summarised below:

Table GDR 19: Dewatering Recommendations

Material	Recommended Methods
Sandy Soils	Spears Deep Well Point
Impermeable Clay	Sump Pumping

Dewatering spears are typically suitable for small scale excavations below groundwater, with a typical recommendation for spears to be installed at 1 m below the base of any excavation. Dewatering spears may not be suitable where there are impermeable/cemented/strong transition layers, i.e., it may not be possible to extract water near an impermeable layer (rock/clay), or the spear may not be readily driven through a hard clay/cemented layer (i.e., coffee rock).

Sump pumping can be done by grading a clayey excavation to drain (i.e., by using spoon drains), and excavating a sump in the excavation. A sump can typically be backfilled with a blue metal gravel, with a pump wrapped in a geofabric (i.e., Bidim A14 or similar), with disposal of water away from the excavation.

Deep well point dewatering is typically suitable for larger excavations, where there are transitional layers or where the aquifer is confined. It may not be suitable where there are impermeable layers within the profile. It involves the installation of a deep filtered well to a depth required to draw down the groundwater level at the entire site. A deep well dewatering system must be designed by a suitable designer to provide design flow rates, draw down depths etc.

GDR16 PAVEMENT SUBGRADES

Unless otherwise specified, the provided subgrade California bearing ratio (CBR) is not a pavement design, but an assessment of the subgrade as an input into any required pavement designs.

Provided design values are based on the assumption that the relevant site preparation measures are completed for all pavement subgrades, including the use of appropriate approved fill and adequate compaction. We highlight that specific requirements such as those outlined by Main Roads WA (MRWA) or the local council in their construction specifications may have different requirements.

The provided design value is based on laboratory testing (where done), local experience, and the advice as outlined in:

- Main Roads Western Australia (2013). “Engineering Road Note 9 – Procedure for the Design of Road Pavements”. Western Australia Supplement to the Austroads Guide to Pavement Technology Part 2: Pavement Structural Design, East Perth.

Where the subgrade differs from that described in the text, the subgrade CBR must be confirmed.

The performance of any pavement is highly dependent on the surface and subsurface drainage provided (also considering factors like capillary rise from seasonally high groundwater tables). Adequate drainage must be provided to any pavements, and capillary rise must be considered by the designer.

GDR17 SOIL CORROSIVITY AND AGGRESSIVITY

The relevant exposure classifications for concrete and steel piles in soils based on the exposure conditions are presented in Table GDR 20 and Table GDR 21 respectively.

The relevant exposure classifications for concrete in sulfate soils based on the exposure conditions are presented in Table GDR 22.

Table GDR 20: Exposure Classification for Concrete Piles in Soil

Exposure Conditions				Exposure Classification	
Sulfates (expressed as SO_4)[1]		pH	Chlorides in Groundwater (ppm)	Soil Conditions A[2]	Soil Conditions B[3]
In Soil (ppm)	In Groundwater (ppm)				
< 5,000	< 1,000	> 5.5	<6000	Mild	Non-aggressive
5,000 – 10,000	1,000 – 3,000	4.5 – 5.5	6,000-12,000	Moderate	Mild
10, 000 – 20,000	3,000 – 10,000	4 – 4.5	12,000-30,000	Severe	Moderate
> 20,000	> 10,000	< 4	>30,000	Very Severe	Severe

NOTES:
1. *Approximately 100 ppm SO_4 = 80 ppm SO_3*
2. *Soil Conditions A – high permeability soils (e.g. sands and gravels) which are in groundwater*
3. *Soil Conditions B – low permeability soils (e.g. silts and clays) or all soils above groundwater*
4. *Table reproduced from Table 6.4.2(C) of AS2159-2009*

Table GDR 21: Exposure Classification for Steel Piles in Soil

pH	Chlorides		Resistivity (ohm.cm)	Exposure Classification	
	In Soil (ppm)	In Water (ppm)		Soil Conditions A[2]	Soil Conditions B[3]
> 5	< 5,000	< 1,000	> 5,000	Non-aggressive	Non-aggressive
4–5	5,000-20,000	1,000–10,000	2,000 – 5,000	Mildly aggressive	Non-aggressive
3–4	20,000-50,000	10,000–20,000	1,000 – 2,000	Moderately aggressive	Mildly aggressive
< 3	> 50,000	> 20,000	< 1,000	Severely aggressive	Moderately aggressive

NOTES:
1. *1 ppm (parts per million) is equivalent to 1 mg/kg*
2. *Soil Conditions A – high permeability soils (e.g. sands and gravels) which are in groundwater*
3. *Soil Conditions B – low permeability soils (e.g. silts and clays) or all soils above groundwater*
4. *Table reproduced from Table 6.5.2(C) of AS2159-2009*

Table GDR 22: Exposure Classification for Concrete in Sulfate Soils

Exposure Conditions			Exposure Classification	
Sulfates (expressed as SO_4)[1]		pH	Soil Conditions A[2]	Soil Conditions B[3]
In Soil (ppm)	In Groundwater (ppm)			
< 5,000	< 1,000	> 5.5	Mild	Non-aggressive
5,000 – 10,000	1,000 – 3,000	4.5 – 5.5	Moderate	Mild
10, 000 – 20,000	3,000 – 10,000	4 – 4.5	Severe	Moderate
> 20,000	> 10,000	< 4	Very Severe	Severe

NOTES:
1. *Approximately 100 ppm SO_4 = 80 ppm SO_3*
2. *Soil Conditions A – high permeability soils (e.g. sands and gravels) which are in groundwater*
3. *Soil Conditions B – low permeability soils (e.g. silts and clays) or all soils above groundwater*
4. *For disturbed soils, the assumption of soil A conditions where accelerated corrosion is possible should be considered.*
5. *Table reproduced from Table 4.8.1 of AS3600-2018*

GDR18 LIQUEFACTION

Soil liquefaction can occur when loose, granular, Holocene age material below the groundwater table is subjected to a seismic event (typically within 15 m of the ground surface). This can cause a loss of strength and result in vertical and lateral movements of the site surface.

Where a liquefaction analysis is carried out and outlined in the report, this has been done in accordance with consideration to the design earthquake details as presented in AS1170.4-2007:

- The hazard factor is taken from Figure 3.2 (C) and Table 3.2. The Hazard Factor (Z) for Western Australia represents the 1 in 500-year annual probability of exceedance of ground motions measured in gravity (g).

- The probability factor (k_p) is taken from Table 3.1.

Unless otherwise stated, an earthquake magnitude of 7.5 for the south-west of WA is based on research by:

- Dhu T., Sinadinovski C., Edwards M., Robinson D., Jones T., Jones A. (2004) “Earthquake Risk Assessment for Perth, Western Australia”. 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada. Paper No. 2748.

GDR19 EXPECTATIONS OF THE REPORT

The following sections have been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

GDR20 THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

GDR21 DATA PROVIDED BY THIRD PARTIES

Where data is provided by third parties, it will be identified as such in our reports. We necessarily rely on the completeness and accuracy of data provided by third parties in order to draw conclusions presented in our reports. We are not responsible for omissions, incomplete or inaccurate data associated with third party data, including where we have been requested to provide advice in relation to field investigation data provided by third parties.

GDR22 SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques prepared by Galt. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

GDR23 THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

GDR24 CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

GDR25 SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

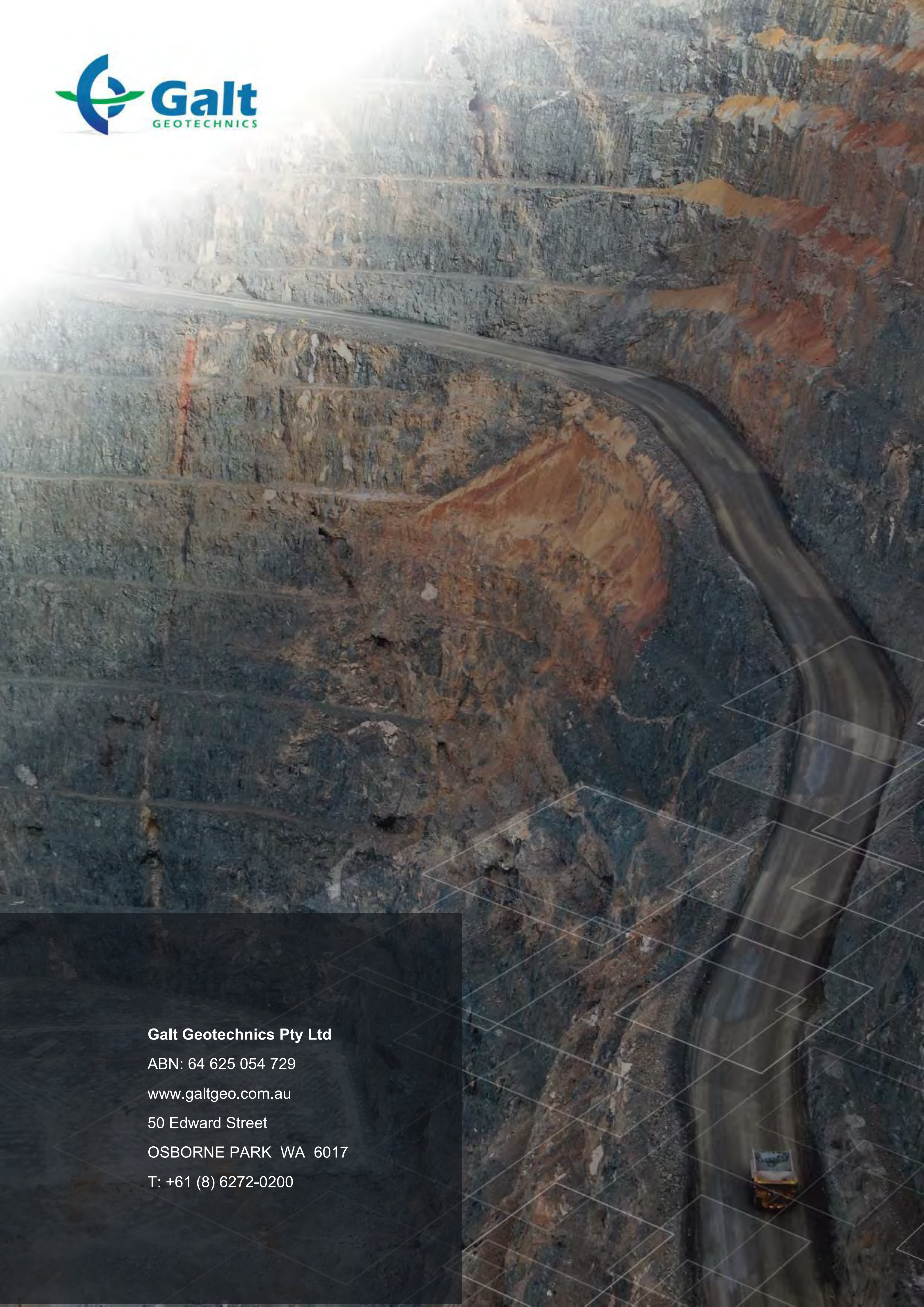
The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

GDR26 ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.

Geotechnical advice presented in a Galt Environmental report has been provided by Galt Geotechnics under a sub-contract agreement. Similarly, environmental advice presented in a Galt Geotechnics report has been provided by Galt Environmental under a sub-contract agreement.

Unless specifically noted otherwise, no parties shall draw any inferences about the applicability of the Western Australian state government landfill levy from the contents of this document.



Galt Geotechnics Pty Ltd
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APPENDIX C

Hyd2o Bore Logs & Survey

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	**17/05/2024**				Bore Name
Client :	**Burgess Design Group**	Job Number :	H24009		
Project:	**Lakefarm Retreat Ballajura GW Monit**	Start Hole :	**7:45**		
Easting	**395285.235**	End Hole :	**9:00**		**GW1**
Northing	**6477934.219**	Logged by :	**AFR**		
Datum:	GDA94	Total Depth :	**6**		
Drill type:	Drill Rig Auger	RL Top of Casing :	**38.239**		
Hole diameter:	2.5 inches	RL Nat Surface :	**37.639**		

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	CEMENT			0.5m	Dark Grey	Fine to Medium	Sand	Low	Dry	Well-sorted Rounded Subangular
	BENTONITE SEAL			1.0m	Grey			None		
				1.5m						Well-sorted Subrounded Subangular
	GRAVEL			2.0m	Grey Light Brown					
				2.5m						
				3.0m	Brown					
			▦	3.5m	Dark Brown					
			▦	4.0m						Traces of Coffee Rock
			▦	4.5m					Moist	Well-sorted Subrounded Subangular
		▽	▦	5.0m					Saturated	

COLOUR : Black, White, Beige
Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue
Composition : Solid , Blemish, Mottle
PARTICLE SIZE : Fine, Medium, Course
TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clayey Loam
Clay, Sandy Clay
ORGANICS : High, Medium, Low
MOISTURE : Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	38.24
Water Level bTOC (m)	37.64
Water Level bNS (m)	

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	**17/05/2024**				
Client :	**Burgess Design Group**	Job Number :	H24009	Bore Name	
Project:	**Lakefarm Retreat Ballajura GW Monit**	Start Hole :	**7:45**		
Easting	**395285.235**	End Hole :	**9:00**	**GW1**	
Northing	**6477934.219**	Logged by :	**AFR**		
Datum:	GDA94	Total Depth :	**6**		
Drill type:	Drill Rig Auger	RL Top of Casing :	**38.239**		
Hole diameter:	2.5 inches	RL Nat Surface :	**37.639**		

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	GRAVEL		▦	5.5m	Brown Dark Brown	Fine to Medium	Sand	None	Saturated	Well-sorted Subrounded Subangular
				6.0m						end of hole at 6.0m
				6.5m						
				7.0m						
				7.5m						
				8.0m						
				8.5m						
				9.0m						
				9.5m						
				10.0m						

COLOUR :	Black, White, Biege Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue Composition : Solid , Blemish, Mottle
PARTICLE SIZE :	Fine, Medium, Course
TEXTURE :	Sand, Loamy Sand, Clayey Sand Silt, Loam, Sandy Loam, Clayey Loam Clay, Sandy Clay
ORGANICS :	High, Medium, Low
MOISTURE :	Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	38.24
Water Level bTOC (m)	37.64
Water Level bNS (m)	

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date : **16/05/2024**
Client : **Burgess Design Group**
Project: **Lakefarm Retreat Ballajura GW Monit**
Easting **395719.848**
Northing **6477627.556**
Datum: GDA94
Drill type: Drill Rig Auger
Hole diameter: 2.5 inches

Job Number : H24009
Start Hole : **9:00**
End Hole : **10:00**
Logged by : **AFR**
Total Depth : **5**
RL Top of Casing : **37.884**
RL Nat Surface : **37.284**

Bore Name
GW2

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	CEMENT			0.5m	Grey	Fine to Medium	Sand	Low	Dry	Moderately Well-sorted Subrounded Subangular
	BENTONITE SEAL			1.0m	Light Grey			None		
	GRAVEL			1.5m	Light Brown				Moist	
				2.0m	Light Beige					
			▦	2.5m	Light Brown					
		▽		3.0m					Saturated	
				3.5m	Brown					
				4.0m						
				4.5m	Beige					
				5.0m	Light Brown					

COLOUR : Black, White, Beige
Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue
Composition : Solid , Blemish, Mottle
PARTICLE SIZE : Fine, Medium, Course
TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clayey Loam
Clay, Sandy Clay
ORGANICS : High, Medium, Low
MOISTURE : Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date 17/05/2024
Stickup above NS (m) 37.88
Water Level bTOC (m) 37.28
Water Level bNS (m)

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date : **16/05/2024**
Client : **Burgess Design Group**
Project: **Lakefarm Retreat Ballajura GW Monit**
Easting **395743.036**
Northing **6477931.444**
Datum: GDA94
Drill type: Drill Rig Auger
Hole diameter: 2.5 inches

Job Number : H24009
Start Hole : **15:30**
End Hole : **16:40**
Logged by : **AFR**
Total Depth : **5**
RL Top of Casing : **37.937**
RL Nat Surface : **37.337**

Bore Name

GW3

support	backfill	water	Slot / Screen Depth	Depth (metres)	Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	CEMENT			0.5m	Dark Grey	Fine to Medium	Sand	Low	Dry	Moderately Well-sorted Subrounded Subangular
	BENTONITE SEAL			1.0m	Grey			None		
	GRAVEL			1.5m	Light Brown					
				2.0m	Brown					
			▦	2.5m						
				3.0m	Dark Brown					Traces of Coffee Rock
				3.5m						
				4.0m	Brown				Moist	Moderately Well-sorted Subrounded Subangular
				4.5m						
		▽		5.0m					Saturated	

COLOUR : Black, White, Beige
Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue
Composition : Solid , Blemish, Mottle
PARTICLE SIZE : Fine, Medium, Course
TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clayey Loam
Clay, Sandy Clay
ORGANICS : High, Medium, Low
MOISTURE : Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	37.94
Water Level bTOC (m)	37.34
Water Level bNS (m)	

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	**17/05/2024**		
Client :	**Burgess Design Group**	Job Number :	H24009
Project:	**Lakefarm Retreat Ballajura GW Monit**	Start Hole :	**9:20**
Easting	**396048.35**	End Hole :	**10:30**
Northing	**6477429.188**	Logged by :	**AFR**
Datum:	GDA94	Total Depth :	**5**
Drill type:	Drill Rig Auger	RL Top of Casing :	**37.418**
Hole diameter:	2.5 inches	RL Nat Surface :	**36.818**

Bore Name

GW4

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	CEMENT			0.5m	Dark Grey Black	Fine to Medium	Sand	Medium	Dry	Moderately Well-sorted Subrounded Subangular
	BENTONITE SEAL			1.0m	Dark Grey			Low		
	GRAVEL			1.5m	Grey			None		
				2.0m						
			▦	2.5m	Light Brown					
			▦	3.0m	Dark Brown					
			▦	3.5m					Slightly Moist	Traces of Coffee Rock
		▽	▦	4.0m	Brown				Saturated	Moderately Well-sorted Subrounded Subangular
			▦	4.5m						
			▦	5.0m	Light Brown Beige					

COLOUR : Black, White, Beige
Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue
Composition : Solid , Blemish, Mottle
PARTICLE SIZE : Fine, Medium, Course
TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clayey Loam
Clay, Sandy Clay
ORGANICS : High, Medium, Low
MOISTURE : Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	37.42
Water Level bTOC (m)	36.82
Water Level bNS (m)	

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	16/05/2024			
Client :	Burgess Design Group	Job Number :	H24009	Bore Name
Project:	Lakefarm Retreat Ballajura GW Monit	Start Hole :	7:45	**GW5**
Easting	396034.504	End Hole :	9:00	
Northing	6477720.219	Logged by :	AFR	
Datum:	GDA94	Total Depth :	5	
Drill type:	Drill Rig Auger	RL Top of Casing :	37.419	
Hole diameter:	2.5 inches	RL Nat Surface :	36.819	

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	CEMENT			0.5m	Dark Grey Black	Fine to Medium	Sand	Medium	Dry	Moderately Well-sorted Rounded Subangular
	BENTONITE SEAL			1.0m	Dark Grey			Low		
	GRAVEL			1.5m	Grey Light Brown			None		
				2.0m	Light Brown					
			▨	2.5m						
				3.0m	Light Brown Beige					
		▽		3.5m	Beige				Moist	
				4.0m					Saturated	
				4.5m	Light Beige					
				5.0m						Moderately Well-sorted Subrounded Subangular

COLOUR : Black, White, Beige
Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue
Composition : Solid , Blemish, Mottle
PARTICLE SIZE : Fine, Medium, Course
TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clayey Loam
Clay, Sandy Clay
ORGANICS : High, Medium, Low
MOISTURE : Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	37.42
Water Level bTOC (m)	36.82
Water Level bNS (m)	

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	**16/05/2024**				Bore Name
Client :	**Burgess Design Group**	Job Number :	H24009		**GW6**
Project:	**Lakefarm Retreat Ballajura GW Monit**	Start Hole :	**14:00**		
Easting	**396070.304**	End Hole :	**15:15**		
Northing	**6477979.457**	Logged by :	**AFR**		
Datum:	GDA94	Total Depth :	**5**		
Drill type:	Drill Rig Auger	RL Top of Casing :	**38.224**		
Hole diameter:	2.5 inches	RL Nat Surface :	**37.624**		

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	CEMENT			0.5m	Dark Grey	Fine to Medium	Sand	Medium	Dry	Moderately Well-sorted Rounded Subangular 
	BENTONITE SEAL			1.0m	Grey			None		
	GRAVEL			1.5m						
				2.0m	Brown					
			▦	2.5m						Traces of Coffee Rock
			▦	3.0m	Beige					
			▦	3.5m					Slightly Moist	
			▦	4.0m	Light Brown				Moist	
		▽	▦	4.5m						
			▦	5.0m	Beige				Saturated	Moderately Well-sorted Subrounded Subangular

COLOUR : Black, White, Beige
Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue
Composition : Solid , Blemish, Mottle
PARTICLE SIZE : Fine, Medium, Course
TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clayey Loam
Clay, Sandy Clay
ORGANICS : High, Medium, Low
MOISTURE : Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	38.22
Water Level bTOC (m)	37.62
Water Level bNS (m)	

Lithological Log

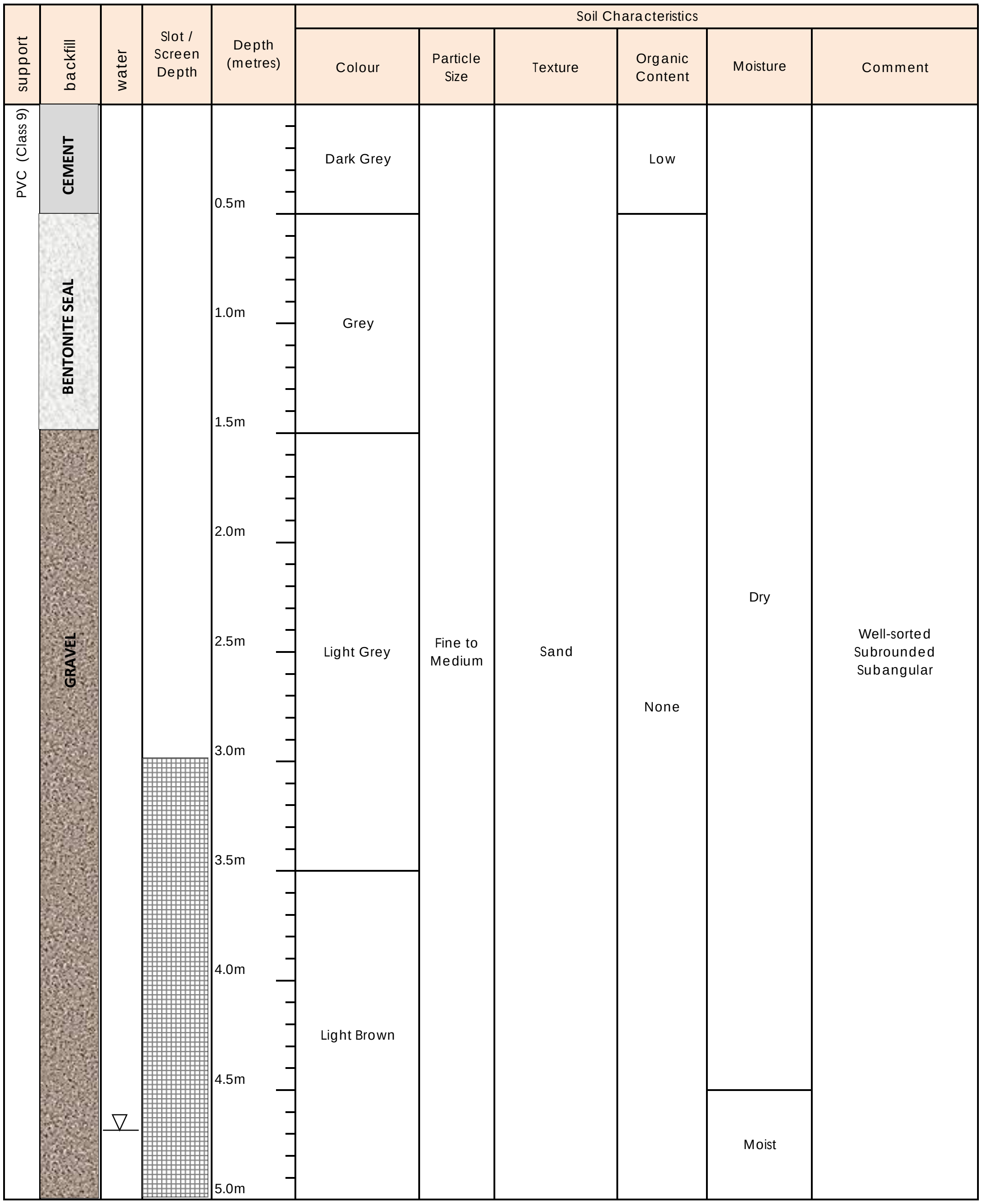
Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	**17/05/2024**		
Client :	**Burgess Design Group**	Job Number :	H24009
Project:	**Lakefarm Retreat Ballajura GW Monit**	Start Hole :	**11:15**
Easting	**396373.045**	End Hole :	**12:35**
Northing	**6477226.652**	Logged by :	**AFR**
Datum:	GDA94	Total Depth :	**6**
Drill type:	Drill Rig Auger	RL Top of Casing :	**38.537**
Hole diameter:	2.5 inches	RL Nat Surface :	**37.937**

Bore Name

GW7



COLOUR :	Black, White, Beige Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue Composition : Solid , Blemish, Mottle
PARTICLE SIZE :	Fine, Medium, Course
TEXTURE :	Sand, Loamy Sand, Clayey Sand Silt, Loam, Sandy Loam, Clayey Loam Clay, Sandy Clay
ORGANICS :	High, Medium, Low
MOISTURE :	Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	38.54
Water Level bTOC (m)	37.94
Water Level bNS (m)	

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	**17/05/2024**				
Client :	**Burgess Design Group**	Job Number :	H24009	Bore Name	
Project:	**Lakefarm Retreat Ballajura GW Monit**	Start Hole :	**11:15**		
Easting	**396373.045**	End Hole :	**12:35**		
Northing	**6477226.652**	Logged by :	**AFR**	**GW7**	
Datum:	GDA94	Total Depth :	**6**		
Drill type:	Drill Rig Auger	RL Top of Casing :	**38.537**		
Hole diameter:	2.5 inches	RL Nat Surface :	**37.937**		

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	GRAVEL		▦	5.5m 6.0m	Brown	Fine to Medium	Sand	None	Saturated	Well-sorted Subrounded Subangular end of hole at 6.0m
				6.5m						
				7.0m						
				7.5m						
				8.0m						
				8.5m						
				9.0m						
				9.5m						
				10.0m						

COLOUR :	Black, White, Biege Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue Composition : Solid , Blemish, Mottle
PARTICLE SIZE :	Fine, Medium, Course
TEXTURE :	Sand, Loamy Sand, Clayey Sand Silt, Loam, Sandy Loam, Clayey Loam Clay, Sandy Clay
ORGANICS :	High, Medium, Low
MOISTURE :	Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	38.54
Water Level bTOC (m)	37.94
Water Level bNS (m)	

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	**16/05/2024**			Bore Name
Client :	**Burgess Design Group**	Job Number :	H24009	**GW8**
Project:	**Lakefarm Retreat Ballajura GW Monit**	Start Hole :	**10:15**	
Easting	**396410.757**	End Hole :	**11:20**	
Northing	**6477622.165**	Logged by :	**AFR**	
Datum:	GDA94	Total Depth :	**5**	
Drill type:	Drill Rig Auger	RL Top of Casing :	**36.475**	
Hole diameter:	2.5 inches	RL Nat Surface :	**35.875**	

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	CEMENT			0.5m	Grey	Fine to Medium	Sand	Low	Dry	Moderately Well-sorted Subrounded Subangular
	BENTONITE SEAL			1.0m	Light Grey			None		
	GRAVEL			1.5m	Light Brown					
				2.0m					Slightly Moist	
			▦	2.5m	Beige					
		▽		3.0m					Moist	
				3.5m					Saturated	
				4.0m						
				4.5m						
				5.0m						

COLOUR : Black, White, Beige
Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue
Composition : Solid , Blemish, Mottle
PARTICLE SIZE : Fine, Medium, Course
TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clayey Loam
Clay, Sandy Clay
ORGANICS : High, Medium, Low
MOISTURE : Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	36.48
Water Level bTOC (m)	35.88
Water Level bNS (m)	

Lithological Log

Hyd2o
Suite 1 387 Hay St
Subiaco, WA 6008

PO Box 1055
Subiaco WA 6904

Date :	**16/05/2024**				
Client :	**Burgess Design Group**	Job Number :	H24009	Bore Name	
Project:	**Lakefarm Retreat Ballajura GW Monit**	Start Hole :	**12:45**		
Easting	**396342.263**	End Hole :	**13:45**	**GW9**	
Northing	**6477982.753**	Logged by :	**AFR**		
Datum:	GDA94	Total Depth :	**5**		
Drill type:	Drill Rig Auger	RL Top of Casing :	**37.903**		
Hole diameter:	2.5 inches	RL Nat Surface :	**37.303**		

support	backfill	water	Slot / Screen Depth	Depth (metres)	Soil Characteristics					
					Colour	Particle Size	Texture	Organic Content	Moisture	Comment
PVC (Class 9)	CEMENT			0.5m	Dark Grey	Fine to Medium	Sand	Low	Dry	Moderately Well-sorted Rounded Subangular
	BENTONITE SEAL			1.0m	Light Grey			None	Slightly Moist	
	GRAVEL			1.5m	Dark Brown					Traces of Coffee Rock
				2.0m	Light Beige				Dry	
			▦	2.5m	Beige					
		▽		3.0m	Dark Beige				Moist	
				3.5m					Saturated	
				4.0m	Light Brown					
				4.5m	Beige					
				5.0m						Moderately Well-sorted Rounded Subangular

COLOUR : Black, White, Beige
Dark/Medium/Light : Brown, Red, Orange, Yellow, Grey, Blue
Composition : Solid , Blemish, Mottle
PARTICLE SIZE : Fine, Medium, Course
TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clayey Loam
Clay, Sandy Clay
ORGANICS : High, Medium, Low
MOISTURE : Dry, Slightly Moist, Moist, Saturated

Static Water Level

Date	17/05/2024
Stickup above NS (m)	37.90
Water Level bTOC (m)	37.60
Water Level bNS (m)	

				GDA94				AHD71						
Location	ID	Description	Easting (m)	Horizontal Accuracy (m)	Northing (m)	Horizontal Accuracy (m)	GDA94 Ellipsoidal Height (m)	Vertical Accuracy (m)	n Value (m)	AHD (m) T.O.C.	Height Pipe A.G.L. (m)	Surface Elevation (m)	RWL (m)	Notes
Ballajura	MW01	Piezometer	395285.235	0.020	6477934.219	0.020	5.965	0.020	-32.274	38.239	0.60	37.639	38.239	DGPS Control
Ballajura	MW02	Piezometer	395719.848	0.020	6477627.556	0.020	5.646	0.020	-32.238	37.884	0.60	37.284	37.884	DGPS Control
Ballajura	MW03	Piezometer	395743.036	0.020	6477931.444	0.020	5.700	0.020	-32.237	37.937	0.60	37.337	37.937	DGPS Control
Ballajura	MW04	Piezometer	396048.350	0.020	6477429.188	0.020	5.202	0.020	-32.216	37.418	0.60	36.818	37.418	DGPS Control
Ballajura	MW05	Piezometer	396034.504	0.020	6477720.219	0.020	5.204	0.020	-32.215	37.419	0.60	36.819	37.419	DGPS Control
Ballajura	MW06	Piezometer	396070.304	0.020	6477979.457	0.020	6.017	0.020	-32.207	38.224	0.60	37.624	38.224	DGPS Control
Ballajura	MW07	Piezometer	396373.045	0.020	6477226.652	0.020	6.352	0.020	-32.185	38.537	0.60	37.937	38.537	DGPS Control
Ballajura	MW08	Piezometer	396410.757	0.020	6477622.165	0.020	4.291	0.020	-32.184	36.475	0.60	35.875	36.475	DGPS Control
Ballajura	MW09	Piezometer	396342.263	0.020	6477982.753	0.020	5.719	0.020	-32.184	37.903	0.60	37.303	37.903	DGPS Control

APPENDIX D

Historical & Current Surface Water Plates

1953

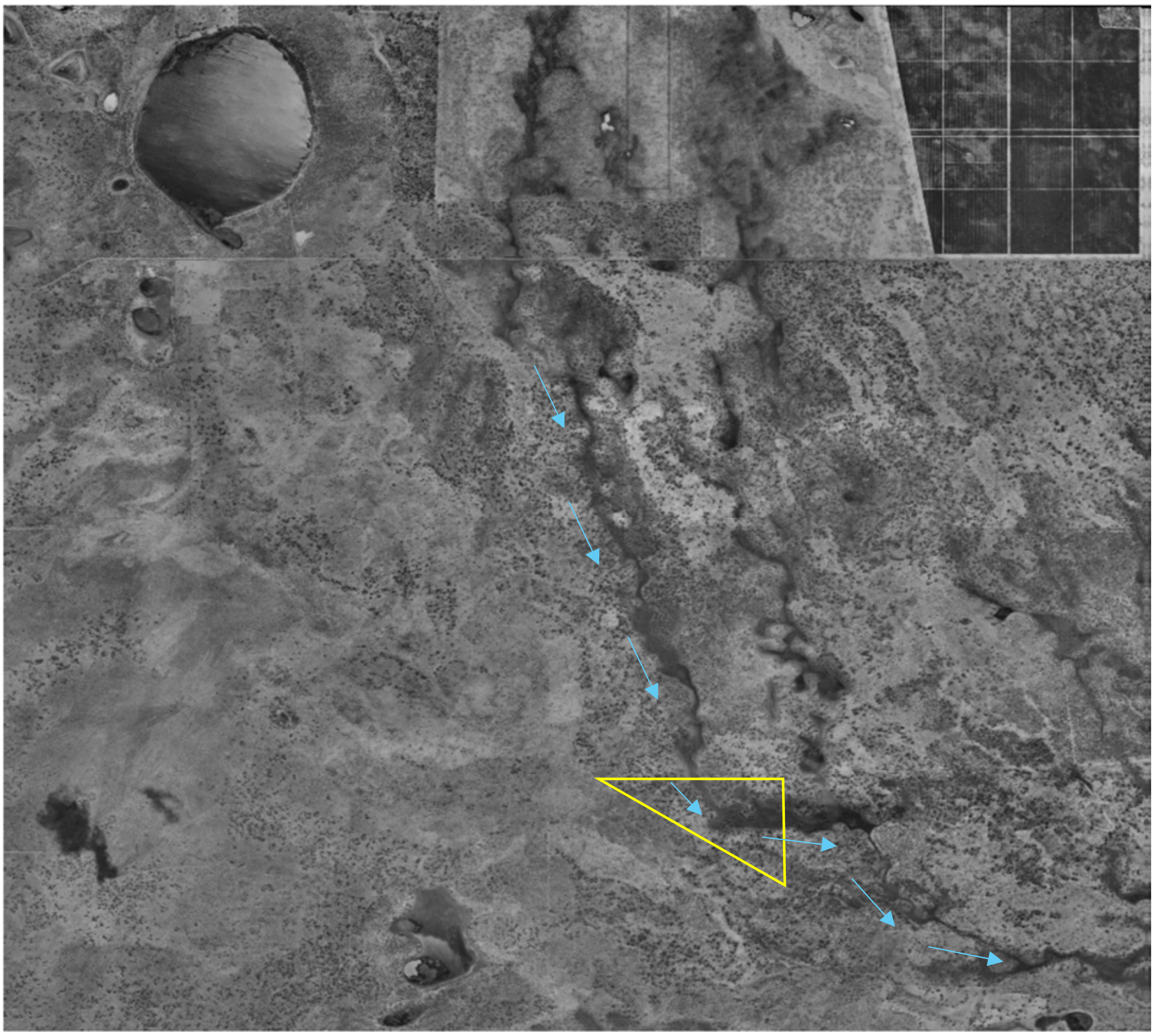


Plate 1: Historical aerial image (Landgate: Perth Metropolitan Area 30/10 – 27/11/1953) showing external catchment draining through the site mid last century.

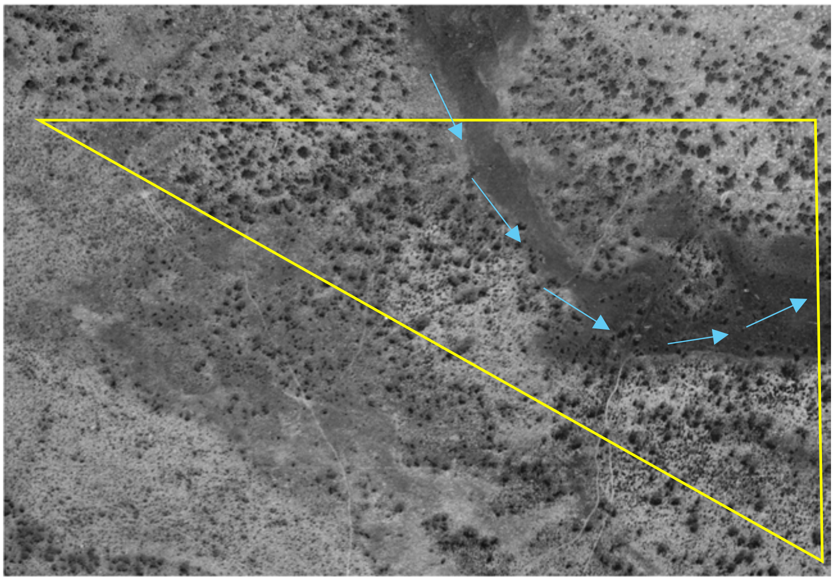


Plate 2: Historical natural surface water pathway from north to east (same image as Plate 1).

1970

Plate 3: Historical aerial image (Landgate: Perth Metro 20/07/1970).

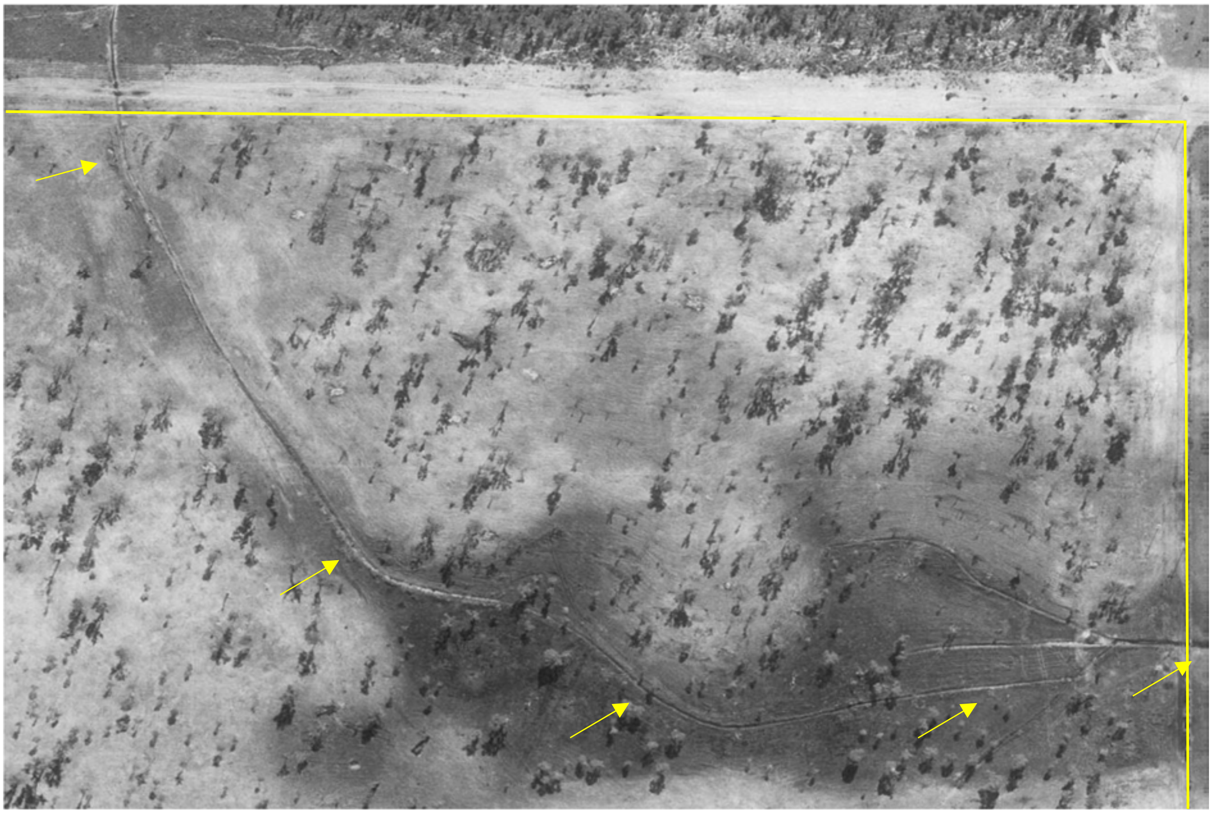


Plate 4: Same image as Plate 3. Formal drainage constructed within site to assist flows/reduce waterlogging. Formal drain at eastern boundary of site evident.

1989

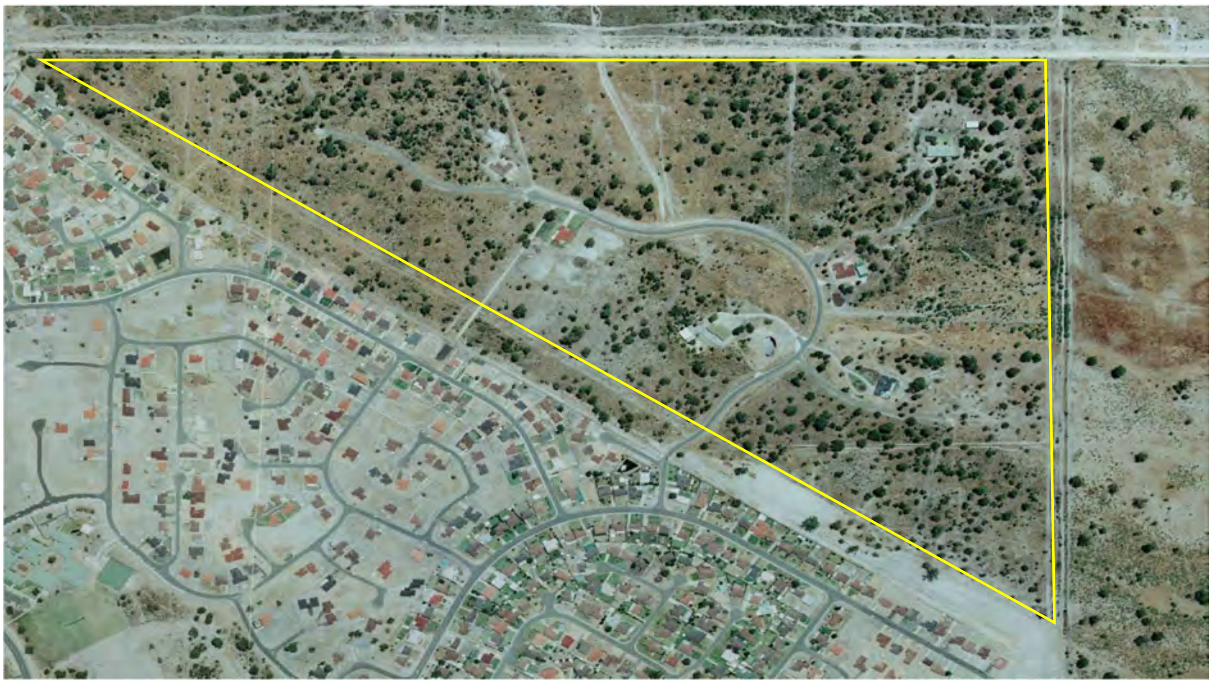


Plate 5: Historical aerial image (Landgate: Perth Metropolitan Area 19-31/12/1989).

Plate 6: Same image as Plate 5, showing the construction of Lakefarm Retreat internal road modifying the drain's configuration.

2024

Plate 7: Historical aerial image (Landgate: Perth Metropolitan Area North 27/01-10/02/2024).

Plate 8: Same image as Plate 7. Drain at northern boundary no longer appears to exist – 4WD use evident in area. Drain within site at east boundary not present due to previous site earthworks and lower groundwater levels which allows infiltration to sandy soils. Formal drain to east of site still present. No water observed in drain during monitoring.

Plate 9: Aerial view. Drain at northern boundary (blue arrow) no longer present.
4WD vehicles activity present. Source of Image: Galt Geotechnics WAG240411-01 001 R Rev0.

Plate 10: Aerial view. Drain within site near eastern boundary no longer exist following earthworks in early 2000s. Yellow arrows show culvert under road, blue arrow shows the previous drain pathway, and orange arrow shows the still existing drain located downstream of the site. Source of Image: Galt Geotechnics WAG240411-01 001 R Rev0.

Plate 11: View from adjacent property toward the northern boundary of the site, N-S direction.
Drain from north not evident and no indication of surface water flow.
Yellow arrow shows the historical drain pathway. Date of image: 09/10/2024

Plate 12: Access track along northern boundary, W-E direction.
Yellow arrow shows historical drain pathway, no longer existing. Date of image: 09/10/2024

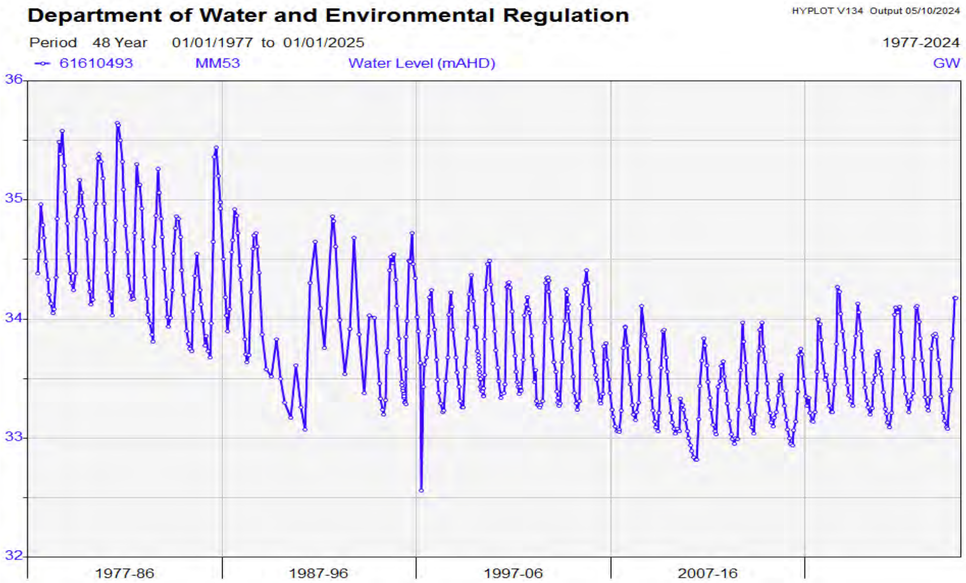
Plate 13: Western boundary of the site, at Lot 14, NE-SW direction. Previous drain filled and no surface water flow path through the site currently exists. Yellow arrow indicatively shows previous surface water pathway. Date of image: 09/10/2024

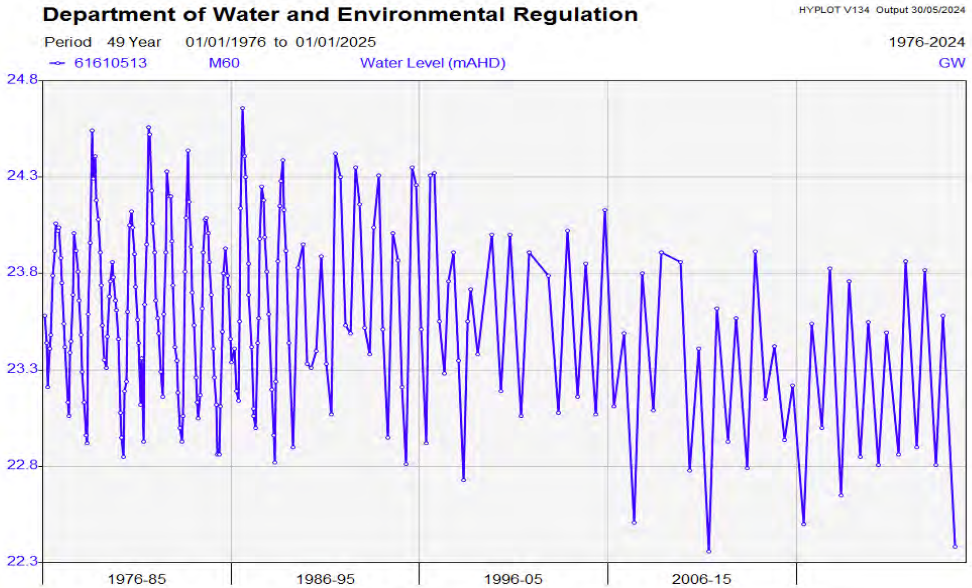
Plate 14: View from site boundary towards adjacent property at east, W-E direction. Drain downstream still exists however no water present. Access track crosses drain without culvert. Flow towards southeast. Date of image: 09/10/2024

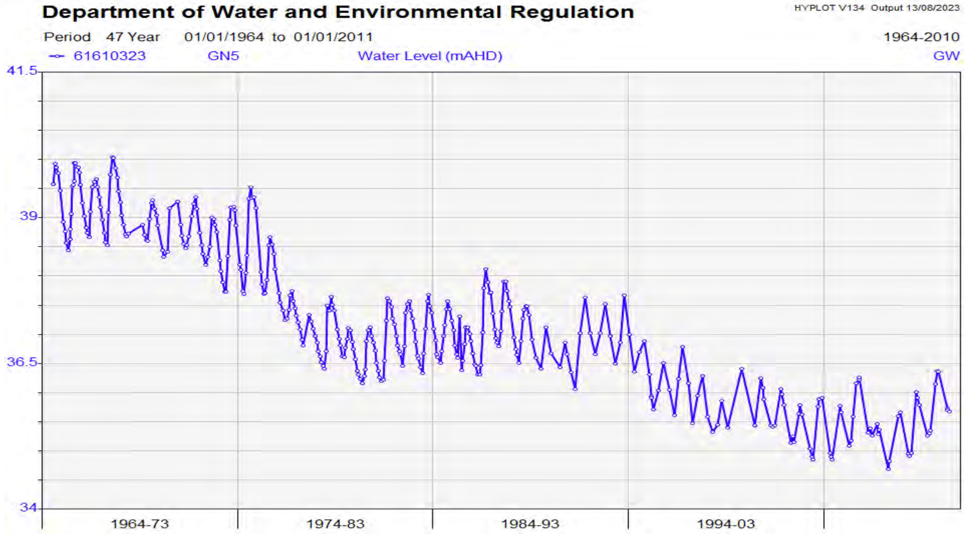
APPENDIX E

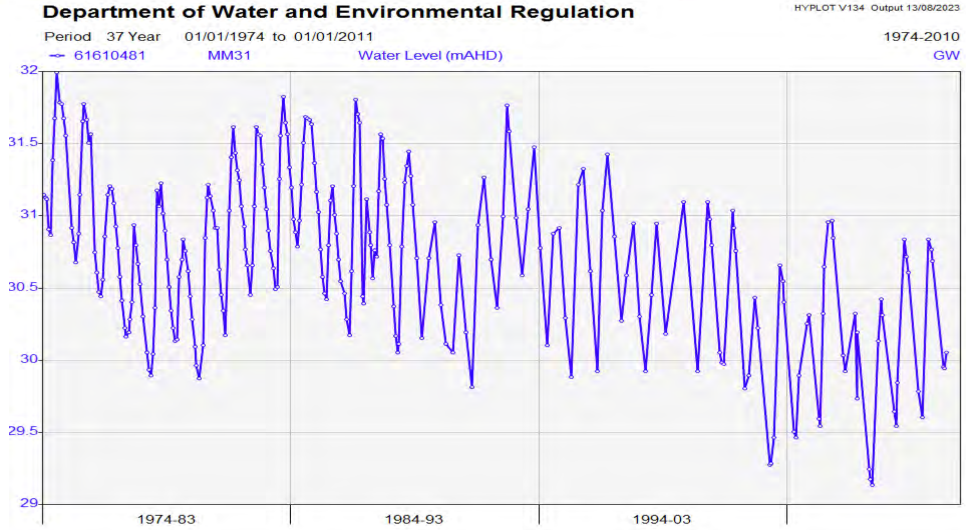
DWER Bore Long Term Hydrographs

Date : 09/10/2024 Job No: H24009









Source : DWER Water Information Reporting (online)

hyd2o

Lakefarm Retreat Ballajura DWMS

DWER Bore Long Term Hydrographs

Appendix E

APPENDIX F

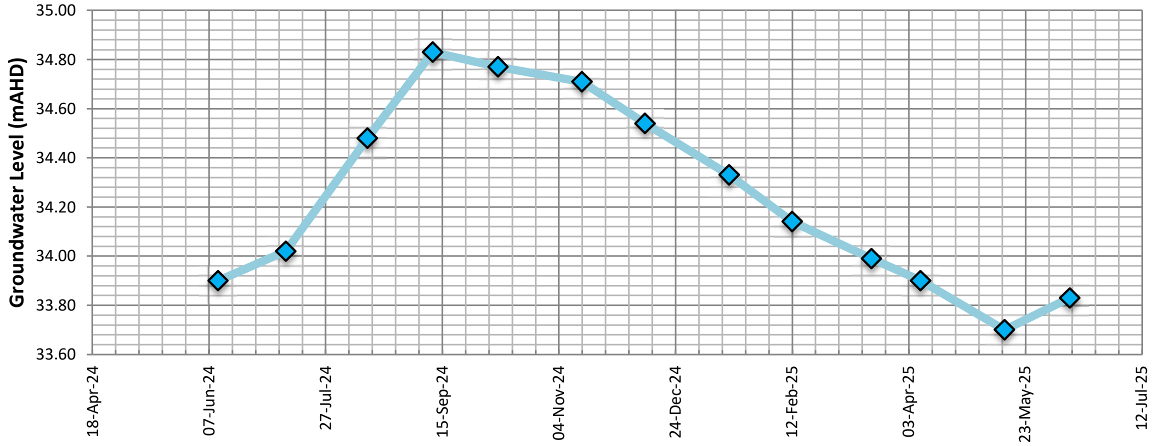
Pre-Development Groundwater Level Monitoring Data

H24009 Lakefarm Retreat Ballajura

GW1 Site Bore GW1

				Natural Surface (mAHD)	37.64
Data Analysis Period Start Date	11/06/2024	Easting	395285.235	Top of Casing (m AHD)	38.24
Data Analysis Period End Date	11/06/2025	Northing	6477934.219	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	4.34	33.90	3.74
10/07/2024	4.22	34.02	3.62
14/08/2024	3.76	34.48	3.16
11/09/2024	3.41	34.83	2.81
9/10/2024	3.47	34.77	2.87
14/11/2024	3.53	34.71	2.93
11/12/2024	3.70	34.54	3.10
16/01/2025	3.91	34.33	3.31
12/02/2025	4.10	34.14	3.50
18/03/2025	4.25	33.99	3.65
8/04/2025	4.34	33.90	3.74
14/05/2025	4.54	33.70	3.94
11/06/2025	4.41	33.83	3.81

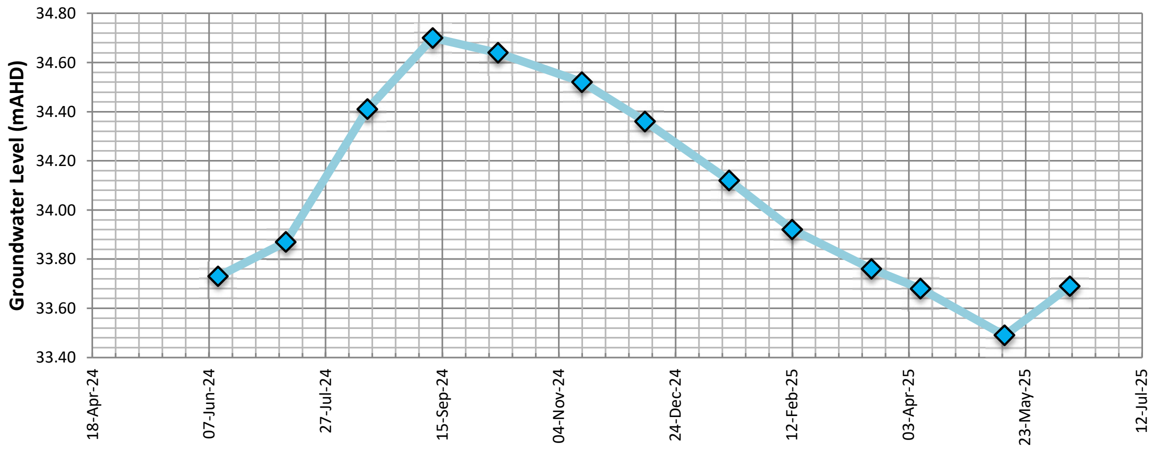
Minimum Recorded Level (mAHD)	33.70
Maximum Recorded Level (mAHD)	34.83

H24009 Lakefarm Retreat Ballajura

GW2 Site Bore GW2

				Natural Surface (mAHD)	37.28
Data Analysis Period Start Date	11/06/2024	Easting	395719.848	Top of Casing (m AHD)	37.88
Data Analysis Period End Date	11/06/2025	Northing	6477627.556	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	4.15	33.73	3.55
10/07/2024	4.01	33.87	3.41
14/08/2024	3.47	34.41	2.87
11/09/2024	3.18	34.70	2.58
9/10/2024	3.24	34.64	2.64
14/11/2024	3.36	34.52	2.76
11/12/2024	3.52	34.36	2.92
16/01/2025	3.76	34.12	3.16
12/02/2025	3.96	33.92	3.36
18/03/2025	4.12	33.76	3.52
8/04/2025	4.20	33.68	3.60
14/05/2025	4.39	33.49	3.79
11/06/2025	4.19	33.69	3.59

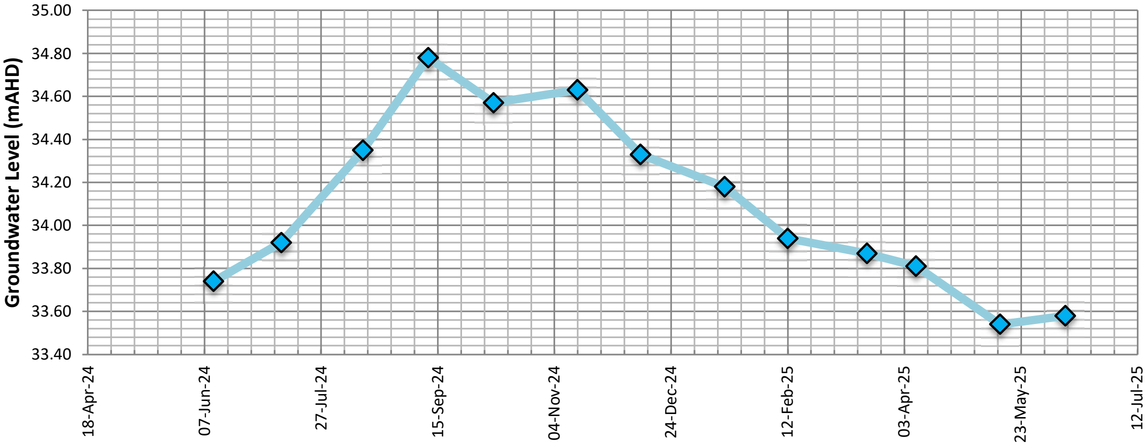
Minimum Recorded Level (mAHD)	33.49
Maximum Recorded Level (mAHD)	34.70

H24009 Lakefarm Retreat Ballajura

GW3 Site Bore GW3

				Natural Surface (mAHD)	37.34
Data Analysis Period Start Date	11/06/2024	Easting	395743.036	Top of Casing (m AHD)	37.94
Data Analysis Period End Date	11/06/2025	Northing	6477931.444	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	4.20	33.74	3.60
10/07/2024	4.02	33.92	3.42
14/08/2024	3.59	34.35	2.99
11/09/2024	3.16	34.78	2.56
9/10/2024	3.37	34.57	2.77
14/11/2024	3.31	34.63	2.71
11/12/2024	3.61	34.33	3.01
16/01/2025	3.76	34.18	3.16
12/02/2025	4.00	33.94	3.40
18/03/2025	4.07	33.87	3.47
8/04/2025	4.13	33.81	3.53
14/05/2025	4.40	33.54	3.80
11/06/2025	4.36	33.58	3.76

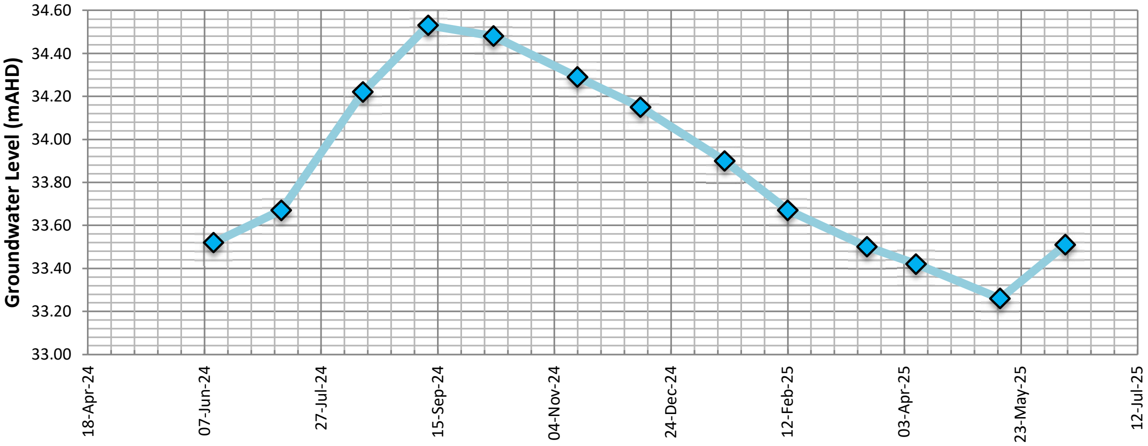
Minimum Recorded Level (mAHD)	33.54
Maximum Recorded Level (mAHD)	34.78

H24009 Lakefarm Retreat Ballajura

GW4 Site Bore GW4

				Natural Surface (mAHD)	36.82
Data Analysis Period Start Date	11/06/2024	Easting	396048.35	Top of Casing (m AHD)	37.42
Data Analysis Period End Date	11/06/2025	Northing	6477429.188	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	3.90	33.52	3.30
10/07/2024	3.75	33.67	3.15
14/08/2024	3.20	34.22	2.60
11/09/2024	2.89	34.53	2.29
9/10/2024	2.94	34.48	2.34
14/11/2024	3.13	34.29	2.53
11/12/2024	3.27	34.15	2.67
16/01/2025	3.52	33.90	2.92
12/02/2025	3.75	33.67	3.15
18/03/2025	3.92	33.50	3.32
8/04/2025	4.00	33.42	3.40
14/05/2025	4.16	33.26	3.56
11/06/2025	3.91	33.51	3.31

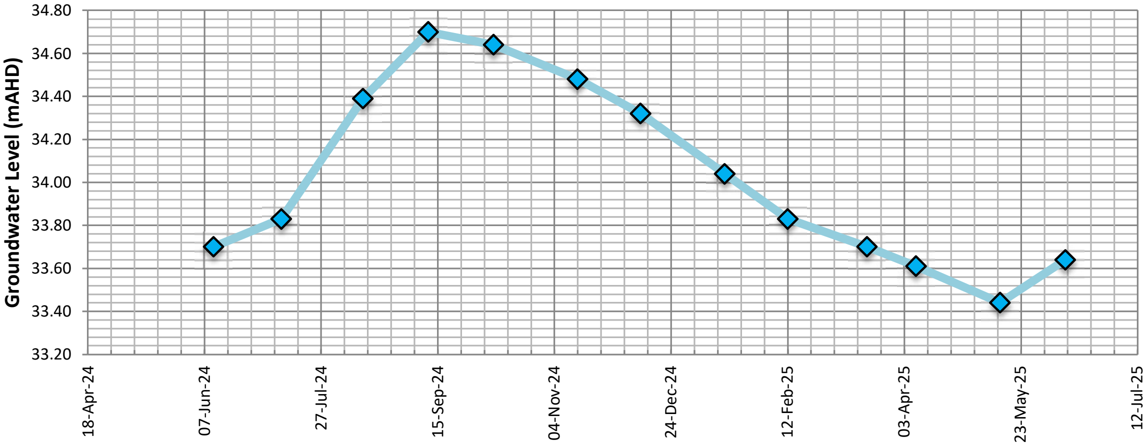
Minimum Recorded Level (mAHD)	33.26
Maximum Recorded Level (mAHD)	34.53

H24009 Lakefarm Retreat Ballajura

GW5 Site Bore GW5

				Natural Surface (mAHD)	36.82
Data Analysis Period Start Date	11/06/2024	Easting	396034.504	Top of Casing (m AHD)	37.42
Data Analysis Period End Date	11/06/2025	Northing	6477720.219	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	3.72	33.70	3.12
10/07/2024	3.59	33.83	2.99
14/08/2024	3.03	34.39	2.43
11/09/2024	2.72	34.70	2.12
9/10/2024	2.78	34.64	2.18
14/11/2024	2.94	34.48	2.34
11/12/2024	3.10	34.32	2.50
16/01/2025	3.38	34.04	2.78
12/02/2025	3.59	33.83	2.99
18/03/2025	3.72	33.70	3.12
8/04/2025	3.81	33.61	3.21
14/05/2025	3.98	33.44	3.38
11/06/2025	3.78	33.64	3.18

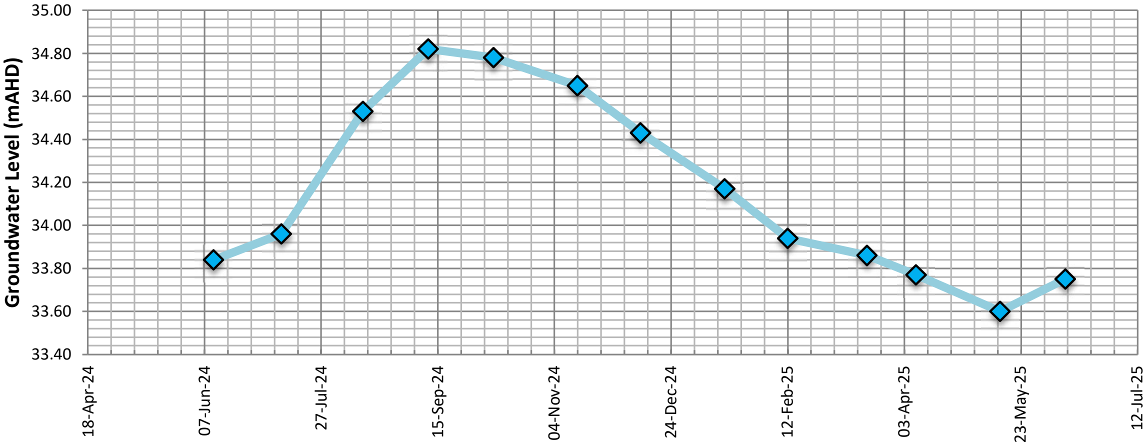
Minimum Recorded Level (mAHD)	33.44
Maximum Recorded Level (mAHD)	34.70

H24009 Lakefarm Retreat Ballajura

GW6 Site Bore GW6

				Natural Surface (mAHD)	37.62
Data Analysis Period Start Date	11/06/2024	Easting	396070.304	Top of Casing (m AHD)	38.22
Data Analysis Period End Date	11/06/2025	Northing	6477979.457	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	4.38	33.84	3.78
10/07/2024	4.26	33.96	3.66
14/08/2024	3.69	34.53	3.09
11/09/2024	3.40	34.82	2.80
9/10/2024	3.44	34.78	2.84
14/11/2024	3.57	34.65	2.97
11/12/2024	3.79	34.43	3.19
16/01/2025	4.05	34.17	3.45
12/02/2025	4.28	33.94	3.68
18/03/2025	4.36	33.86	3.76
8/04/2025	4.45	33.77	3.85
14/05/2025	4.62	33.60	4.02
11/06/2025	4.47	33.75	3.87

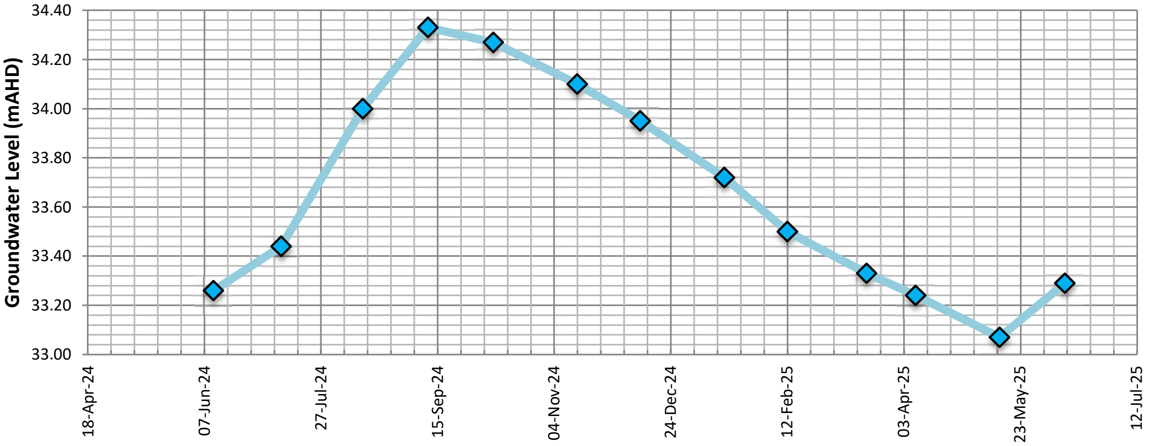
Minimum Recorded Level (mAHD)	33.60
Maximum Recorded Level (mAHD)	34.82

H24009 Lakefarm Retreat Ballajura

GW7 Site Bore GW7

				Natural Surface (mAHD)	37.94
Data Analysis Period Start Date	11/06/2024	Easting	396373.045	Top of Casing (m AHD)	38.54
Data Analysis Period End Date	11/06/2025	Northing	6477226.652	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	5.28	33.26	4.68
10/07/2024	5.10	33.44	4.50
14/08/2024	4.54	34.00	3.94
11/09/2024	4.21	34.33	3.61
9/10/2024	4.27	34.27	3.67
14/11/2024	4.44	34.10	3.84
11/12/2024	4.59	33.95	3.99
16/01/2025	4.82	33.72	4.22
12/02/2025	5.04	33.50	4.44
18/03/2025	5.21	33.33	4.61
8/04/2025	5.30	33.24	4.70
14/05/2025	5.47	33.07	4.87
11/06/2025	5.25	33.29	4.65

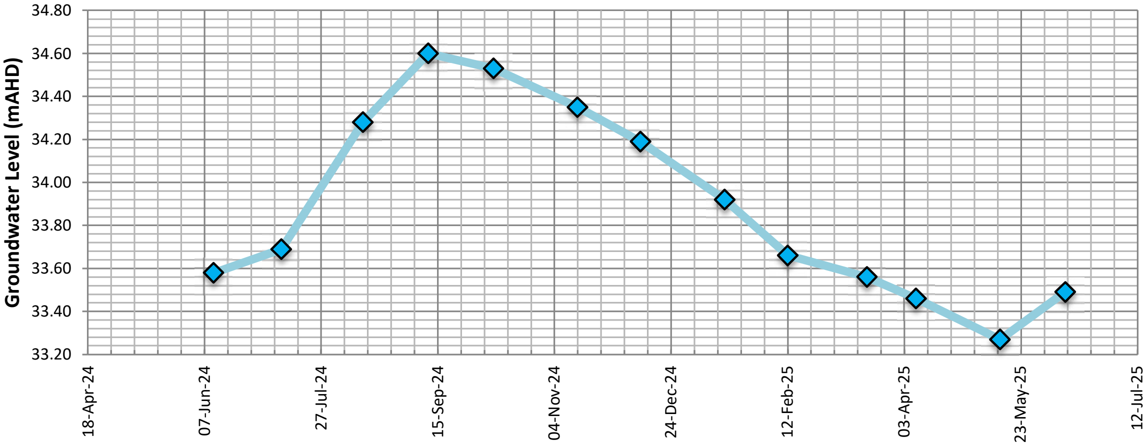
Minimum Recorded Level (mAHD)	33.07
Maximum Recorded Level (mAHD)	34.33

H24009 Lakefarm Retreat Ballajura

GW8 Site Bore GW8

				Natural Surface (mAHD)	35.88
Data Analysis Period Start Date	11/06/2024	Easting	396410.757	Top of Casing (m AHD)	36.48
Data Analysis Period End Date	11/06/2025	Northing	6477622.165	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	2.90	33.58	2.30
10/07/2024	2.79	33.69	2.19
14/08/2024	2.20	34.28	1.60
11/09/2024	1.88	34.60	1.28
9/10/2024	1.95	34.53	1.35
14/11/2024	2.13	34.35	1.53
11/12/2024	2.29	34.19	1.69
16/01/2025	2.56	33.92	1.96
12/02/2025	2.82	33.66	2.22
18/03/2025	2.92	33.56	2.32
8/04/2025	3.02	33.46	2.42
14/05/2025	3.21	33.27	2.61
11/06/2025	2.99	33.49	2.39

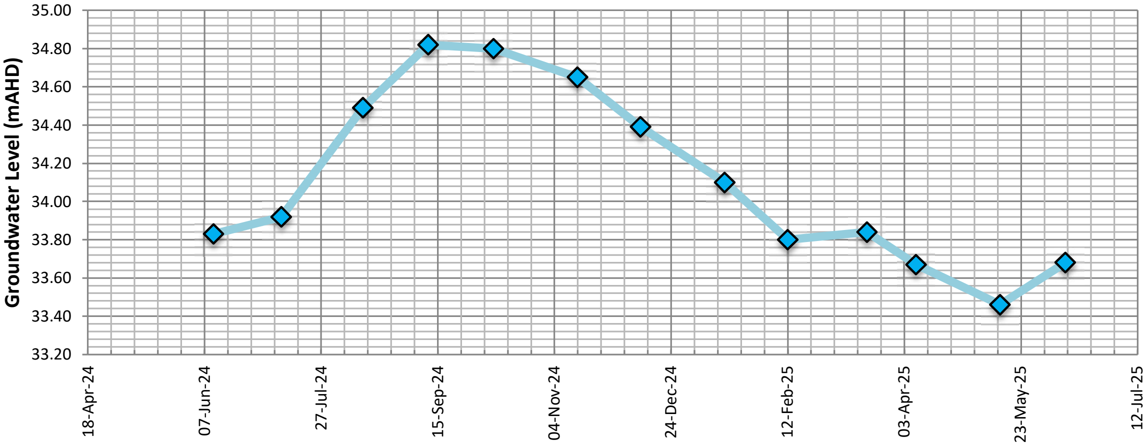
Minimum Recorded Level (mAHD)	33.27
Maximum Recorded Level (mAHD)	34.60

H24009 Lakefarm Retreat Ballajura

GW9 Site Bore GW9

				Natural Surface (mAHD)	37.30
Data Analysis Period Start Date	11/06/2024	Easting	396342.263	Top of Casing (m AHD)	37.90
Data Analysis Period End Date	11/06/2025	Northing	6477982.753	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
11/06/2024	4.07	33.83	3.47
10/07/2024	3.98	33.92	3.38
14/08/2024	3.41	34.49	2.81
11/09/2024	3.08	34.82	2.48
9/10/2024	3.10	34.80	2.50
14/11/2024	3.25	34.65	2.65
11/12/2024	3.51	34.39	2.91
16/01/2025	3.80	34.10	3.20
12/02/2025	4.10	33.80	3.50
18/03/2025	4.06	33.84	3.46
8/04/2025	4.23	33.67	3.63
14/05/2025	4.44	33.46	3.84
11/06/2025	4.22	33.68	3.62

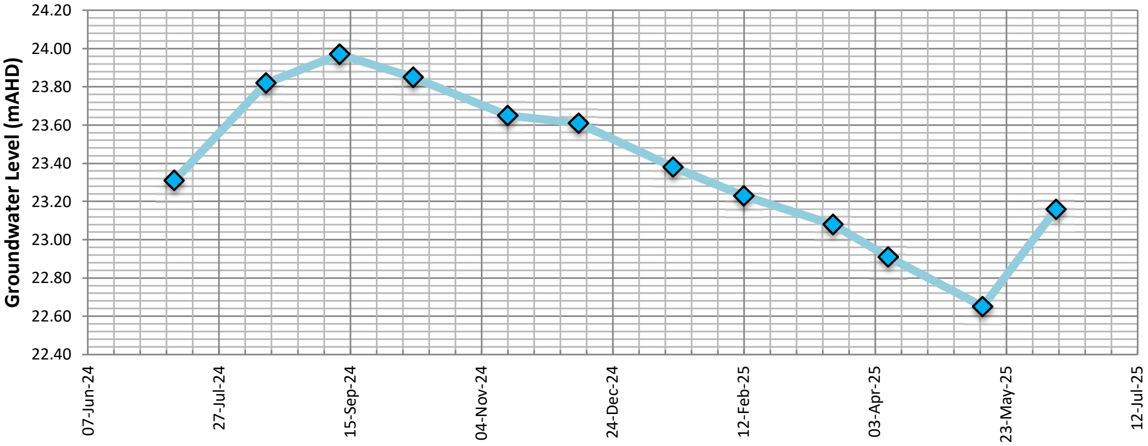
Minimum Recorded Level (mAHD)	33.46
Maximum Recorded Level (mAHD)	34.82

H24009 Lakefarm Retreat Ballajura

M60 DWER Mirrabooka Observation M60

				Natural Surface (mAHD)	
Data Analysis Period Start Date	11/06/2024	Easting	399380.99	Top of Casing (m AHD)	25.79
Data Analysis Period End Date	11/06/2025	Northing	6476121.51	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
10/07/2024	2.48	23.31	
14/08/2024	1.97	23.82	
11/09/2024	1.82	23.97	
9/10/2024	1.94	23.85	
14/11/2024	2.14	23.65	
11/12/2024	2.18	23.61	
16/01/2025	2.41	23.38	
12/02/2025	2.56	23.23	
18/03/2025	2.71	23.08	
8/04/2025	2.88	22.91	
14/05/2025	3.14	22.65	
11/06/2025	2.63	23.16	

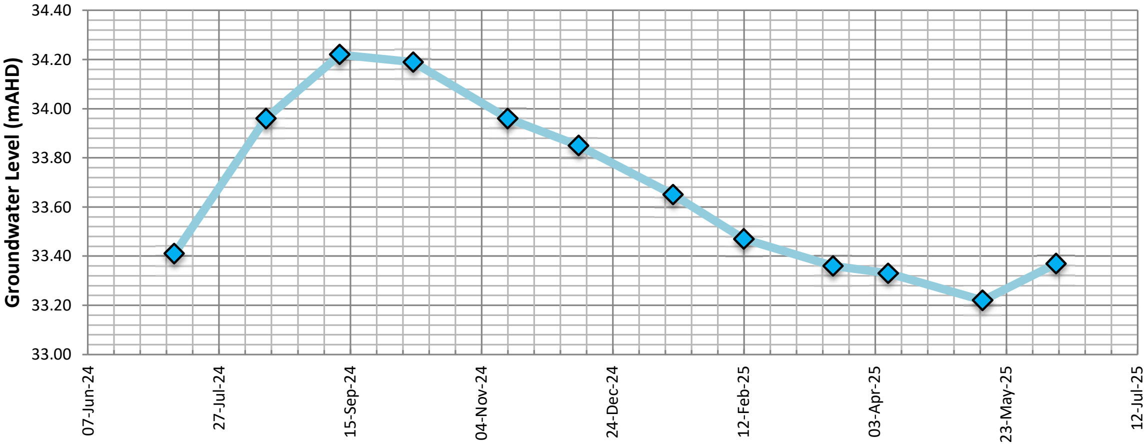
Minimum Recorded Level (mAHD)	22.65
Maximum Recorded Level (mAHD)	23.97

H24009 Lakefarm Retreat Ballajura

MM53 DWER Mirrabooka Monitoring MM53

				Natural Surface (mAHD)	
Data Analysis Period Start Date	11/06/2024	Easting	398944	Top of Casing (m AHD)	37.27
Data Analysis Period End Date	11/06/2025	Northing	6479048.5	End of Hole (mAHD)	

Report Date : 3/07/2025



Date	Groundwater bTOC	Groundwater mAHD	Depth Below NS m
10/07/2024	3.86	33.41	
14/08/2024	3.31	33.96	
11/09/2024	3.05	34.22	
9/10/2024	3.08	34.19	
14/11/2024	3.31	33.96	
11/12/2024	3.42	33.85	
16/01/2025	3.62	33.65	
12/02/2025	3.80	33.47	
18/03/2025	3.91	33.36	
8/04/2025	3.94	33.33	
14/05/2025	4.05	33.22	
11/06/2025	3.90	33.37	

Minimum Recorded Level (mAHD)	33.22
Maximum Recorded Level (mAHD)	34.22

APPENDIX G

UNDO Nutrient Modelling
Pre-Development

Government of **Western Australia**
Department of **Water and Environmental Regulation**

Project:	Lakefarm Ballajura DWMS Pre Development	Date:	7/10/2024
		Version:	Version 1.2.0.19289

Subregion name: **Lots 11 to 23 Lakefarm Retreat Ballajura**

			Input load	
Landuse	**Percent (%)**	**Area (ha)**	**Nitrogen (kg)**	**Phosphorus (kg)**
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	100	53.55	3194.26	444.47
Public open space	0	0.00	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
53.55	**100**
Nitrogen input (kg/yr)	Phosphorus input (kg/yr)
3474.32	**452.50**
Nitrogen export (kg/yr)	Phosphorus (kg/yr)
340.47	**16.52**

Rural living

Landuse	Percent (%)	Area (ha)
Unrestricted	50	26.78
No livestock	50	26.78
No clearing apart from the housing pad	0	0.00

Total area (ha)	Total percent (%)
53.55	**100**
Nitrogen input (kg)	Phosphorus input (kg)
3194.26	**444.47**

Note: Commercial horticultre is not permitted in the rural living zone, due to spray drift buffers.

Soil and drainage information

Type of drainage	**Infiltration**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**Yes**
Depth to groundwater (m)	**2**	Type of system installed	**Septic tank**
Groundwater slope (%)	**0.5**	No. of units installed	**9**
Soil PRI	**5.0**		

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

Summary: Nutrient stripping devices

Treatment	Name	Size (m²)	Treated area (ha)	Treating	N removed (kg/yr)	P removed (kg/yr)
Load removed					0.00	0.00
Net export					340.47	16.52

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/yr)	N export (kg/yr)
Lots 11 to 23 Lakefarm Retreat Ballajura	53.55	16.52	340.47

PRE-TREATMENT LOAD (kg/yr)		LOAD REMOVED (kg/yr)		NET LOAD EXPORT (kg/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
340.47	16.52	0.00	0.00	340.47	16.52

APPENDIX H

Groundwater Quality Summary Results

H24009 Lakefarm Retreat Ballajura

Aggregated Data for All Sites
Groundwater

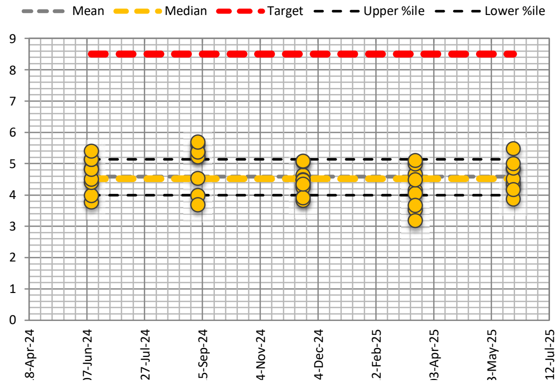
Data Analysis Period Start Date **11/06/2024**
Data Analysis Period End Date **11/06/2025**

Report Date : 3/07/2025

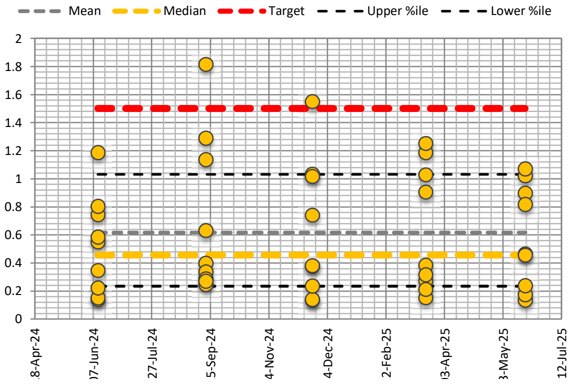
Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC - SWA Wetlands	Times Exceeded
GWL bToC	Groundwater Level	mBToC	141	1.82	3.03	3.64	**3.75**	4.23	5.47		✓ 0
GWL mAHD	Groundwater Level	mAHD	141	22.65	33.46	33.08	**33.86**	34.39	34.83		✓ 0
T	Temperature	°C	45	19.00	20.00	22.351	**21.800**	24.620	28.000		✓ 0
EC	Electrical Conductivity	mS/cm	45	0.14	0.23	0.617	**0.457**	1.030	1.815	1.500	✗ 2
pH	pH	pH	45	3.19	3.99	4.59	**4.52**	5.14	5.70	8.50	✓ 0
DO	Dissolved Oxygen	%	45	9.10	13.82	21.75	**19.00**	28.34	53.70	120.00	✓ 0
TN	Total Nitrogen	mg/L	45	0.59	0.87	2.55	**1.40**	2.86	18.00	1.50	✗ 20
TKN	Total Kejdhal Nitrogen	mg/L	45	0.18	0.73	1.48	**1.00**	2.06	5.90		✓ 0
NO3	Nitrate	mg/L	45	0.01	0.02	1.08	**0.06**	0.72	15.00		✓ 0
NO2	Nitrite	mg/L	45	0.01	0.01	0.02	**0.01**	0.05	0.14		✓ 0
Nox	Nox	mg/L	45	0.01	0.02	1.09	**0.06**	0.75	15.00	0.10	✗ 22
NH3	Ammonia	mg/L	45	0.01	0.05	0.18	**0.14**	0.27	0.65		✓ 0
TP	Total Phosphorous	mg/L	45	0.05	0.05	0.06	**0.05**	0.05	0.36	0.06	✗ 8
FRP	Filterable Reactive Phosphrous	mg/L	45	0.01	0.01	0.01	**0.01**	0.01	0.06	0.03	✗ 4
As	Arsenic	mg/L	45	0.00100	0.00100	0.00112	**0.00100**	0.00110	0.00260		✓ 0
Cd	Cadmium	mg/L	45	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00019		✓ 0
Cr	Chromium	mg/L	45	0.00100	0.00100	0.00264	**0.00230**	0.00370	0.01000		✓ 0
Cu	Copper	mg/L	45	0.00100	0.00100	0.00147	**0.00100**	0.00150	0.00610		✓ 0
Pb	Lead	mg/L	45	0.00100	0.00100	0.00252	**0.00100**	0.00210	0.02400		✓ 0
Hg	Mercury	mg/L	45	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	45	0.00100	0.00100	0.00422	**0.00330**	0.00612	0.01800		✓ 0
Zn	Zinc	mg/L	45	0.00100	0.00130	0.00444	**0.00290**	0.00664	0.01900		✓ 0
E.Coli	E. Coli	cfu/100mL	12	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	12	10.00000	10.00000	51.66667	**10.00000**	10.00000	480.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

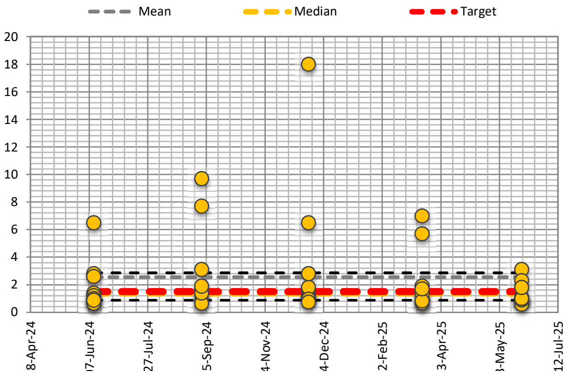
pH



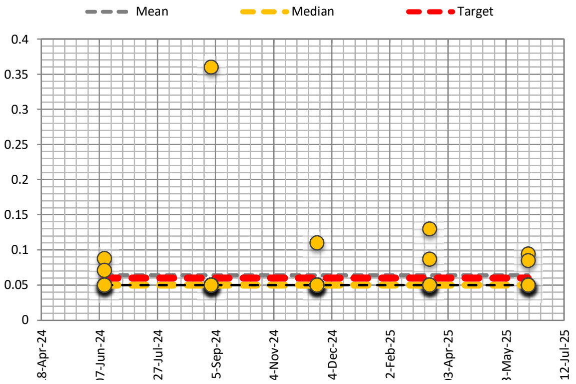
Electrical Conductivity



Total Nitrogen



Total Phosphorous



FieldDAE

H24009 Lakefarm Retreat Ballajura

GW1 Site Bore GW1

Easting	395285.24	Data Analysis Period Start Date	11/06/2024
Northing	6477934.2	Data Analysis Period End Date	11/06/2025

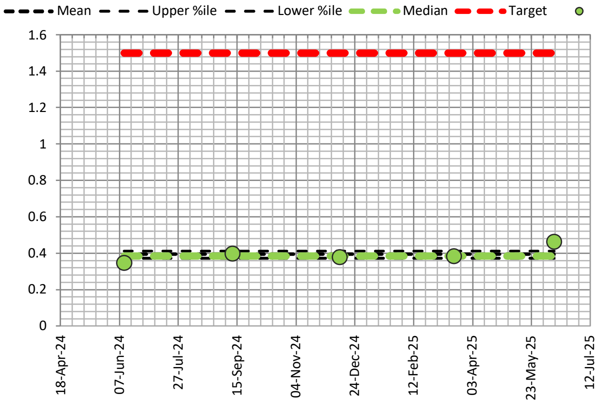
hyd2o
HYDROLOGY

Report Date : 3/07/2025

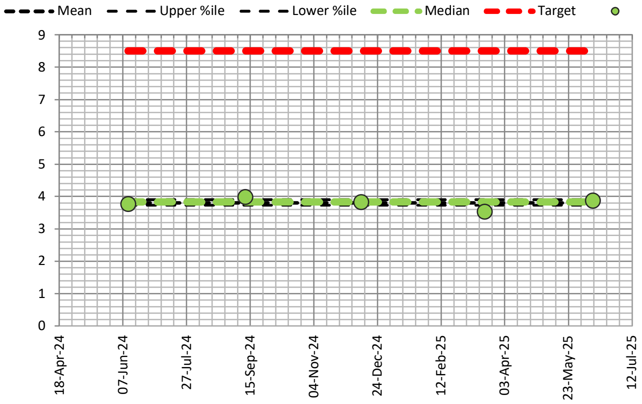
					Low %ile			High %ile		Target	Times
Parameter	Description	Units	Samples	Minimum	20	Mean	Median	80	Maximum	ANZECC - SWA Wetlands	Exceeded
GWL bToC	Groundwater Level	mBToC	13	3.41	3.60	4.00	**4.10**	4.34	4.54		✓ 0
GWL mAHD	Groundwater Level	mAHD	13	33.70	33.90	34.24	**34.14**	34.64	34.83		✓ 0
T	Temperature	°C	5	20.00	20.640	23.520	**24.10**	25.360	28.000		✓ 0
EC	Electrical Conductivity	mS/cm	5	0.35	0.37	0.39	**0.38**	0.41	0.46	1.500	✓ 0
pH	pH	pH	5	3.54	3.73	3.80	**3.83**	3.90	3.99	8.50	✓ 0
DO	Dissolved Oxygen	%	5	10.90	11.46	16.58	**15.50**	19.72	27.00	120.00	✓ 0
TN	Total Nitrogen	mg/L	5	1.10	1.18	1.30	**1.40**	1.40	1.40	1.50	✓ 0
TKN	Total Kejdhal Nitrogen	mg/L	5	0.91	1.14	1.26	**1.40**	1.40	1.40		✓ 0
NO3	Nitrate	mg/L	5	0.01	0.01	0.04	**0.01**	0.05	0.19		✓ 0
NO2	Nitrite	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01		✓ 0
Nox	Nox	mg/L	5	0.01	0.01	0.04	**0.01**	0.05	0.19	0.10	✗ 1
NH3	Ammonia	mg/L	5	0.29	0.49	0.53	**0.55**	0.61	0.65		✓ 0
TP	Total Phosphorous	mg/L	5	0.05	0.05	0.05	**0.05**	0.05	0.05	0.06	✓ 0
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01	0.03	✓ 0
As	Arsenic	mg/L	5	0.00100	0.00100	0.00112	**0.00110**	0.00116	0.00140		✓ 0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010		✓ 0
Cr	Chromium	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00122	**0.00120**	0.00142	0.00150		✓ 0
Pb	Lead	mg/L	5	0.00100	0.00100	0.00106	**0.00100**	0.00106	0.00130		✓ 0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	5	0.00870	0.01054	0.01254	**0.01200**	0.01400	0.01800		✓ 0
Zn	Zinc	mg/L	5	0.00120	0.00152	0.00318	**0.00220**	0.00458	0.00690		✓ 0
E.Coli	E. Coli	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

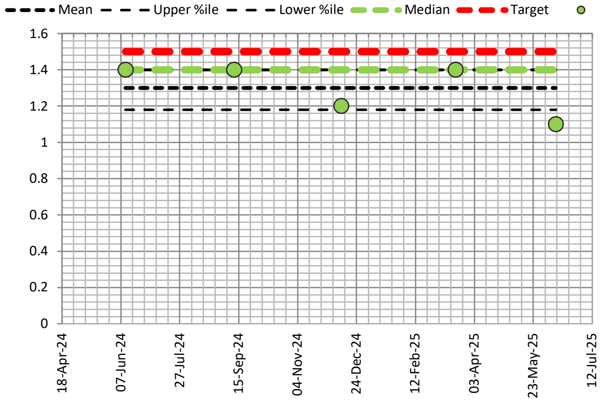
Electrical Conductivity



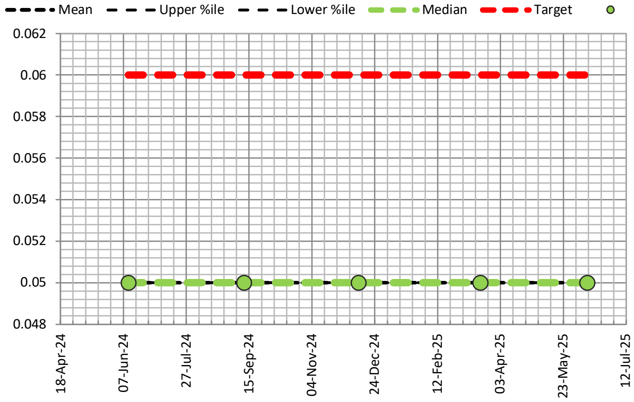
pH



Total Nitrogen



Total Phosphorous



H24009 Lakefarm Retreat Ballajura

GW2 Site Bore GW2

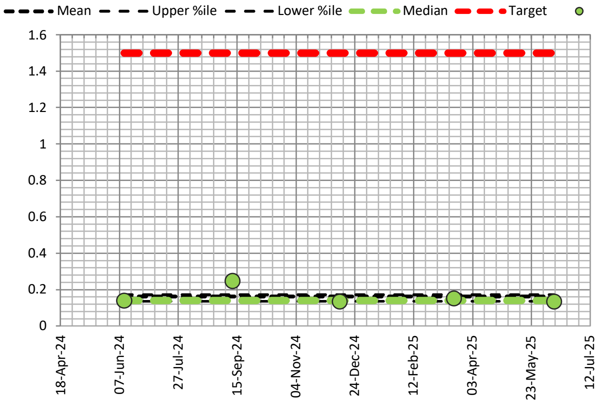
Easting	395719.85	Data Analysis Period Start Date	11/06/2024
Northing	6477627.6	Data Analysis Period End Date	11/06/2025

Report Date : 3/07/2025

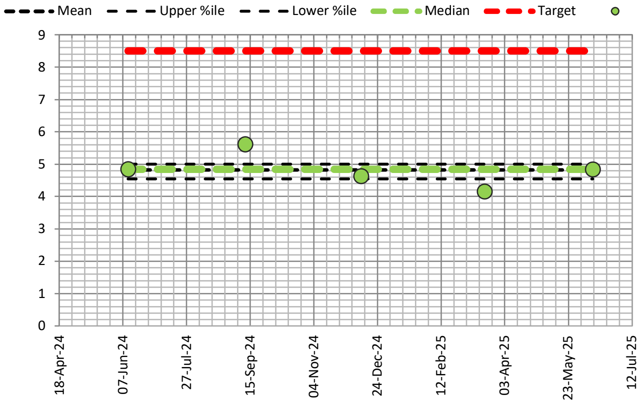
Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC - SWA Wetlands	Times Exceeded
GWL bToC	Groundwater Level	mBToC	13	3.18	3.40	3.81	**3.96**	4.17	4.39		✓ 0
GWL mAHD	Groundwater Level	mAHD	13	33.49	33.71	34.07	**33.92**	34.48	34.70		✓ 0
T	Temperature	°C	5	21.50	21.740	23.660	**22.10**	26.120	27.000		✓ 0
EC	Electrical Conductivity	mS/cm	5	0.14	0.14	0.16	**0.14**	0.17	0.25	1.500	✓ 0
pH	pH	pH	5	4.16	4.54	4.82	**4.84**	5.00	5.62	8.50	✓ 0
DO	Dissolved Oxygen	%	5	14.00	23.76	31.86	**27.30**	41.22	53.70	120.00	✓ 0
TN	Total Nitrogen	mg/L	5	0.75	2.63	5.41	**6.50**	7.54	9.70	1.50	✗ 4
TKN	Total Kejdhal Nitrogen	mg/L	5	0.42	0.48	0.99	**0.74**	1.14	2.50		✓ 0
NO3	Nitrate	mg/L	5	0.26	2.21	4.41	**5.70**	6.40	7.20		✓ 0
NO2	Nitrite	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01		✓ 0
Nox	Nox	mg/L	5	0.26	2.21	4.43	**5.70**	6.48	7.20	0.10	✗ 5
NH3	Ammonia	mg/L	5	0.01	0.01	0.02	**0.02**	0.02	0.03		✓ 0
TP	Total Phosphorous	mg/L	5	0.05	0.05	0.05	**0.05**	0.05	0.05	0.06	✓ 0
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01	0.03	✓ 0
As	Arsenic	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010		✓ 0
Cr	Chromium	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Pb	Lead	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	5	0.00100	0.00100	0.00102	**0.00100**	0.00102	0.00110		✓ 0
Zn	Zinc	mg/L	5	0.00100	0.00108	0.00162	**0.00150**	0.00186	0.00290		✓ 0
E.Coli	E. Coli	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

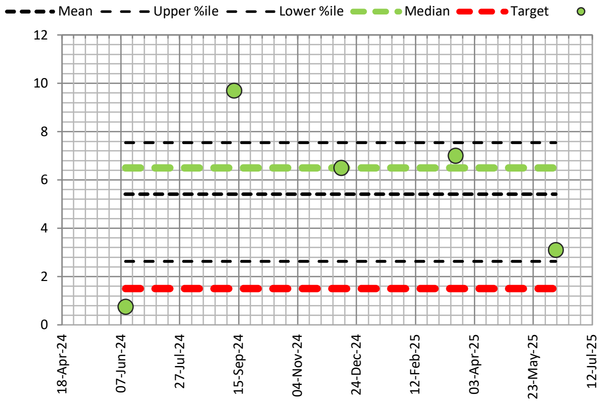
Electrical Conductivity



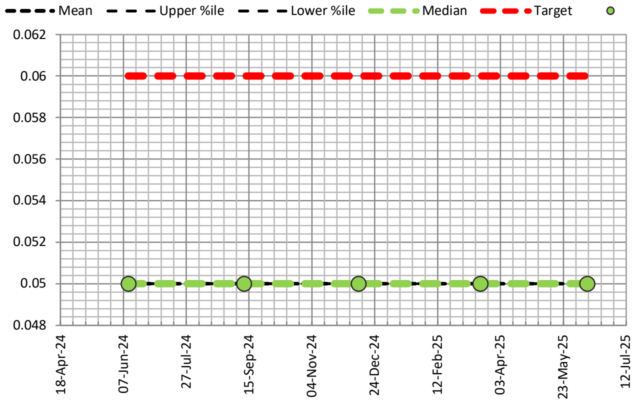
pH



Total Nitrogen



Total Phosphorous



H24009 Lakefarm Retreat Ballajura

GW3 Site Bore GW3

Easting	395743.04	Data Analysis Period Start Date	11/06/2024
Northing	6477931.4	Data Analysis Period End Date	11/06/2025

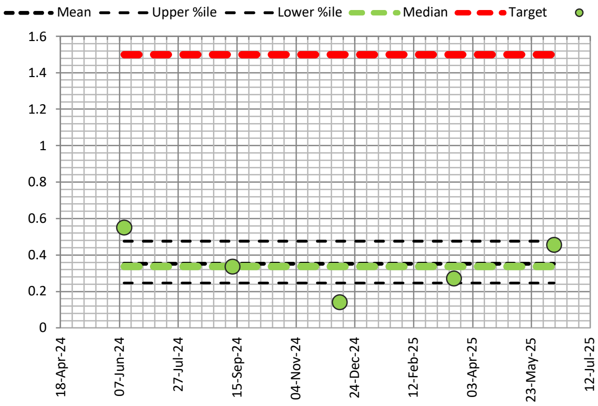
hyd2o HYDROLOGY

Report Date :   3/07/2025

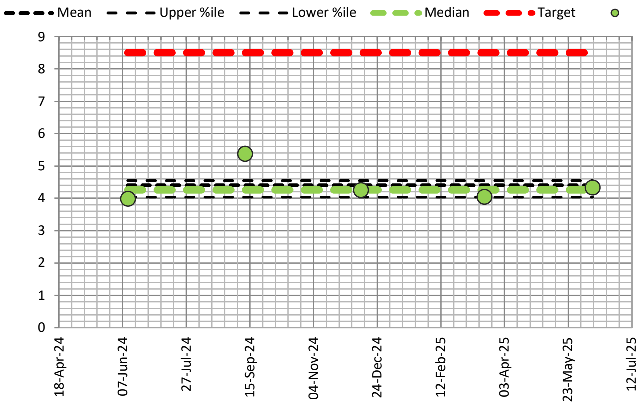
					Low %ile			High %ile		Target	Times
Parameter	Description	Units	Samples	Minimum	20	Mean	Median	80	Maximum	ANZECC - SWA Wetlands	Exceeded
GWL bToC	Groundwater Level	mBToC	13	3.16	3.46	3.84	**4.00**	4.17	4.40		✓ 0
GWL mAHD	Groundwater Level	mAHD	13	33.54	33.77	34.10	**33.94**	34.48	34.78		✓ 0
T	Temperature	°C	5	20.40	20.720	22.920	**21.20**	25.560	27.000		✓ 0
EC	Electrical Conductivity	mS/cm	5	0.14	0.25	0.35	**0.34**	0.48	0.55	1.500	✓ 0
pH	pH	pH	5	3.99	4.04	4.40	**4.26**	4.55	5.38	8.50	✓ 0
DO	Dissolved Oxygen	%	5	19.00	19.80	23.64	**20.50**	24.58	37.30	120.00	✓ 0
TN	Total Nitrogen	mg/L	5	0.82	0.87	2.44	**1.20**	2.82	7.70	1.50	✗ 2
TKN	Total Kejdhal Nitrogen	mg/L	5	0.40	0.58	1.17	**0.71**	1.48	3.00		✓ 0
NO3	Nitrate	mg/L	5	0.02	0.15	1.26	**0.18**	1.90	4.70		✓ 0
NO2	Nitrite	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.05		✓ 0
Nox	Nox	mg/L	5	0.02	0.15	1.26	**0.19**	1.90	4.70	0.10	✗ 4
NH3	Ammonia	mg/L	5	0.05	0.05	0.11	**0.14**	0.16	0.16		✓ 0
TP	Total Phosphorous	mg/L	5	0.05	0.05	0.05	**0.05**	0.05	0.05	0.06	✓ 0
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01	0.03	✓ 0
As	Arsenic	mg/L	5	0.00100	0.00100	0.00106	**0.00100**	0.00106	0.00130		✓ 0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010		✓ 0
Cr	Chromium	mg/L	5	0.00100	0.00132	0.00166	**0.00170**	0.00204	0.00220		✓ 0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00116	**0.00100**	0.00116	0.00180		✓ 0
Pb	Lead	mg/L	5	0.00100	0.00100	0.00114	**0.00100**	0.00114	0.00170		✓ 0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	5	0.00170	0.00202	0.00310	**0.00250**	0.00382	0.00590		✓ 0
Zn	Zinc	mg/L	5	0.00130	0.00186	0.00374	**0.00230**	0.00484	0.00940		✓ 0
E.Coli	E. Coli	cfu/100mL	4	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	4	10.00000	10.00000	########	**25.00000**	216.00000	480.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

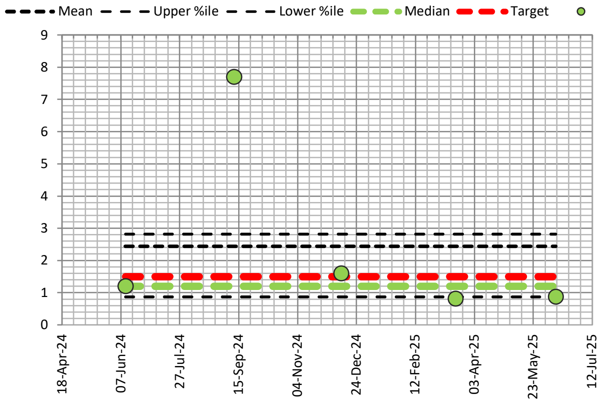
Electrical Conductivity



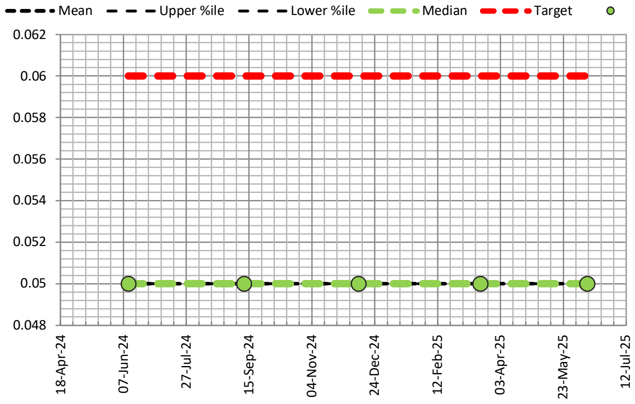
pH



Total Nitrogen



Total Phosphorous



H24009 Lakefarm Retreat Ballajura

GW4 Site Bore GW4

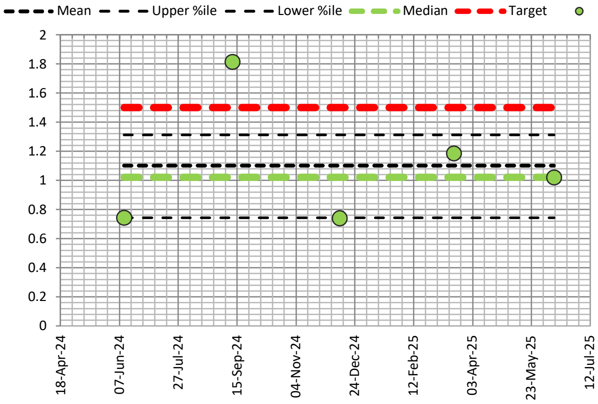
Easting	396048.35	Data Analysis Period Start Date	11/06/2024
Northing	6477429.2	Data Analysis Period End Date	11/06/2025

Report Date : 3/07/2025

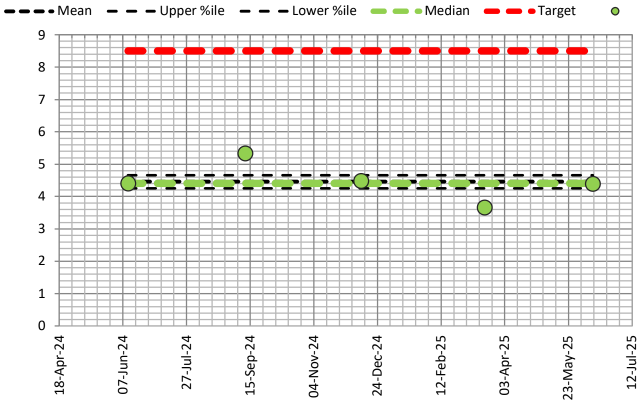
					Low %ile			High %ile		Target	Times
Parameter	Description	Units	Samples	Minimum	20	Mean	Median	80	Maximum	**ANZECC - SWA Wetlands**	Exceeded
GWL bToC	Groundwater Level	mBToC	13	2.89	3.16	3.56	**3.75**	3.92	4.16		✓ 0
GWL mAHD	Groundwater Level	mAHD	13	33.26	33.50	33.86	**33.67**	34.26	34.53		✓ 0
T	Temperature	°C	5	19.20	19.760	20.880	**20.00**	22.620	22.700		✓ 0
EC	Electrical Conductivity	mS/cm	5	0.74	0.74	1.10	**1.02**	1.31	1.82	1.500	✗ 1
pH	pH	pH	5	3.67	4.25	4.46	**4.41**	4.66	5.34	8.50	✓ 0
DO	Dissolved Oxygen	%	5	14.70	16.70	21.04	**21.20**	23.68	30.00	120.00	✓ 0
TN	Total Nitrogen	mg/L	5	1.10	1.34	1.86	**1.70**	2.40	2.80	1.50	✗ 3
TKN	Total Kejdhal Nitrogen	mg/L	5	1.00	1.32	1.80	**1.70**	2.36	2.60		✓ 0
NO3	Nitrate	mg/L	5	0.05	0.05	0.08	**0.05**	0.09	0.21		✓ 0
NO2	Nitrite	mg/L	5	0.01	0.01	0.03	**0.05**	0.05	0.05		✓ 0
Nox	Nox	mg/L	5	0.05	0.05	0.09	**0.05**	0.10	0.22	0.10	✗ 1
NH3	Ammonia	mg/L	5	0.10	0.11	0.22	**0.24**	0.29	0.39		✓ 0
TP	Total Phosphorous	mg/L	5	0.05	0.05	0.06	**0.05**	0.06	0.09	0.06	✗ 1
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01	0.03	✓ 0
As	Arsenic	mg/L	5	0.00100	0.00100	0.00110	**0.00100**	0.00116	0.00140		✓ 0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010		✓ 0
Cr	Chromium	mg/L	5	0.00200	0.00248	0.00276	**0.00260**	0.00306	0.00370		✓ 0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00122	**0.00100**	0.00152	0.00160		✓ 0
Pb	Lead	mg/L	5	0.00100	0.00100	0.00134	**0.00100**	0.00152	0.00240		✓ 0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	5	0.00440	0.00440	0.00586	**0.00450**	0.00680	0.01000		✓ 0
Zn	Zinc	mg/L	5	0.00190	0.00390	0.00518	**0.00600**	0.00668	0.00700		✓ 0
E.Coli	E. Coli	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

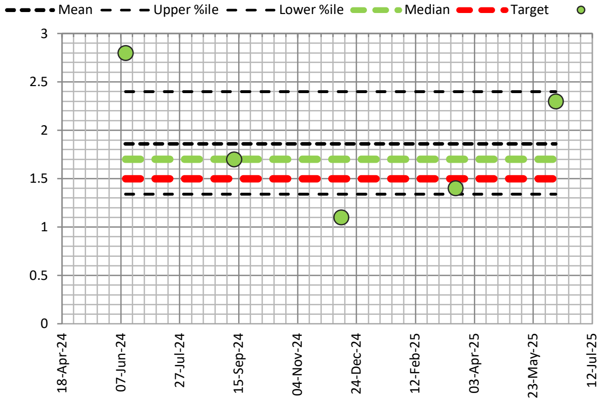
Electrical Conductivity



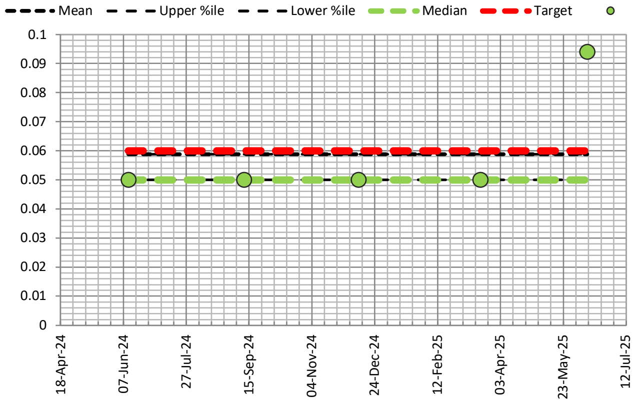
pH



Total Nitrogen



Total Phosphorous



H24009 Lakefarm Retreat Ballajura

GW5 Site Bore GW5

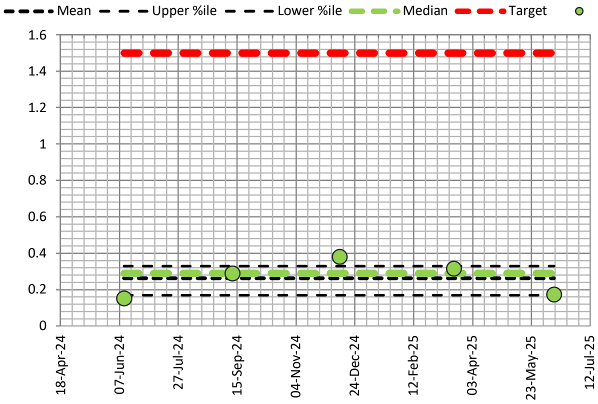
Easting	396034.5	Data Analysis Period Start Date	11/06/2024
Northing	6477720.2	Data Analysis Period End Date	11/06/2025

Report Date : 3/07/2025

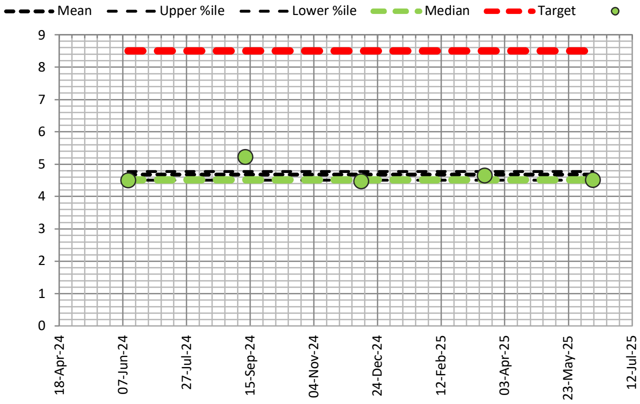
Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC - SWA Wetlands	Times Exceeded
GWL bToC	Groundwater Level	mBToC	13	2.72	2.98	3.40	**3.59**	3.76	3.98		✓ 0
GWL mAHD	Groundwater Level	mAHD	13	33.44	33.66	34.02	**33.83**	34.44	34.70		✓ 0
T	Temperature	°C	5	21.20	21.520	22.720	**21.80**	24.440	24.600		✓ 0
EC	Electrical Conductivity	mS/cm	5	0.15	0.17	0.26	**0.29**	0.33	0.38	1.500	✓ 0
pH	pH	pH	5	4.48	4.50	4.68	**4.52**	4.77	5.23	8.50	✓ 0
DO	Dissolved Oxygen	%	5	9.10	11.82	15.72	**14.30**	18.08	26.80	120.00	✓ 0
TN	Total Nitrogen	mg/L	5	0.59	0.65	0.91	**0.68**	1.01	1.80	1.50	✗ 1
TKN	Total Kejdhal Nitrogen	mg/L	5	0.18	0.57	0.79	**0.68**	0.99	1.60		✓ 0
NO3	Nitrate	mg/L	5	0.01	0.01	0.14	**0.05**	0.26	0.41		✓ 0
NO2	Nitrite	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.05		✓ 0
Nox	Nox	mg/L	5	0.01	0.01	0.14	**0.05**	0.26	0.41	0.10	✗ 2
NH3	Ammonia	mg/L	5	0.12	0.12	0.13	**0.13**	0.14	0.16		✓ 0
TP	Total Phosphorous	mg/L	5	0.05	0.05	0.05	**0.05**	0.05	0.05	0.06	✓ 0
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01	0.03	✓ 0
As	Arsenic	mg/L	5	0.00100	0.00100	0.00118	**0.00100**	0.00136	0.00160		✓ 0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010		✓ 0
Cr	Chromium	mg/L	5	0.00120	0.00208	0.00242	**0.00240**	0.00280	0.00360		✓ 0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Pb	Lead	mg/L	5	0.00100	0.00100	0.00108	**0.00100**	0.00108	0.00140		✓ 0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Zn	Zinc	mg/L	5	0.00100	0.00100	0.00228	**0.00280**	0.00300	0.00380		✓ 0
E.Coli	E. Coli	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

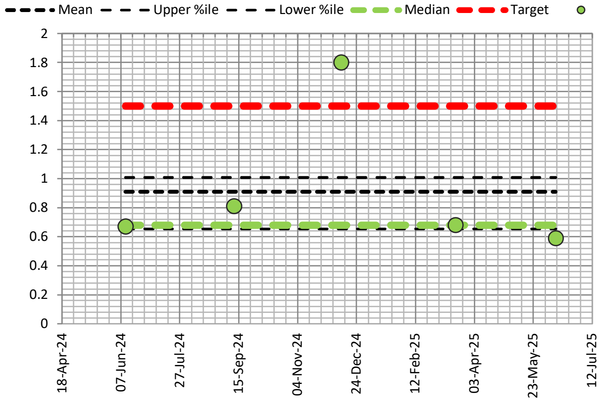
Electrical Conductivity



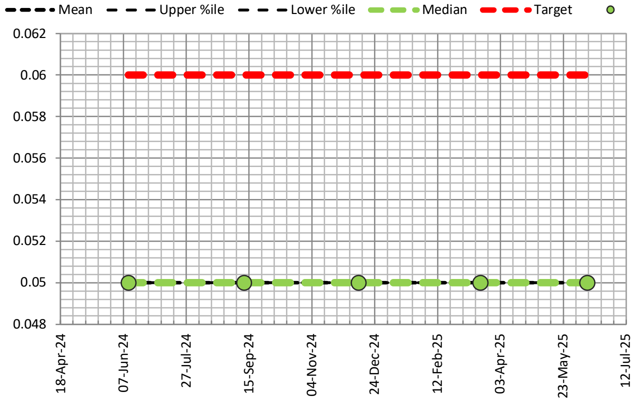
pH



Total Nitrogen



Total Phosphorous



H24009 Lakefarm Retreat Ballajura

GW6 Site Bore GW6

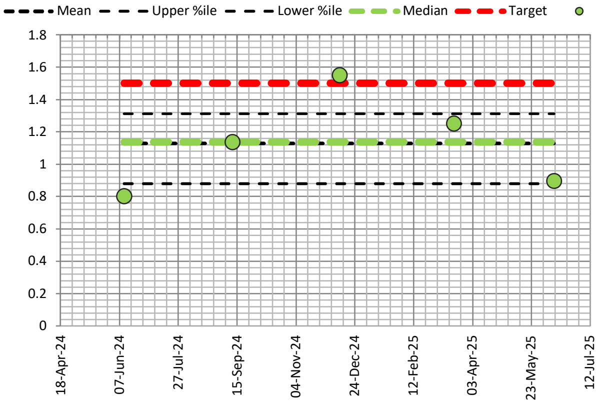
Easting	396070.3	Data Analysis Period Start Date	11/06/2024
Northing	6477979.5	Data Analysis Period End Date	11/06/2025

Report Date : 3/07/2025

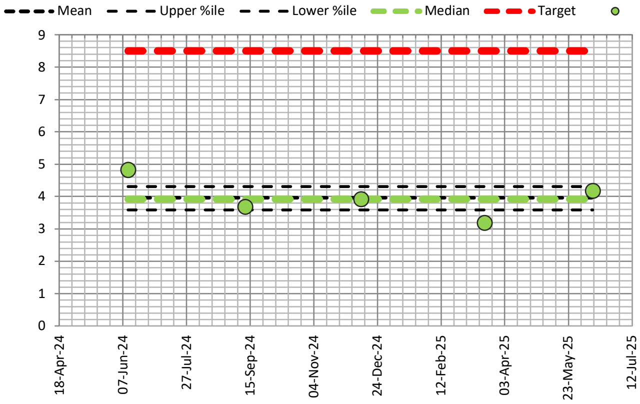
Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC - SWA Wetlands		Times Exceeded
GWL bToC	Groundwater Level	mBToC	13	3.40	3.62	4.06	**4.26**	4.42	4.62		✓	0
GWL mAHD	Groundwater Level	mAHD	13	33.60	33.80	34.16	**33.96**	34.60	34.82		✓	0
T	Temperature	°C	5	20.30	20.380	22.280	**20.90**	24.660	25.300		✓	0
EC	Electrical Conductivity	mS/cm	5	0.80	0.88	1.13	**1.14**	1.31	1.55	1.500	☒	1
pH	pH	pH	5	3.19	3.59	3.96	**3.92**	4.31	4.83	8.50	✓	0
DO	Dissolved Oxygen	%	5	13.90	15.26	21.66	**17.00**	29.70	32.90	120.00	✓	0
TN	Total Nitrogen	mg/L	5	0.90	0.95	3.43	**3.10**	5.86	6.50	1.50	☒	3
TKN	Total Kejdhal Nitrogen	mg/L	5	0.73	0.87	3.05	**2.00**	5.74	5.90		✓	0
NO3	Nitrate	mg/L	5	0.01	0.04	0.40	**0.17**	0.75	1.10		✓	0
NO2	Nitrite	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01		✓	0
Nox	Nox	mg/L	5	0.01	0.04	0.40	**0.17**	0.75	1.10	0.10	☒	3
NH3	Ammonia	mg/L	5	0.05	0.08	0.10	**0.10**	0.13	0.15		✓	0
TP	Total Phosphorous	mg/L	5	0.05	0.05	0.07	**0.05**	0.10	0.13	0.06	☒	2
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01	0.03	✓	0
As	Arsenic	mg/L	5	0.00100	0.00100	0.00160	**0.00100**	0.00244	0.00260		✓	0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00012	**0.00010**	0.00012	0.00019		✓	0
Cr	Chromium	mg/L	5	0.00240	0.00528	0.00636	**0.00630**	0.00768	0.01000		✓	0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00274	**0.00340**	0.00394	0.00450		✓	0
Pb	Lead	mg/L	5	0.00210	0.00346	0.01128	**0.00550**	0.02160	0.02400		✓	0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓	0
Ni	Nickel	mg/L	5	0.00320	0.00344	0.00418	**0.00470**	0.00472	0.00480		✓	0
Zn	Zinc	mg/L	5	0.00100	0.00500	0.01040	**0.01100**	0.01580	0.01900		✓	0
E.Coli	E. Coli	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓	0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓	0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

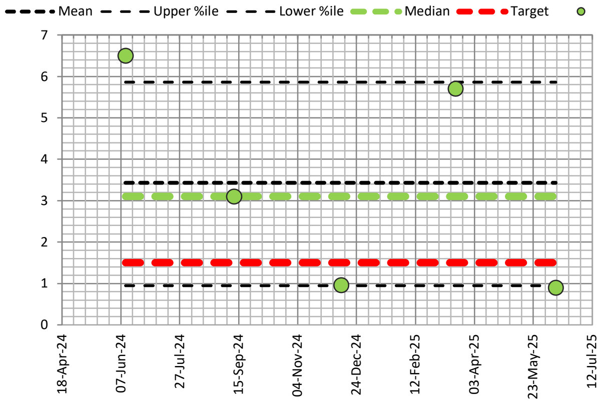
Electrical Conductivity



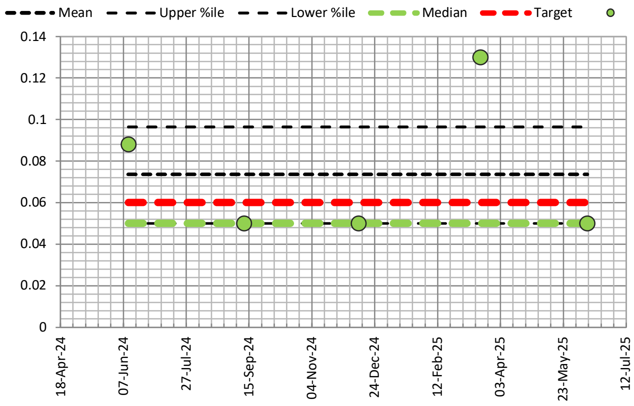
pH



Total Nitrogen



Total Phosphorous



H24009 Lakefarm Retreat Ballajura

GW7 Site Bore GW7

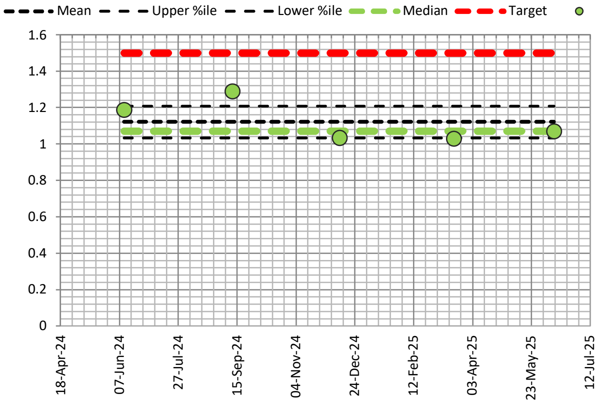
Easting	396373.05	Data Analysis Period Start Date	11/06/2024
Northing	6477226.7	Data Analysis Period End Date	11/06/2025

Report Date : 3/07/2025

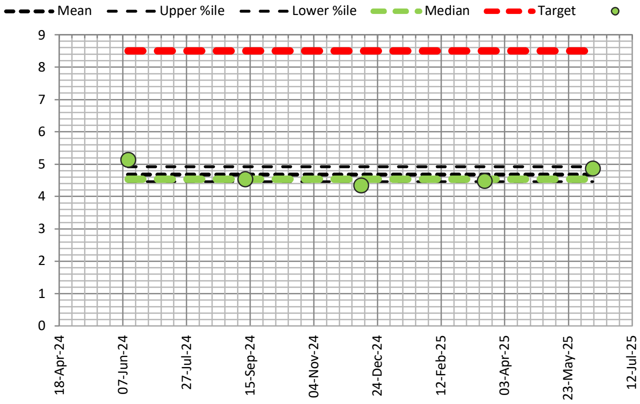
					Low %ile			High %ile		Target	Times
Parameter	Description	Units	Samples	Minimum	20	Mean	Median	80	Maximum	ANZECC - SWA Wetlands	Exceeded
GWL bToC	Groundwater Level	mBToC	13	4.21	4.48	4.89	**5.04**	5.27	5.47		✓ 0
GWL mAHD	Groundwater Level	mAHD	13	33.07	33.27	33.65	**33.50**	34.06	34.33		✓ 0
T	Temperature	°C	5	19.40	19.560	20.760	**19.80**	22.080	23.200		✓ 0
EC	Electrical Conductivity	mS/cm	5	1.03	1.03	1.12	**1.07**	1.21	1.29	1.500	✓ 0
pH	pH	pH	5	4.35	4.46	4.68	**4.54**	4.92	5.14	8.50	✓ 0
DO	Dissolved Oxygen	%	5	11.90	12.54	18.08	**17.30**	21.10	29.50	120.00	✓ 0
TN	Total Nitrogen	mg/L	5	0.65	0.73	0.84	**0.82**	1.00	1.00	1.50	✓ 0
TKN	Total Kejdhal Nitrogen	mg/L	5	0.65	0.71	0.80	**0.81**	0.85	0.99		✓ 0
NO3	Nitrate	mg/L	5	0.01	0.01	0.05	**0.02**	0.06	0.18		✓ 0
NO2	Nitrite	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01		✓ 0
Nox	Nox	mg/L	5	0.01	0.01	0.05	**0.02**	0.06	0.18	0.10	✗ 1
NH3	Ammonia	mg/L	5	0.22	0.24	0.27	**0.27**	0.29	0.31		✓ 0
TP	Total Phosphorous	mg/L	5	0.05	0.05	0.05	**0.05**	0.05	0.05	0.06	✓ 0
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01	0.03	✓ 0
As	Arsenic	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010		✓ 0
Cr	Chromium	mg/L	5	0.00200	0.00200	0.00222	**0.00230**	0.00240	0.00240		✓ 0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Pb	Lead	mg/L	5	0.00100	0.00100	0.00122	**0.00100**	0.00122	0.00210		✓ 0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	5	0.00390	0.00550	0.00614	**0.00660**	0.00706	0.00730		✓ 0
Zn	Zinc	mg/L	5	0.00100	0.00236	0.00310	**0.00290**	0.00418	0.00490		✓ 0
E.Coli	E. Coli	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

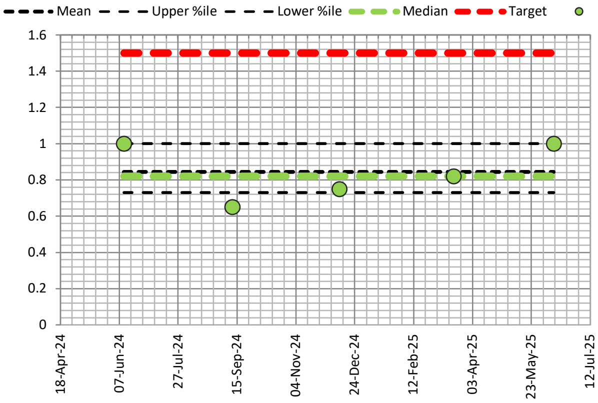
Electrical Conductivity



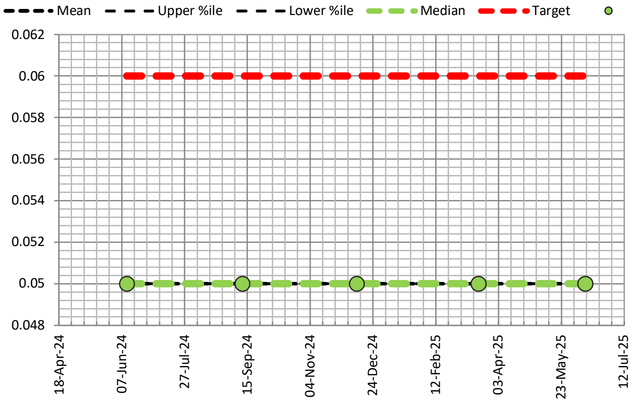
pH



Total Nitrogen



Total Phosphorous



H24009 Lakefarm Retreat Ballajura

GW8 Site Bore GW8

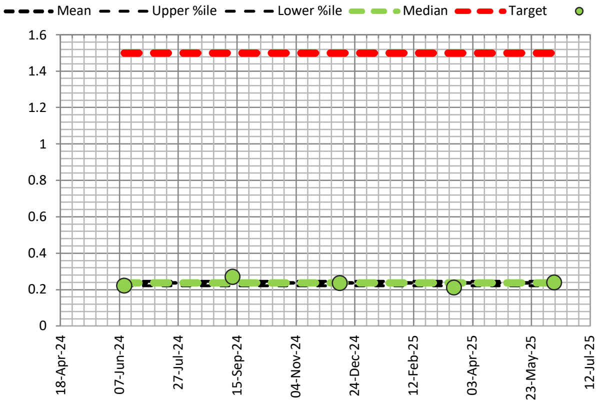
Easting	396410.76	Data Analysis Period Start Date	11/06/2024
Northing	6477622.2	Data Analysis Period End Date	11/06/2025

Report Date :   3/07/2025

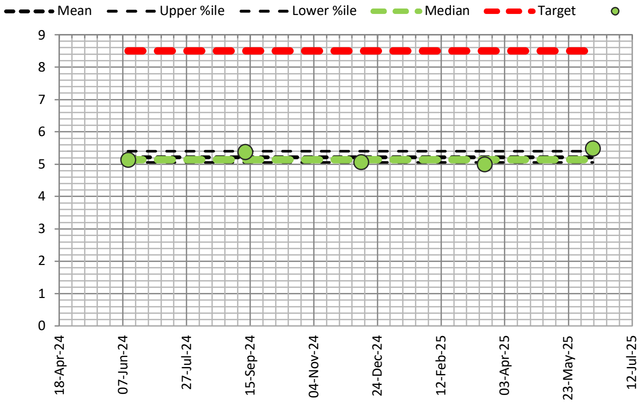
					Low %ile			High %ile		Target	Times
Parameter	Description	Units	Samples	Minimum	20	Mean	Median	80	Maximum	ANZECC - SWA Wetlands	Exceeded
GWL bToC	Groundwater Level	mBToC	13	1.88	2.16	2.59	**2.79**	2.96	3.21		✓ 0
GWL mAHD	Groundwater Level	mAHD	13	33.27	33.52	33.89	**33.69**	34.32	34.60		✓ 0
T	Temperature	°C	5	21.00	21.240	23.580	**22.10**	26.720	26.800		✓ 0
EC	Electrical Conductivity	mS/cm	5	0.21	0.22	0.24	**0.24**	0.25	0.27	1.500	✓ 0
pH	pH	pH	5	5.00	5.06	5.22	**5.14**	5.40	5.49	8.50	✓ 0
DO	Dissolved Oxygen	%	5	9.80	12.12	16.98	**14.70**	22.56	26.00	120.00	✓ 0
TN	Total Nitrogen	mg/L	5	0.88	0.98	4.64	**1.40**	5.12	18.00	1.50	✗ 2
TKN	Total Kejdhal Nitrogen	mg/L	5	0.80	0.85	1.41	**1.00**	1.72	3.00		✓ 0
NO3	Nitrate	mg/L	5	0.02	0.04	3.22	**0.05**	3.78	15.00		✓ 0
NO2	Nitrite	mg/L	5	0.01	0.01	0.05	**0.05**	0.07	0.14		✓ 0
Nox	Nox	mg/L	5	0.02	0.04	3.24	**0.05**	3.88	15.00	0.10	✗ 2
NH3	Ammonia	mg/L	5	0.04	0.11	0.13	**0.14**	0.16	0.19		✓ 0
TP	Total Phosphorous	mg/L	5	0.07	0.08	0.14	**0.09**	0.16	0.36	0.06	✗ 5
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.03	0.04	**0.03**	0.05	0.06	0.03	✗ 4
As	Arsenic	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00010	**0.00010**	0.00010	0.00010		✓ 0
Cr	Chromium	mg/L	5	0.00130	0.00322	0.00340	**0.00390**	0.00402	0.00410		✓ 0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Pb	Lead	mg/L	5	0.00100	0.00100	0.00116	**0.00100**	0.00116	0.00180		✓ 0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	5	0.00100	0.00100	0.00112	**0.00100**	0.00112	0.00160		✓ 0
Zn	Zinc	mg/L	5	0.00130	0.00218	0.00424	**0.00310**	0.00636	0.00860		✓ 0
E.Coli	E. Coli	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

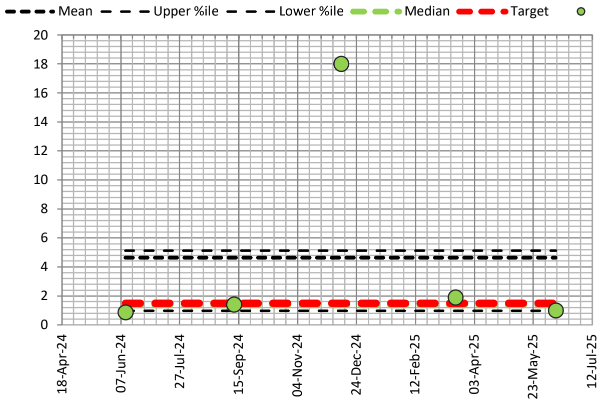
Electrical Conductivity



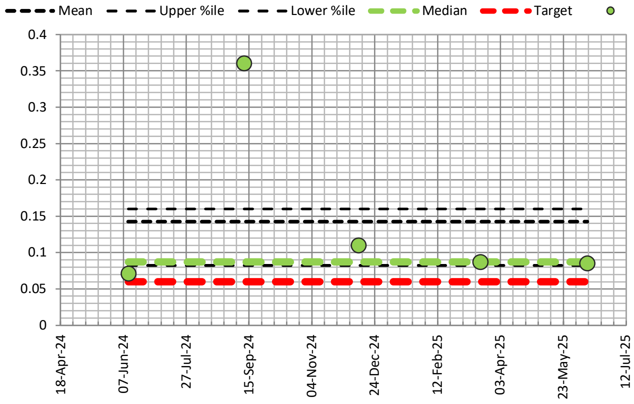
pH



Total Nitrogen



Total Phosphorous



H24009 Lakefarm Retreat Ballajura

GW9 Site Bore GW9

Easting 396342.26
Northing 6477982.8

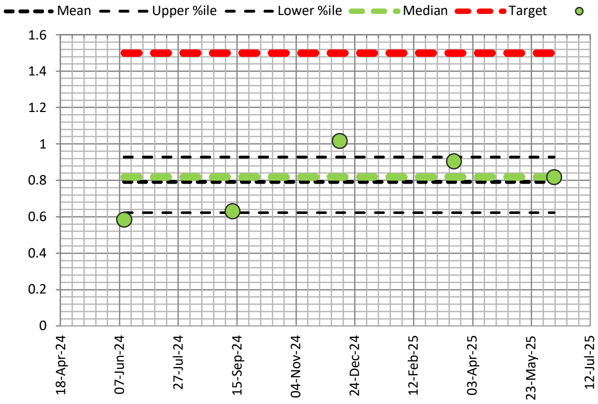
Data Analysis Period Start Date 11/06/2024
Data Analysis Period End Date 11/06/2025

Report Date : 3/07/2025

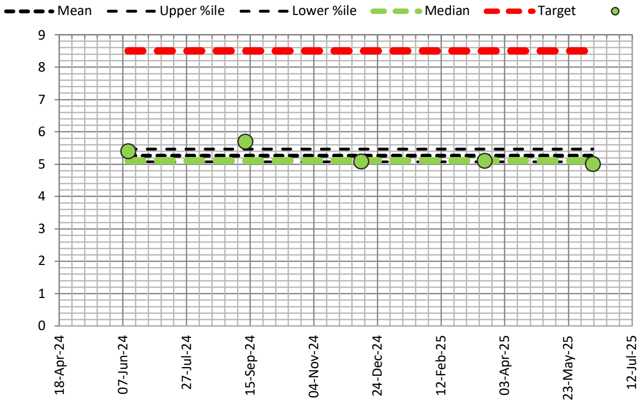
Parameter	Description	Units	Samples	Minimum	Low %ile 20	Mean	Median	High %ile 80	Maximum	Target ANZECC - SWA Wetlands	Times Exceeded
GWL bToC	Groundwater Level	mBToC	13	3.08	3.31	3.79	**3.98**	4.17	4.44		✓ 0
GWL mAHD	Groundwater Level	mAHD	13	33.46	33.73	34.11	**33.92**	34.59	34.82		✓ 0
T	Temperature	°C	5	19.00	19.560	20.840	**19.70**	22.600	23.400		✓ 0
EC	Electrical Conductivity	mS/cm	5	0.59	0.62	0.79	**0.82**	0.93	1.02	1.500	✓ 0
pH	pH	pH	5	5.01	5.07	5.26	**5.11**	5.47	5.70	8.50	✓ 0
DO	Dissolved Oxygen	%	5	13.50	23.90	30.22	**28.20**	38.60	46.20	120.00	✓ 0
TN	Total Nitrogen	mg/L	5	1.70	1.78	2.16	**1.90**	2.64	2.80	1.50	✗ 5
TKN	Total Kejdhal Nitrogen	mg/L	5	1.60	1.60	2.02	**1.70**	2.48	2.80		✓ 0
NO3	Nitrate	mg/L	5	0.04	0.05	0.15	**0.18**	0.21	0.31		✓ 0
NO2	Nitrite	mg/L	5	0.01	0.01	0.02	**0.01**	0.05	0.06		✓ 0
Nox	Nox	mg/L	5	0.04	0.05	0.16	**0.19**	0.22	0.33	0.10	✗ 3
NH3	Ammonia	mg/L	5	0.01	0.01	0.09	**0.05**	0.14	0.27		✓ 0
TP	Total Phosphorous	mg/L	5	0.05	0.05	0.05	**0.05**	0.05	0.05	0.06	✓ 0
FRP	Filterable Reactive Phosphrous	mg/L	5	0.01	0.01	0.01	**0.01**	0.01	0.01	0.03	✓ 0
As	Arsenic	mg/L	5	0.00100	0.00100	0.00100	**0.00100**	0.00100	0.00100		✓ 0
Cd	Cadmium	mg/L	5	0.00010	0.00010	0.00011	**0.00010**	0.00011	0.00015		✓ 0
Cr	Chromium	mg/L	5	0.00190	0.00230	0.00294	**0.00280**	0.00332	0.00460		✓ 0
Cu	Copper	mg/L	5	0.00100	0.00100	0.00288	**0.00270**	0.00410	0.00610		✓ 0
Pb	Lead	mg/L	5	0.00100	0.00100	0.00336	**0.00220**	0.00582	0.00710		✓ 0
Hg	Mercury	mg/L	5	0.00005	0.00005	0.00005	**0.00005**	0.00005	0.00005		✓ 0
Ni	Nickel	mg/L	5	0.00100	0.00196	0.00306	**0.00300**	0.00440	0.00480		✓ 0
Zn	Zinc	mg/L	5	0.00100	0.00196	0.00622	**0.00410**	0.00884	0.01700		✓ 0
E.Coli	E. Coli	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0
Thermotolerant	Thermotolerant coliforms	cfu/100mL	1	10.00000	10.00000	10.00000	**10.00000**	10.00000	10.00000		✓ 0

* For EC, pH, and DO, upper and lower limits apply - exceedences and targets shown in table apply to upper limit values only

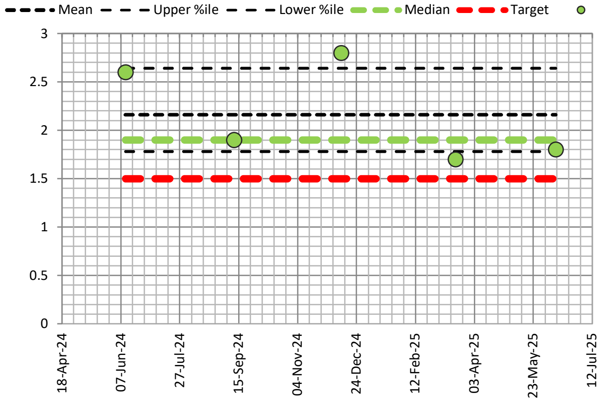
Electrical Conductivity



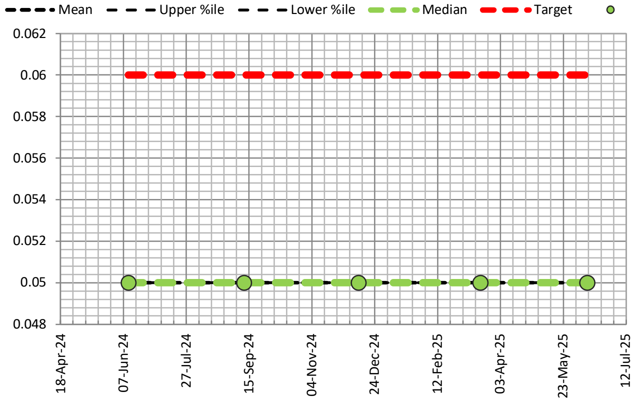
pH



Total Nitrogen



Total Phosphorous



APPENDIX I

Laboratory Reports

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
ABN 53 140 099 207
16-18 Hayden Court Myaree WA 6154
ph +61 8 9317 2505
lab@mpl.com.au
www.mpl.com.au

Certificate of Analysis PFF0711

Client Details

Client	Hyd2O
Contact	Ted Dann
Address	Suite 6B, 103 Rokeby Rd, SUBIACO, WA, 6008

Sample Details

Your Reference	H24009 - Ballajura Monitoring
Number of Samples	9 Groundwater
Date Samples Received	12/06/2024
Date Instructions Received	12/06/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date Results Requested by	19/06/2024
Date of Issue	19/06/2024

NATA Accreditation Number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. Tests not covered by NATA are denoted with *.

Authorisation Details

Results Approved By	Ben Carpenter, Metals Technician Heram Halim, Operations Manager Michael Mowle, Inorganics Supervisor Varsha Ho Wing, Inorganics and Metals Supervisor
Laboratory Manager	Michael Kubiak

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Samples in this Report

Envirolab ID	Sample ID	Matrix	Date Sampled	Date Received
PFF0711-01	GW1	Groundwater	11/06/2024	12/06/2024
PFF0711-02	GW2	Groundwater	11/06/2024	12/06/2024
PFF0711-03	GW3	Groundwater	11/06/2024	12/06/2024
PFF0711-04	GW4	Groundwater	11/06/2024	12/06/2024
PFF0711-05	GW5	Groundwater	11/06/2024	12/06/2024
PFF0711-06	GW6	Groundwater	11/06/2024	12/06/2024
PFF0711-07	GW7	Groundwater	11/06/2024	12/06/2024
PFF0711-08	GW8	Groundwater	11/06/2024	12/06/2024
PFF0711-09	GW9	Groundwater	11/06/2024	12/06/2024

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Acid Extractable Metals (Groundwater)

Envirolab ID	**Units**	**PQL**	PFF0711-01	PFF0711-02	PFF0711-03	PFF0711-04	PFF0711-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/06/2024	11/06/2024	11/06/2024	11/06/2024	11/06/2024
Phosphorus	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Envirolab ID	**Units**	**PQL**	PFF0711-06	PFF0711-07	PFF0711-08	PFF0711-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/06/2024	11/06/2024	11/06/2024	11/06/2024
Phosphorus	mg/L	0.050	0.088	<0.050	0.071	<0.050

Certificate of Analysis PFF0711

Dissolved Low Level Metals (Groundwater)

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PFF0711-01 GW1 11/06/2024	PFF0711-02 GW2 11/06/2024	PFF0711-03 GW3 11/06/2024	PFF0711-04 GW4 11/06/2024	PFF0711-05 GW5 11/06/2024
Arsenic	µg/L	1.0	1.1	<1.0	1.3	<1.0	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	1.0	<1.0	2.2	2.6	2.4
Copper	µg/L	1.0	<1.0	<1.0	<1.0	1.6	<1.0
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	13	1.1	5.9	4.4	<1.0
Lead	µg/L	1.0	<1.0	<1.0	1.7	2.4	1.4
Zinc	µg/L	1.0	2.2	2.9	9.4	6.6	2.8

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PFF0711-06 GW6 11/06/2024	PFF0711-07 GW7 11/06/2024	PFF0711-08 GW8 11/06/2024	PFF0711-09 GW9 11/06/2024
Arsenic	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Cadmium	µg/L	0.10	0.19	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	6.0	2.4	4.0	2.4
Copper	µg/L	1.0	4.5	<1.0	<1.0	6.1
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	3.5	3.9	<1.0	2.2
Lead	µg/L	1.0	3.8	2.1	1.8	7.1
Zinc	µg/L	1.0	11	2.7	3.1	6.8

Inorganics - Ionic Balance and Indexes (Groundwater)

Envirolab ID	**Units**	**PQL**	PFF0711-01	PFF0711-02	PFF0711-03	PFF0711-04	PFF0711-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/06/2024	11/06/2024	11/06/2024	11/06/2024	11/06/2024
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	10	<5.0	<5.0	<5.0
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	10	<5.0	<5.0	<5.0

Envirolab ID	**Units**	**PQL**	PFF0711-06	PFF0711-07	PFF0711-08	PFF0711-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/06/2024	11/06/2024	11/06/2024	11/06/2024
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	9.8	14	15	21
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	9.8	14	15	21

Certificate of Analysis PFF0711

Inorganics - Nutrients (Groundwater)

Envirolab ID	**Units**	**PQL**	PFF0711-01	PFF0711-02	PFF0711-03	PFF0711-04	PFF0711-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/06/2024	11/06/2024	11/06/2024	11/06/2024	11/06/2024
Ammonia as N	mg/L	0.0050	0.55	0.024	0.16	0.26	0.12
Nitrate as N	mg/L	0.0050	<0.0050	0.26	0.020	0.21	<0.0050
Nitrate as NO3 by calculation	mg/L	0.020	<0.020	1.2	0.087	0.94	<0.020
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	<0.020	<0.020	<0.020
NOx as N	mg/L	0.0050	<0.0050	0.26	0.020	0.22	<0.0050
TKN as N by calculation	mg/L	0.10	1.4	0.49	1.1	2.6	0.67
Organic Nitrogen by calc.	mg/L	0.10	0.82	0.47	0.97	2.3	0.55
Total Nitrogen	mg/L	0.10	1.4	0.75	1.2	2.8	0.67
Phosphate as P	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

Envirolab ID	**Units**	**PQL**	PFF0711-06	PFF0711-07	PFF0711-08	PFF0711-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/06/2024	11/06/2024	11/06/2024	11/06/2024
Ammonia as N	mg/L	0.0050	0.10	0.27	0.13	0.0095
Nitrate as N	mg/L	0.0050	0.66	0.025	0.016	0.18
Nitrate as NO3 by calculation	mg/L	0.020	2.9	0.11	0.072	0.81
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	<0.020	<0.020
NOx as N	mg/L	0.0050	0.66	0.025	0.016	0.19
TKN as N by calculation	mg/L	0.10	5.9	0.99	0.86	2.4
Organic Nitrogen by calc.	mg/L	0.10	5.8	0.72	0.73	2.4
Total Nitrogen	mg/L	0.10	6.5	1.0	0.88	2.6
Phosphate as P	mg/L	0.0050	0.0070	<0.0050	0.045	0.0056

Method Summary

Method ID	Methodology Summary
Calc	Calculation
Calc - TKN	TKN determined by calculation (Total Nitrogen - NOx).
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition 2320-B. Solids reported from a 1:5 water extract unless otherwise specified. Total Carbon Dioxide - determined by calculation in accordance with APHA latest edition,4500-CO2 D.
INORG-055	Nitrate/Nitrite/NOx/TKN - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils/solids are analysed following a water extraction.
INORG-057	Ammonia - determined colourimetrically. Water samples are filtered on receipt prior to analysis. Soils and OHS media are analysed following a water extraction. Alternatively, Ammonia can be extracted from soil using 1M KCl.
INORG-060	Phosphate - determined colourimetrically using APHA latest edition 4500 P E. Water samples are filtered on receipt prior to analysis. Soils are analysed from a water extract.
INORG-127	Total Nitrogen by high temperature catalytic combustion with chemiluminescence detection. Organic Carbon forms (inorganic, organic, total) determined using a TOC/NDIR analyser via combustion. Dissolved forms require filtering prior to determination.
METALS-020	Determination of various metals by ICP-OES.
METALS-021	Determination of Mercury by Cold Vapour AAS.
METALS-022	Determination of various metals by ICP-MS.Please note for Bromine and Iodine, any forms of these elements that are present are included together in the one result reported for each of these two elements.Salt forms and/or anion/cation forms (e.g. FeO, PbO, ZnO, BO3) are determined stoichiometrically from the base metal concentration.

Result Definitions

Identifier	Description
NR	Not reported
NEPM	National Environment Protection Measure
NS	Not specified
LCS	Laboratory Control Sample
RPD	Relative Percent Difference
>	Greater than
<	Less than
PQL	Practical Quantitation Limit
INS	Insufficient sample for this test
NA	Test not required
NT	Not tested
DOL	Samples rejected due to particulate overload (air filters only)
RFD	Samples rejected due to filter damage (air filters only)
RUD	Samples rejected due to uneven deposition (air filters only)
##	Indicates a laboratory acceptance criteria outlier, for further details, see Result Comments and/or QC Comments

Quality Control Definitions

Blank

This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, and is determined by processing solvents and reagents in exactly the same manner as for samples.

Surrogate Spike

Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

LCS (Laboratory Control Sample)

This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Matrix Spike

A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

Duplicate

This is the complete duplicate analysis of a sample from the process batch. The sample selected should be one where the analyte concentration is easily measurable.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria. Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction. Spikes for Physical and Aggregate Tests are not applicable. For VOCs in water samples, three vials are required for duplicate or spike analysis.

General Acceptance Criteria (GAC) - Analyte specific criteria applies for some analytes and is reflected in QC recovery tables.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% - see ELN-P05 QAQC tables for details (available on request); <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase. Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was typically insufficient in order to satisfy laboratory QA/QC protocols.

Miscellaneous Information

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached. We have taken the sampling date as being the date received at the laboratory.

Two significant figures are reported for the majority of tests and with a high degree of confidence, for results <10*PQL, the second significant figure may be in doubt i.e. has a relatively high degree of uncertainty and is provided for information only.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS where sediment/solids are included by default.

Urine Analysis - The BEI values listed are taken from the 2022 edition of *TLVs and BEIs Threshold Limits by ACGIH*.

Air volume measurements are not covered by Envirolab's NATA accreditation.

Data Quality Assessment Summary PFF0711

Client Details

Client	Hyd2O
Your Reference	H24009 - Ballajura Monitoring
Date Issued	19/06/2024

Recommended Holding Time Compliance

Recommended holding time exceedances exist - See detailed list below

Quality Control and QC Frequency

QC Type	Compliant	Details
Blank	Yes	No Outliers
LCS	Yes	No Outliers
Duplicates	No	Duplicate Outliers Exist - See detailed list below
Matrix Spike	Yes	No Outliers
Surrogates / Extracted Internal Standards	Yes	No Outliers
QC Frequency	Yes	No Outliers

Surrogates/Extracted Internal Standards, Duplicates and/or Matrix Spikes are not always relevant/applicable to certain analyses and matrices. Therefore, said QC measures are deemed compliant in these situations by default. See Laboratory Acceptance Criteria for more information

Data Quality Assessment Summary PFF0711

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
Total Phosphorus | Water	1-9	11/06/2024	13/06/2024	14/06/2024	Yes
Dissolved Metals (LL) | Water	1-8	11/06/2024	13/06/2024	14/06/2024	Yes
	9	11/06/2024	13/06/2024	17/06/2024	Yes
Dissolved Metals (LL)-Hg | Water	1-9	11/06/2024	13/06/2024	13/06/2024	Yes
Alkalinity Suite | Water	1-9	11/06/2024	13/06/2024	13/06/2024	Yes
Nitrogen - Ammonia | Water	1-9	11/06/2024	14/06/2024	14/06/2024	Yes
Nitrogen - Nitrate | Water	1-9	11/06/2024	14/06/2024	14/06/2024	Yes
Nitrogen - Nitrite | Water	1-9	11/06/2024	14/06/2024	14/06/2024	No
Nitrogen - NOx | Water	1-9	11/06/2024	14/06/2024	14/06/2024	Yes
Nitrogen - Total N | Water	1-8	11/06/2024	14/06/2024	14/06/2024	Yes
	9	11/06/2024	14/06/2024	15/06/2024	Yes
Phosphate as P | Water	1-9	11/06/2024	14/06/2024	14/06/2024	No
TKN as N calc | Water	1-9	11/06/2024	13/06/2024	18/06/2024	Yes

Outliers: Duplicates

METALS-022|Dissolved Low Level Metals (Water)| Batch BFF1889

Sample ID	Duplicate ID	Analyte	% Limits	RPD
BFF1889-DUP1#	DUP1	Copper	20.00	200[1]
BFF1889-DUP1#	DUP1	Nickel	20.00	200[1]

Quality Control PFF0711

METALS-020 | Acid Extractable Metals (Water) | Batch BFF1891

Analyte	Units	PQL	Blank	DUP1 BFF1891-DUP1# Samp | QC | RPD %	DUP2 BFF1891-DUP2# Samp | QC | RPD %	LCS %	Spike % BFF1891-MS1#
Phosphorus	mg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	0.773 | 0.781 | 1.11	96.7	94.9

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-021 | Dissolved Low Level Metals (Water) | Batch BFF1811

Analyte	Units	PQL	Blank	DUP1 BFF1811-DUP1# Samp | QC | RPD %	DUP2 PFF0711-01 Samp | QC | RPD %	LCS %	Spike % BFF1811-MS1#
Mercury	µg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	106	105

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-022 | Dissolved Low Level Metals (Water) | Batch BFF1830

Analyte	Units	PQL	Blank	DUP1 BFF1830-DUP1# Samp | QC | RPD %	DUP2 BFF1830-DUP2# Samp | QC | RPD %	LCS %	Spike % BFF1830-MS1#
Arsenic	µg/L	1.0	<1.0	11.1 | 10.9 | 2.13	<1.0 | <1.0 | [NA]	113	110
Cadmium	µg/L	0.10	<0.10	0.510 | 0.515 | 0.976	<0.10 | <0.10 | [NA]	116	114
Chromium	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	114	110
Copper	µg/L	1.0	<1.0	4.86 | 4.96 | 2.04	<1.0 | <1.0 | [NA]	118	113
Lead	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	105	103
Nickel	µg/L	1.0	<1.0	5.00 | 5.26 | 4.87	<1.0 | <1.0 | [NA]	115	112
Zinc	µg/L	1.0	<1.0	36.8 | 34.9 | 5.38	2.87 | 2.67 | 7.08	110	92.6

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-022 | Dissolved Low Level Metals (Water) | Batch BFF1889

Analyte	Units	PQL	Blank	DUP1 BFF1889-DUP1# Samp | QC | RPD %	LCS %	Spike % PFF0711-09
Arsenic	µg/L	1.0	<1.0	<2.0 | <2.0 | [NA]	108	108
Cadmium	µg/L	0.10	<0.10	<0.20 | <0.20 | [NA]	108	110
Chromium	µg/L	1.0	<1.0	<2.0 | <2.0 | [NA]	107	105
Copper	µg/L	1.0	<1.0	2.78 | <2.0 | 200 [1]	108	105
Lead	µg/L	1.0	<1.0	<2.0 | <2.0 | [NA]	102	102
Nickel	µg/L	1.0	<1.0	2.10 | <2.0 | 200 [1]	108	105
Zinc	µg/L	1.0	<1.0	<2.0 | <2.0 | [NA]	108	101

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-006 | Inorganics - Ionic Balance and Indexes (Water) | Batch BFF1751

Analyte	Units	PQL	Blank	DUP1 BFF1751-DUP1# Samp | QC | RPD %	DUP2 PFF0711-03 Samp | QC | RPD %	LCS %
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	25.0 | 24.3 | 2.84	<5.0 | <5.0 | [NA]	[NA]
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	25.0 | 24.3 | 2.84	<5.0 | <5.0 | [NA]	96.4

Analyte	Units	PQL	Blank	LCS %
Total Alkalinity as CaCO3	mg/L as CaCO3	5		103

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PFF0711

INORG-006 | Inorganics - Ionic Balance and Indexes (Water) | Batch BFF1752

Analyte	Units	PQL	Blank	DUP1 PFF0711-05 Samp | QC | RPD %	LCS %
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	[NA]
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	101

Analyte	Units	PQL	Blank	LCS %
Total Alkalinity as CaCO3	mg/L as CaCO3	5		105

INORG-127 | Inorganics - Nutrients (Water) | Batch BFF2081

Analyte	Units	PQL	Blank	DUP1 BFF2081-DUP1# Samp | QC | RPD %	DUP2 PFF0711-02 Samp | QC | RPD %	LCS %	Spike % BFF2081-MS1#
Total Nitrogen	mg/L	0.10	<0.10	2.05 | 2.10 | 1.97	0.752 | 0.795 | 5.57	109	108

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-057 | Inorganics - Nutrients (Water) | Batch BFF2121

Analyte	Units	PQL	Blank	DUP1 PFF0711-01 Samp | QC | RPD %	DUP2 BFF2121-DUP2# Samp | QC | RPD %	LCS %	Spike % PFF0711-02
Ammonia as N	mg/L	0.0050	<0.0050	0.552 | 0.624 | 12.2	53.3 | 52.8 | 0.885	88.5	110
Nitrate as N	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	<0.0050 | <0.0050 | [NA]	101	129
Nitrate as NO3 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	<0.0050 | <0.0050 | [NA]	91.6	106
Nitrite as NO2 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
NOx as N	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	<0.0050 | <0.0050 | [NA]	101	129
Phosphate as P	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	7.80 | 7.85 | 0.611	113	118

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

QC Comments

Identifier	Description
[1]	Duplicate %RPD may be flagged as an outlier to routine laboratory acceptance, however, where one or both results are <10*PQL, the RPD acceptance criteria increases exponentially.

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Client Details

Client	Hyd2O
Contact	Sean O'Sullivan
Address	Suite 6B, 103 Rokeby Rd, SUBIACO, WA, 6008

Sample Details

Your Reference	H24009 - Ballajura Monitoring
Number of Samples	9 Groundwater
Date Samples Received	12/09/2024
Date Instructions Received	12/09/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for soils and on an as received basis for other matrices.

Report Details

Date Results Requested by	19/09/2024
Date of Issue	19/09/2024

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Authorisation Details

Results Approved By	Jessica Miller, Microbiological Supervisor Lien Tang, Assistant Operations Manager Lucas Yii, Inorganics Team Leader Sally Rogers, Senior Microbiological Analyst Travis Carey, Organics Supervisor Varsha Ho Wing, Inorganics and Metals Supervisor
Laboratory Manager	Michael Kubiak

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Samples in this Report

Envirolab ID	Sample ID	Matrix	Date Sampled	Date Received
PFI0937-01	GW1	Groundwater	11/09/2024	12/09/2024
PFI0937-02	GW2	Groundwater	11/09/2024	12/09/2024
PFI0937-03	GW3	Groundwater	11/09/2024	12/09/2024
PFI0937-04	GW4	Groundwater	11/09/2024	12/09/2024
PFI0937-05	GW5	Groundwater	11/09/2024	12/09/2024
PFI0937-06	GW6	Groundwater	11/09/2024	12/09/2024
PFI0937-07	GW7	Groundwater	11/09/2024	12/09/2024
PFI0937-08	GW8	Groundwater	11/09/2024	12/09/2024
PFI0937-09	GW9	Groundwater	11/09/2024	12/09/2024

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Organochlorine Pesticides (Groundwater)

Envirolab ID	**Units**	**PQL**	PFI0937-05	PFI0937-06	PFI0937-09
Your Reference			GW5	GW6	GW9
Date Sampled			11/09/2024	11/09/2024	11/09/2024
alpha-BHC	µg/L	0.20	<0.20	<0.20	<0.20
Hexachlorobenzene	µg/L	0.20	<0.20	<0.20	<0.20
beta-BHC	µg/L	0.20	<0.20	<0.20	<0.20
gamma-BHC	µg/L	0.20	<0.20	<0.20	<0.20
delta-BHC	µg/L	0.20	<0.20	<0.20	<0.20
Heptachlor	µg/L	0.20	<0.20	<0.20	<0.20
Aldrin	µg/L	0.20	<0.20	<0.20	<0.20
Heptachlor epoxide	µg/L	0.20	<0.20	<0.20	<0.20
trans-Chlordane	µg/L	0.20	<0.20	<0.20	<0.20
cis-Chlordane	µg/L	0.20	<0.20	<0.20	<0.20
Endosulfan I	µg/L	0.20	<0.20	<0.20	<0.20
4,4'-DDE	µg/L	0.20	<0.20	<0.20	<0.20
Dieldrin	µg/L	0.20	<0.20	<0.20	<0.20
Endrin	µg/L	0.20	<0.20	<0.20	<0.20
4,4'-DDD	µg/L	0.20	<0.20	<0.20	<0.20
Endosulfan II	µg/L	0.20	<0.20	<0.20	<0.20
Endrin aldehyde	µg/L	0.20	<0.20	<0.20	<0.20
4,4'-DDT	µg/L	0.20	<0.20	<0.20	<0.20
Endosulfan sulfate	µg/L	0.20	<0.20	<0.20	<0.20
Endrin ketone	µg/L	0.20	<0.20	<0.20	<0.20
Methoxychlor	µg/L	0.20	<0.20	<0.20	<0.20
Mirex	µg/L	0.20	<0.20	<0.20	<0.20
Total +ve OCP	µg/L	0.20	<0.20	<0.20	<0.20
Surrogate 4-chloro-3-nitrobenzotrifluoride	%		*75.1*	*84.2*	*70.0*

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Organophosphorus Pesticides (Groundwater)

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PFI0937-05 GW5 11/09/2024	PFI0937-06 GW6 11/09/2024	PFI0937-09 GW9 11/09/2024
Dichlorvos	µg/L	0.20	<0.20	<0.20	<0.20
Dimethoate	µg/L	0.20	<0.20	<0.20	<0.20
Diazinon	µg/L	0.20	<0.20	<0.20	<0.20
Chlorpyrifos-methyl	µg/L	0.20	<0.20	<0.20	<0.20
Ronnel	µg/L	0.20	<0.20	<0.20	<0.20
Fenitrothion	µg/L	0.20	<0.20	<0.20	<0.20
Malathion	µg/L	0.20	<0.20	<0.20	<0.20
Chlorpyrifos	µg/L	0.20	<0.20	<0.20	<0.20
Parathion	µg/L	0.20	<0.20	<0.20	<0.20
Bromophos-ethyl	µg/L	0.20	<0.20	<0.20	<0.20
Ethion	µg/L	0.20	<0.20	<0.20	<0.20
Coumaphos	µg/L	0.20	<0.20	<0.20	<0.20
Disulfoton	µg/L	0.20	<0.20	<0.20	<0.20
Fenamiphos	µg/L	0.20	<0.20	<0.20	<0.20
Fenthion	µg/L	0.20	<0.20	<0.20	<0.20
Methidathion	µg/L	0.20	<0.20	<0.20	<0.20
Mevinphos	µg/L	0.20	<0.20	<0.20	<0.20
Parathion-methyl	µg/L	0.20	<0.20	<0.20	<0.20
Phorate	µg/L	0.20	<0.20	<0.20	<0.20
Phosalone	µg/L	0.20	<0.20	<0.20	<0.20
Azinphos-methyl	µg/L	0.20	<0.20	<0.20	<0.20
Surrogate 4-chloro-3-nitrobenzotrifluoride	%		*75.1*	*84.2*	*70.0*

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Glyphosate (Groundwater)

Envirolab ID	**Units**	**PQL**	PFI0937-05	PFI0937-06	PFI0937-09
Your Reference			GW5	GW6	GW9
Date Sampled			11/09/2024	11/09/2024	11/09/2024
Glyphosate	mg/L	0.010	<0.010	<0.010	<0.010

Acid Extractable Metals (Groundwater)

Envirolab ID	**Units**	**PQL**	PFI0937-01	PFI0937-02	PFI0937-03	PFI0937-04	PFI0937-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/09/2024	11/09/2024	11/09/2024	11/09/2024	11/09/2024
Phosphorus	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Envirolab ID	**Units**	**PQL**	PFI0937-06	PFI0937-07	PFI0937-08	PFI0937-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/09/2024	11/09/2024	11/09/2024	11/09/2024
Phosphorus	mg/L	0.050	<0.050	<0.050	0.36	<0.050

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Dissolved Low Level Metals (Groundwater)

Envirolab ID	**Units**	**PQL**	PFI0937-01	PFI0937-02	PFI0937-03	PFI0937-04	PFI0937-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/09/2024	11/09/2024	11/09/2024	11/09/2024	11/09/2024
Arsenic	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	1.3
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	<1.0	<1.0	1.7	3.7	3.6
Copper	µg/L	1.0	1.5	<1.0	1.8	1.5	<1.0
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	11	<1.0	2.1	10	<1.0
Lead	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	µg/L	1.0	1.2	<1.0	3.7	6.0	2.8

Envirolab ID	**Units**	**PQL**	PFI0937-06	PFI0937-07	PFI0937-08	PFI0937-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/09/2024	11/09/2024	11/09/2024	11/09/2024
Arsenic	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	6.3	2.3	3.9	1.9
Copper	µg/L	1.0	3.8	<1.0	<1.0	2.7
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	3.2	7.3	<1.0	<1.0
Lead	µg/L	1.0	5.5	<1.0	<1.0	<1.0
Zinc	µg/L	1.0	15	4.0	2.4	2.2

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Inorganics - Ionic Balance and Indexes (Groundwater)

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PFI0937-01 GW1 11/09/2024	PFI0937-02 GW2 11/09/2024	PFI0937-03 GW3 11/09/2024	PFI0937-04 GW4 11/09/2024	PFI0937-05 GW5 11/09/2024
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	7.9	14	13	11
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	7.9	14	13	11

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PFI0937-06 GW6 11/09/2024	PFI0937-07 GW7 11/09/2024	PFI0937-08 GW8 11/09/2024	PFI0937-09 GW9 11/09/2024
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	9.8	29
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	9.8	29

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Inorganics - Nutrients (Groundwater)

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PFI0937-01 GW1 11/09/2024	PFI0937-02 GW2 11/09/2024	PFI0937-03 GW3 11/09/2024	PFI0937-04 GW4 11/09/2024	PFI0937-05 GW5 11/09/2024
Ammonia as N	mg/L	0.0050	0.54	0.026	0.045	0.11	0.14
Nitrate as N	mg/L	0.0050	0.011	7.2	4.7	<0.050 [2]	<0.050 [2]
Nitrate as NO3 by calculation	mg/L	0.020	0.049	32	21	<0.20 [2]	<0.20 [2]
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.050 [2]	<0.050 [2]
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	<0.020	<0.20 [2]	<0.20 [2]
NOx as N	mg/L	0.0050	0.012	7.2	4.7	<0.050 [2]	<0.050 [2]
TKN as N by calculation	mg/L	0.10	1.4	2.5	3.0	1.7	0.84
Organic Nitrogen by calc.	mg/L	0.10	0.85	2.5	3.0	1.6	0.69
Total Nitrogen	mg/L	0.10	1.4	9.7	7.7	1.7	0.81
Phosphate as P	mg/L	0.0050	0.011	0.0082	0.0062	0.0070	<0.0050

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PFI0937-06 GW6 11/09/2024	PFI0937-07 GW7 11/09/2024	PFI0937-08 GW8 11/09/2024	PFI0937-09 GW9 11/09/2024
Ammonia as N	mg/L	0.0050	0.081	0.29	0.19	0.051
Nitrate as N	mg/L	0.0050	1.1	<0.0050	<0.050 [2]	0.31 [2]
Nitrate as NO3 by calculation	mg/L	0.020	4.7	<0.020	<0.20 [2]	1.4 [2]
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	<0.050 [2]	<0.050 [2]
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	<0.20 [2]	<0.20 [2]
NOx as N	mg/L	0.0050	1.1	<0.0050	<0.050 [2]	0.33
TKN as N by calculation	mg/L	0.10	2.0	0.65	1.4	1.6
Organic Nitrogen by calc.	mg/L	0.10	2.0	0.35	1.3	1.5
Total Nitrogen	mg/L	0.10	3.1	0.65	1.4	1.9
Phosphate as P	mg/L	0.0050	0.0054	<0.0050	0.033	0.011

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Microbiological Suite (Groundwater)

Envirolab ID	**Units**	**PQL**	PFI0937-01	PFI0937-02	PFI0937-03	PFI0937-04	PFI0937-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/09/2024	11/09/2024	11/09/2024	11/09/2024	11/09/2024
Thermotolerant Coliforms	cfu/100mL	1	<10 [1]	<10 [1]	480 [1]	<10 [1]	<10 [1]
E.coli	cfu/100mL	1	<10 [1]	<10 [1]	<10 [1]	<10 [1]	<10 [1]

Envirolab ID	**Units**	**PQL**	PFI0937-06	PFI0937-07	PFI0937-08	PFI0937-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/09/2024	11/09/2024	11/09/2024	11/09/2024
Thermotolerant Coliforms	cfu/100mL	1	<10 [1]	<10 [1]	<10 [1]	<10 [1]
E.coli	cfu/100mL	1	<10 [1]	<10 [1]	<10 [1]	<10 [1]

Result Comments

Identifier	Description
[1]	Microbiological testing PQL raised due to high sample turbidity and/or matrix interference.
[2]	PQL(s) has/have been raised due to matrix interference.

Method Summary

Method ID	Methodology Summary
Calc	Calculation
Calc - TKN	TKN determined by calculation (Total Nitrogen - NOx).
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition 2320-B. Solids reported from a 1:5 water extract unless otherwise specified. Total Carbon Dioxide - determined by calculation in accordance with APHA latest edition,4500-CO2 D.
INORG-055	Nitrate/Nitrite/NOx/TKN - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils/solids are analysed following a water extraction.
INORG-057	Ammonia - determined colourimetrically. Water samples are filtered on receipt prior to analysis. Soils and OHS media are analysed following a water extraction. Alternatively, Ammonia can be extracted from soil using 1M KCl.
INORG-060	Phosphate - determined colourimetrically using APHA latest edition 4500 P E. Water samples are filtered on receipt prior to analysis. Soils are analysed from a water extract.
INORG-127	Total Nitrogen by high temperature catalytic combustion with chemiluminescence detection. Organic Carbon forms (inorganic, organic, total) determined using a TOC/NDIR analyser via combustion. Dissolved forms require filtering prior to determination.
METALS-020	Determination of various metals by ICP-OES.
METALS-021	Determination of Mercury by Cold Vapour AAS.
METALS-022	Determination of various metals by ICP-MS.Please note for Bromine and Iodine, any forms of these elements that are present are included together in the one result reported for each of these two elements.Salt forms and/or anion/cation forms (e.g. FeO, PbO, ZnO, BO3) are determined stoichiometrically from the base metal concentration.
MICRO-001B	E. coli/Thermotolerant coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.5-latest edition). Recommended maximums based on NHMRC Australian Drinking Water Guidelines. Please note that results for this test derived from counts outside of the range 10-100 are considered approximate as per AS4276.1.
ORG-022	Determination of semi-volatile organic compounds (SVOCs) by GC-MS. Water samples are extracted by LLE and soils using DCM/Acetone/Methanol.
ORG-022_OC	Determination of semi-volatile organic compounds (SVOCs) by GC-MS. Water samples are extracted by LLE and soils using DCM/Acetone/Methanol.
ORG-029_SVOC_VOC_LCMSMS	Water samples are run directly, soils are extracted using an aqueous buffer and plant material using solvent extraction/cleanup. Further cleanup maybe necessary. Analysis using LC-MSMS.

Result Definitions

Identifier	Description
NR	Not reported
NEPM	National Environment Protection Measure
NS	Not specified
LCS	Laboratory Control Sample
RPD	Relative Percent Difference
>	Greater than
<	Less than
PQL	Practical Quantitation Limit
INS	Insufficient sample for this test
NA	Test not required
NT	Not tested
DOL	Samples rejected due to particulate overload (air filters only)
RFD	Samples rejected due to filter damage (air filters only)
RUD	Samples rejected due to uneven deposition (air filters only)
##	Indicates a laboratory acceptance criteria outlier, for further details, see Result Comments and/or QC Comments

Quality Control Definitions

Blank

This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, and is determined by processing solvents and reagents in exactly the same manner as for samples.

Surrogate Spike

Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

LCS (Laboratory Control Sample)

This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Matrix Spike

A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

Duplicate

This is the complete duplicate analysis of a sample from the process batch. The sample selected should be one where the analyte concentration is easily measurable.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria. Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction. Spikes for Physical and Aggregate Tests are not applicable. For VOCs in water samples, three vials are required for duplicate or spike analysis.

General Acceptance Criteria (GAC) - Analyte specific criteria applies for some analytes and is reflected in QC recovery tables.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% - see ELN-P05 QAQC tables for details (available on request); <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase. Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was typically insufficient in order to satisfy laboratory QA/QC protocols.

Miscellaneous Information

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached. We have taken the sampling date as being the date received at the laboratory.

Two significant figures are reported for the majority of tests and with a high degree of confidence, for results <10*PQL, the second significant figure may be in doubt i.e. has a relatively high degree of uncertainty and is provided for information only.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS where sediment/solids are included by default.

Urine Analysis - The BEI values listed are taken from the 2022 edition of *TLVs and BEIs Threshold Limits by ACGIH*.

Air volume measurements are not covered by Envirolab's NATA accreditation.

Data Quality Assessment Summary PFI0937

Client Details

Client	Hyd2O
Your Reference	H24009 - Ballajura Monitoring
Date Issued	19/09/2024

Recommended Holding Time Compliance

No recommended holding time exceedances

Quality Control and QC Frequency

QC Type	Compliant	Details
Blank	Yes	No Outliers
LCS	Yes	No Outliers
Duplicates	Yes	No Outliers
Matrix Spike	Yes	No Outliers
Surrogates / Extracted Internal Standards	Yes	No Outliers
QC Frequency	Yes	No Outliers

Surrogates/Extracted Internal Standards, Duplicates and/or Matrix Spikes are not always relevant/applicable to certain analyses and matrices. Therefore, said QC measures are deemed compliant in these situations by default. See Laboratory Acceptance Criteria for more information

Data Quality Assessment Summary PFI0937

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
OCP | Water	5-6, 9	11/09/2024	13/09/2024	13/09/2024	Yes
OPP (21 list) | Water	5-6, 9	11/09/2024	13/09/2024	13/09/2024	Yes
Glyphosate | Water	5-6, 9	11/09/2024	17/09/2024	17/09/2024	Yes
Total Phosphorus | Water	1-9	11/09/2024	18/09/2024	18/09/2024	Yes
Dissolved Metals (LL) | Water	1-9	11/09/2024	18/09/2024	18/09/2024	Yes
Dissolved Metals (LL)-Hg | Water	1-9	11/09/2024	18/09/2024	18/09/2024	Yes
Alkalinity Suite | Water	1-9	11/09/2024	13/09/2024	13/09/2024	Yes
Nitrogen - Ammonia | Water	1-9	11/09/2024	13/09/2024	13/09/2024	Yes
Nitrogen - Nitrate | Water	1-3, 6-7	11/09/2024	13/09/2024	13/09/2024	Yes
	4-5, 8-9	11/09/2024	13/09/2024	16/09/2024	Yes
Nitrogen - Nitrite | Water	1-3, 6-7	11/09/2024	13/09/2024	13/09/2024	Yes
	4-5, 8-9	11/09/2024	13/09/2024	16/09/2024	Yes
Nitrogen - NOx | Water	1-3, 6-7	11/09/2024	13/09/2024	13/09/2024	Yes
	4-5, 8-9	11/09/2024	13/09/2024	16/09/2024	Yes
Nitrogen - Total N | Water	1-9	11/09/2024	17/09/2024	18/09/2024	Yes
Phosphate as P | Water	1-9	11/09/2024	13/09/2024	13/09/2024	Yes
TKN as N calc | Water	1-9	11/09/2024	16/09/2024	19/09/2024	Yes
E. coli & T.T.coli | Water	1-9	11/09/2024	12/09/2024	12/09/2024	Yes

Quality Control PFI0937

ORG-022_OC | Organochlorine Pesticides (Water) | Batch BFI2420

Analyte	Units	PQL	Blank	DUP1	DUP2	LCS %	Spike %
				BFI2420-DUP1#	BFI2420-DUP2#		BFI2420-MS2#
				Samp | QC | RPD %	Samp | QC | RPD %		
alpha-BHC	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	84.1	96.1
Hexachlorobenzene	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
beta-BHC	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	80.9	93.2
gamma-BHC	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
delta-BHC	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Heptachlor	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	87.6	90.8
Aldrin	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	72.9	61.5
Heptachlor epoxide	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	86.2	92.3
trans-Chlordane	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
cis-Chlordane	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Endosulfan I	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
4,4'-DDE	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	60.5	62.2
Dieldrin	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	86.7	89.8
Endrin	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	88.9	99.6
4,4'-DDD	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	78.5	79.3
Endosulfan II	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Endrin aldehyde	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
4,4'-DDT	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Endosulfan sulfate	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	81.4	94.3
Endrin ketone	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Methoxychlor	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Mirex	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Surrogate *4-chloro-3-nitrobenzotrifluoride*	*%*		*77.6*	*77.8 | 92.1*	*89.1 | 87.3*	*84.4*	*97.2*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

ORG-022 | Organophosphorus Pesticides (Water) | Batch BFI2420

Analyte	Units	PQL	Blank	DUP1	DUP2	LCS %	Spike %
				BFI2420-DUP1#	BFI2420-DUP2#		BFI2420-MS2#
				Samp | QC | RPD %	Samp | QC | RPD %		
Dichlorvos	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	78.5	92.5
Dimethoate	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Diazinon	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Chlorpyrifos-methyl	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	83.9	93.0
Ronnel	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	77.6	84.0
Fenitrothion	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	90.6	107
Malathion	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	90.4	103
Chlorpyrifos	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	82.0	86.5
Parathion	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	90.5	111
Bromophos-ethyl	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Ethion	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	75.7	80.4
Coumaphos	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Disulfoton	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Fenamiphos	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Fenthion	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Methidathion	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Mevinphos	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Parathion-methyl	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Phorate	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Phosalone	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Azinphos-methyl	µg/L	0.20	<0.20	<0.20 | <0.20 | [NA]	<0.20 | <0.20 | [NA]	[NA]	[NA]
Surrogate *4-chloro-3-nitrobenzotrifluoride*	*%*		*77.6*	*77.8 | 92.1*	*89.1 | 87.3*	*84.4*	*97.2*

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PFI0937

ORG-029_SVOC_VOC_LCMSMS | Glyphosate (Water) | Batch BFI2968

Analyte	Units	PQL	Blank	DUP1 PFI0937-05 Samp | QC | RPD %	LCS %	Spike % PFI0937-06
Glyphosate	mg/L	0.010	<0.010	<0.010 | <0.010 | [NA]	105	93.1

METALS-020 | Acid Extractable Metals (Water) | Batch BFI3176

Analyte	Units	PQL	Blank	DUP1 BFI3176-DUP1# Samp | QC | RPD %	DUP2 BFI3176-DUP2# Samp | QC | RPD %	LCS %	Spike % BFI3176-MS1#
Phosphorus	mg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	103	103

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-020 | Acid Extractable Metals (Water) | Batch BFI3177

Analyte	Units	PQL	Blank	DUP1 PFI0937-04 Samp | QC | RPD %	DUP2 BFI3177-DUP2# Samp | QC | RPD %	LCS %	Spike % PFI0937-05
Phosphorus	mg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	0.649 | 0.632 | 2.63	98.9	99.5

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-021 | Dissolved Low Level Metals (Water) | Batch BFI3194

Analyte	Units	PQL	Blank	DUP1 PFI0937-01 Samp | QC | RPD %	DUP2 BFI3194-DUP2# Samp | QC | RPD %	LCS %	Spike % PFI0937-02
Mercury	µg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	105	107

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-022 | Dissolved Low Level Metals (Water) | Batch BFI3198

Analyte	Units	PQL	Blank	DUP1 PFI0937-01 Samp | QC | RPD %	DUP2 PFI0937-09 Samp | QC | RPD %	LCS %	Spike % PFI0937-02
Arsenic	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	101	102
Cadmium	µg/L	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	102	105
Chromium	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	1.93 | 1.97 | [NA]	101	104
Copper	µg/L	1.0	<1.0	1.50 | 1.58 | [NA]	2.68 | 2.70 | [NA]	95.6	97.0
Lead	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	91.3	92.5
Nickel	µg/L	1.0	<1.0	11.4 | 11.6 | 1.83	<1.0 | <1.0 | [NA]	97.6	98.4
Zinc	µg/L	1.0	<1.0	1.20 | 1.22 | [NA]	2.24 | 2.56 | [NA]	98.7	104

INORG-006 | Inorganics - Ionic Balance and Indexes (Water) | Batch BFI2475

Analyte	Units	PQL	Blank	DUP1 BFI2475-DUP1# Samp | QC | RPD %	DUP2 BFI2475-DUP2# Samp | QC | RPD %	LCS %
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	274 | 268 | 2.31	329 | 336 | 2.07	[NA]
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	274 | 268 | 2.31	329 | 336 | 2.07	91.9

Analyte	Units	PQL	Blank	LCS %
Total Alkalinity as CaCO3	mg/L as CaCO3	5		101

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PFI0937

INORG-057 | Inorganics - Nutrients (Water) | Batch BFI2496

Analyte	Units	PQL	Blank	DUP1 BFI2496-DUP1# Samp | QC | RPD %	DUP2 PFI0937-09 Samp | QC | RPD %	LCS %	Spike % PFI0937-01
Ammonia as N	mg/L	0.0050	<0.0050	0.0334 | 0.0301 | 10.5	0.0510 | 0.0477 | 6.67	104	99.9
Nitrate as N	mg/L	0.0050	<0.0050	0.945 | 0.928 | 1.78	0.312 | 0.318 | 1.73	93.5	92.7
Nitrate as NO3 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	<0.050 | <0.050 | [NA] [2]	102	91.5
Nitrite as NO2 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
NOx as N	mg/L	0.0050	<0.0050	0.947 | 0.930 | 1.79	0.331 | 0.336 | 1.59	93.5	92.5
Phosphate as P	mg/L	0.0050	<0.0050	0.0116 | 0.0107 | [NA]	0.0105 | 0.0120 | [NA]	99.4	71.7

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-127 | Inorganics - Nutrients (Water) | Batch BFI3117

Analyte	Units	PQL	Blank	DUP1 BFI3117-DUP1# Samp | QC | RPD %	DUP2 PFI0937-01 Samp | QC | RPD %	LCS %	Spike % BFI3117-MS1#
Total Nitrogen	mg/L	0.10	<0.10	22.3 | 22.6 | 1.15	1.38 | 1.43 | 3.58	118	128

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

MICRO-001B | Microbiological Suite (Water) | Batch BFI2422

Analyte	Units	PQL	Blank	DUP1 BFI2422-DUP1# Samp | QC | RPD %	DUP2 BFI2422-DUP2# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1	<1	<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1	<1	<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP3 BFI2422-DUP3# Samp | QC | RPD %	DUP4 BFI2422-DUP4# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP5 BFI2422-DUP5# Samp | QC | RPD %	DUP6 BFI2422-DUP6# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP7 BFI2422-DUP7# Samp | QC | RPD %	DUP8 BFI2422-DUP8# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP9 BFI2422-DUP9# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	[NA]

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

QC Comments

Identifier	Description
[2]	PQL(s) has/have been raised due to matrix interference.

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
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Certificate of Analysis PFL0917

Client Details

Client	Hyd2O
Contact	Ted Dann
Address	Suite 6B, 103 Rokeby Rd, SUBIACO, WA, 6008

Sample Details

Your Reference	H24009 - Ballajura Monitoring
Number of Samples	9 Groundwater
Date Samples Received	12/12/2024
Date Instructions Received	12/12/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for soils and on an as received basis for other matrices.

Report Details

Date Results Requested by	19/12/2024
Date of Issue	19/12/2024

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Authorisation Details

Results Approved By	Ben Carpenter, Metals Technician Jessica Miller, Microbiological Supervisor Lien Tang, Assistant Operations Manager Lucas Yii, Inorganics Team Leader Michael Mowle, Inorganics Supervisor Varsha Ho Wing, Inorganics and Metals Supervisor
Laboratory Manager	Michael Kubiak

Certificate of Analysis PFL0917

Samples in this Report

Envirolab ID	Sample ID	Matrix	Date Sampled	Date Received
PFL0917-01	GW1	Groundwater	11/12/2024	12/12/2024
PFL0917-02	GW2	Groundwater	11/12/2024	12/12/2024
PFL0917-03	GW3	Groundwater	11/12/2024	12/12/2024
PFL0917-04	GW4	Groundwater	11/12/2024	12/12/2024
PFL0917-05	GW5	Groundwater	11/12/2024	12/12/2024
PFL0917-06	GW6	Groundwater	11/12/2024	12/12/2024
PFL0917-07	GW7	Groundwater	11/12/2024	12/12/2024
PFL0917-08	GW8	Groundwater	11/12/2024	12/12/2024
PFL0917-09	GW9	Groundwater	11/12/2024	12/12/2024

Certificate of Analysis PFL0917

Acid Extractable Metals (Groundwater)

Envirolab ID	**Units**	**PQL**	PFL0917-01	PFL0917-02	PFL0917-03	PFL0917-04	PFL0917-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/12/2024	11/12/2024	11/12/2024	11/12/2024	11/12/2024
Phosphorus	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Envirolab ID	**Units**	**PQL**	PFL0917-06	PFL0917-07	PFL0917-08	PFL0917-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/12/2024	11/12/2024	11/12/2024	11/12/2024
Phosphorus	mg/L	0.050	<0.050	<0.050	0.11	<0.050

Certificate of Analysis PFL0917

Dissolved Low Level Metals (Groundwater)

Envirolab ID	**Units**	**PQL**	PFL0917-01	PFL0917-02	PFL0917-03	PFL0917-04	PFL0917-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/12/2024	11/12/2024	11/12/2024	11/12/2024	11/12/2024
Arsenic	µg/L	1.0	<1.0	<1.0	<1.0	1.4	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	<1.0	<1.0	1.0	2.0	2.6
Copper	µg/L	1.0	1.4	<1.0	1.0	<1.0	1.0
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	8.7	<1.0	1.7	4.5	<1.0
Lead	µg/L	1.0	<1.0	<1.0	<1.0	1.3	<1.0
Zinc	µg/L	1.0	6.9	1.5	2.0	1.9	3.8

Envirolab ID	**Units**	**PQL**	PFL0917-06	PFL0917-07	PFL0917-08	PFL0917-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/12/2024	11/12/2024	11/12/2024	11/12/2024
Arsenic	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	0.15
Chromium	µg/L	1.0	10	2.0	1.3	4.6
Copper	µg/L	1.0	<1.0	<1.0	1.0	3.6
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	4.7	6.6	1.6	3.0
Lead	µg/L	1.0	21	<1.0	<1.0	5.5
Zinc	µg/L	1.0	6.0	4.9	8.6	17

Certificate of Analysis PFL0917

Inorganics - Ionic Balance and Indexes (Groundwater)

Envirolab ID	**Units**	**PQL**	PFL0917-01	PFL0917-02	PFL0917-03	PFL0917-04	PFL0917-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/12/2024	11/12/2024	11/12/2024	11/12/2024	11/12/2024
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	6.2	<5.0	<5.0	<5.0
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	6.2	<5.0	<5.0	<5.0

Envirolab ID	**Units**	**PQL**	PFL0917-06	PFL0917-07	PFL0917-08	PFL0917-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/12/2024	11/12/2024	11/12/2024	11/12/2024
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	5.0	31
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	5.0	31

Certificate of Analysis PFL0917

Inorganics - Nutrients (Groundwater)

Envirolab ID	**Units**	**PQL**	PFL0917-01	PFL0917-02	PFL0917-03	PFL0917-04	PFL0917-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/12/2024	11/12/2024	11/12/2024	11/12/2024	11/12/2024
Ammonia as N	mg/L	0.0050	0.65	0.016	0.054	0.39	0.12
Nitrate as N	mg/L	0.0050	<0.0050	5.7	1.2	0.057	0.22
Nitrate as NO3 by calculation	mg/L	0.020	<0.020	25	5.4	0.25	0.98
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.050 [1]	<0.0050
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	<0.020	<0.20 [1]	<0.020
NOx as N	mg/L	0.0050	<0.0050	5.7	1.2	0.064	0.22
TKN as N by calculation	mg/L	0.10	1.2	0.80	0.40	1.0	1.6
Organic Nitrogen by calc.	mg/L	0.10	0.55	0.78	0.35	0.65	1.5
Total Nitrogen	mg/L	0.10	1.2	6.5	1.6	1.1	1.8
Phosphate as P	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

Envirolab ID	**Units**	**PQL**	PFL0917-06	PFL0917-07	PFL0917-08	PFL0917-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/12/2024	11/12/2024	11/12/2024	11/12/2024
Ammonia as N	mg/L	0.0050	0.054	0.22	0.041	0.011
Nitrate as N	mg/L	0.0050	0.050	0.022	15	0.042
Nitrate as NO3 by calculation	mg/L	0.020	0.22	0.097	67	0.19
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	0.0089	<0.0050
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	0.029	<0.020
NOx as N	mg/L	0.0050	0.054	0.022	15	0.042
TKN as N by calculation	mg/L	0.10	0.91	0.73	3.0	2.8
Organic Nitrogen by calc.	mg/L	0.10	0.85	0.51	3.0	2.7
Total Nitrogen	mg/L	0.10	0.96	0.75	18	2.8
Phosphate as P	mg/L	0.0050	<0.0050	<0.0050	0.0064	<0.0050

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Microbiological Suite (Groundwater)

Envirolab ID	**Units**	**PQL**	PFL0917-03
Your Reference			GW3
Date Sampled			11/12/2024
Thermotolerant Coliforms	cfu/100mL	1	40
E.coli	cfu/100mL	1	10

Certificate of Analysis PFL0917

Result Comments

Identifier	Description
[1]	PQL has been raised due to matrix requiring dilution

Method Summary

Method ID	Methodology Summary
Calc	Calculation
Calc - TKN	TKN determined by calculation (Total Nitrogen - NOx).
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition 2320-B. Solids reported from a 1:5 water extract unless otherwise specified. Total Carbon Dioxide - determined by calculation in accordance with APHA latest edition,4500-CO2 D.
INORG-055	Nitrate/Nitrite/NOx/TKN - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils/solids are analysed following a water extraction.
INORG-057	Ammonia - determined colourimetrically. Water samples are filtered on receipt prior to analysis. Soils and OHS media are analysed following a water extraction. Alternatively, Ammonia can be extracted from soil using 1M KCl.
INORG-060	Phosphate - determined colourimetrically using APHA latest edition 4500 P E. Water samples are filtered on receipt prior to analysis. Soils are analysed from a water extract.
INORG-127	Total Nitrogen by high temperature catalytic combustion with chemiluminescence detection. Organic Carbon forms (inorganic, organic, total) determined using a TOC/NDIR analyser via combustion. Dissolved forms require filtering prior to determination.
METALS-020	Determination of various metals by ICP-OES.
METALS-021	Determination of Mercury by Cold Vapour AAS.
METALS-022	Determination of various metals by ICP-MS.Please note for Bromine and Iodine, any forms of these elements that are present are included together in the one result reported for each of these two elements.Salt forms and/or anion/cation forms (e.g. FeO, PbO, ZnO, BO3) are determined stoichiometrically from the base metal concentration.
MICRO-001B	E. coli/Thermotolerant coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.5-latest edition). Recommended maximums based on NHMRC Australian Drinking Water Guidelines. Please note that results for this test derived from counts outside of the range 10-100 are considered approximate as per AS4276.1.

Result Definitions

Identifier	Description
NR	Not reported
NEPM	National Environment Protection Measure
NS	Not specified
LCS	Laboratory Control Sample
RPD	Relative Percent Difference
>	Greater than
<	Less than
PQL	Practical Quantitation Limit
INS	Insufficient sample for this test
NA	Test not required
NT	Not tested
DOL	Samples rejected due to particulate overload (air filters only)
RFD	Samples rejected due to filter damage (air filters only)
RUD	Samples rejected due to uneven deposition (air filters only)
##	Indicates a laboratory acceptance criteria outlier, for further details, see Result Comments and/or QC Comments

Quality Control Definitions

Blank

This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, and is determined by processing solvents and reagents in exactly the same manner as for samples.

Surrogate Spike

Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

LCS (Laboratory Control Sample)

This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Matrix Spike

A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

Duplicate

This is the complete duplicate analysis of a sample from the process batch. The sample selected should be one where the analyte concentration is easily measurable.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria. Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction. Spikes for Physical and Aggregate Tests are not applicable. For VOCs in water samples, three vials are required for duplicate or spike analysis.

General Acceptance Criteria (GAC) - Analyte specific criteria applies for some analytes and is reflected in QC recovery tables.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% - see ELN-P05 QAQC tables for details (available on request); <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase. Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was typically insufficient in order to satisfy laboratory QA/QC protocols.

Miscellaneous Information

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached. We have taken the sampling date as being the date received at the laboratory.

Two significant figures are reported for the majority of tests and with a high degree of confidence, for results <10*PQL, the second significant figure may be in doubt i.e. has a relatively high degree of uncertainty and is provided for information only.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS where sediment/solids are included by default.

Urine Analysis - The BEI values listed are taken from the 2022 edition of *TLVs and BEIs Threshold Limits by ACGIH*.

Air volume measurements are not covered by Envirolab's NATA accreditation.

Data Quality Assessment Summary PFL0917

Client Details

Client	Hyd2O
Your Reference	H24009 - Ballajura Monitoring
Date Issued	19/12/2024

Recommended Holding Time Compliance

Recommended holding time exceedances exist - See detailed list below

Quality Control and QC Frequency

QC Type	Compliant	Details
Blank	Yes	No Outliers
LCS	Yes	No Outliers
Duplicates	Yes	No Outliers
Matrix Spike	Yes	No Outliers
Surrogates / Extracted Internal Standards	Yes	No Outliers
QC Frequency	Yes	No Outliers

Surrogates/Extracted Internal Standards, Duplicates and/or Matrix Spikes are not always relevant/applicable to certain analyses and matrices. Therefore, said QC measures are deemed compliant in these situations by default. See Laboratory Acceptance Criteria for more information

Data Quality Assessment Summary PFL0917

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
Total Phosphorus | Water	1-9	11/12/2024	17/12/2024	18/12/2024	Yes
Dissolved Metals (LL) | Water	1-9	11/12/2024	17/12/2024	17/12/2024	Yes
Dissolved Metals (LL)-Hg | Water	1-9	11/12/2024	17/12/2024	18/12/2024	Yes
Alkalinity Suite | Water	1-9	11/12/2024	13/12/2024	13/12/2024	Yes
Nitrogen - Ammonia | Water	1-9	11/12/2024	18/12/2024	18/12/2024	Yes
Nitrogen - Nitrate | Water	1-9	11/12/2024	18/12/2024	18/12/2024	Yes
Nitrogen - Nitrite | Water	1-9	11/12/2024	18/12/2024	18/12/2024	No
Nitrogen - NOx | Water	1-9	11/12/2024	18/12/2024	18/12/2024	No
Nitrogen - Total N | Water	1-9	11/12/2024	13/12/2024	13/12/2024	Yes
Phosphate as P | Water	1-9	11/12/2024	18/12/2024	18/12/2024	No
TKN as N calc | Water	1-9	11/12/2024	16/12/2024	19/12/2024	Yes
E. coli & T.T.coli | Water	3	11/12/2024	12/12/2024	12/12/2024	Yes

Quality Control PFL0917

METALS-020 | Acid Extractable Metals (Water) | Batch BFL3204

Analyte	Units	PQL	Blank	DUP1 BFL3204-DUP1# Samp | QC | RPD %	DUP2 PFL0917-05 Samp | QC | RPD %	LCS %	Spike % BFL3204-MS1#
Phosphorus	mg/L	0.050	<0.050	0.177 | 0.179 | [NA]	<0.050 | <0.050 | [NA]	114	98.9

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-021 | Dissolved Low Level Metals (Water) | Batch BFL3194

Analyte	Units	PQL	Blank	DUP1 BFL3194-DUP1# Samp | QC | RPD %	DUP2 PFL0917-07 Samp | QC | RPD %	LCS %	Spike % BFL3194-MS1#
Mercury	µg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	100	110

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-022 | Dissolved Low Level Metals (Water) | Batch BFL3198

Analyte	Units	PQL	Blank	DUP1 BFL3198-DUP1# Samp | QC | RPD %	DUP2 PFL0917-06 Samp | QC | RPD %	LCS %	Spike % PFL0917-01
Arsenic	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	103	101
Cadmium	µg/L	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	97.8	94.9
Chromium	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	10.1 | 9.60 | 4.71	104	99.2
Copper	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	103	95.3
Lead	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	21.2 | 20.3 | 4.26	94.7	89.0
Nickel	µg/L	1.0	<1.0	1.19 | 1.16 | [NA]	4.66 | 4.53 | [NA]	103	95.4
Zinc	µg/L	1.0	<1.0	6.43 | 6.22 | 3.19	5.95 | 2.82 | [NA] [2]	99.0	86.9

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-006 | Inorganics - Ionic Balance and Indexes (Water) | Batch BFL2389

Analyte	Units	PQL	Blank	DUP1 BFL2389-DUP1# Samp | QC | RPD %	DUP2 PFL0917-03 Samp | QC | RPD %	LCS %
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	383 | 368 | 3.96	<5.0 | <5.0 | [NA]	[NA]
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	383 | 368 | 3.96	<5.0 | <5.0 | [NA]	100

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-127 | Inorganics - Nutrients (Water) | Batch BFL2383

Analyte	Units	PQL	Blank	DUP1 BFL2383-DUP1# Samp | QC | RPD %	DUP2 BFL2383-DUP2# Samp | QC | RPD %	LCS %	Spike % BFL2383-MS1#
Total Nitrogen	mg/L	0.10	<0.10	30.7 | 29.3 | 4.49	2.03 | 1.86 | 8.86	103	102

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-057 | Inorganics - Nutrients (Water) | Batch BFL3318

Analyte	Units	PQL	Blank	DUP1 PFL0917-01 Samp | QC | RPD %	DUP2 BFL3318-DUP2# Samp | QC | RPD %	LCS %	Spike % PFL0917-02
Ammonia as N	mg/L	0.0050	<0.0050	0.647 | 0.635 | 1.78	59.2 | 56.6 | 4.54	103	96.2
Nitrate as N	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	<0.050 | <0.050 | [NA] [1]	97.1	76.2
Nitrate as NO3 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	<0.050 | <0.050 | [NA] [1]	107	121
Nitrite as NO2 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
NOx as N	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	<0.050 | <0.050 | [NA] [1]	97.1	76.0
Phosphate as P	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	8.44 | 8.37 | 0.927	94.0	101

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PFL0917

MICRO-001B | Microbiological Suite (Water) | Batch BFL2538

Analyte	Units	PQL	Blank	DUP1 BFL2538-DUP1# Samp | QC | RPD %	DUP2 BFL2538-DUP2# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1	<1	<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1	<1	<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP3 BFL2538-DUP3# Samp | QC | RPD %	DUP4 BFL2538-DUP4# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP5 BFL2538-DUP5# Samp | QC | RPD %	DUP6 BFL2538-DUP6# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP7 BFL2538-DUP7# Samp | QC | RPD %	DUP8 BFL2538-DUP8# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP9 BFL2538-DUP9# Samp | QC | RPD %	DUPA BFL2538-DUPA# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUPB BFL2538-DUPB# Samp | QC | RPD %		LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]		[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]		[NA]

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

QC Comments

Identifier	Description
[1]	PQL has been raised due to matrix requiring dilution
[2]	Duplicate %RPD may be flagged as an outlier to routine laboratory acceptance, however, where one or both results are <10*PQL, the RPD acceptance criteria increases exponentially.

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Certificate of Analysis PGC1267

Client Details

Client	Hyd2O
Contact	Andre Righetti
Address	Suite 6B, 103 Rokeby Rd, SUBIACO, WA, 6008

Sample Details

Your Reference	H24009 - Ballajura Monitoring
Number of Samples	9 Groundwater
Date Samples Received	19/03/2025
Date Instructions Received	19/03/2025

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for soils and on an as received basis for other matrices.

Report Details

Date Results Requested by	27/03/2025
Date of Issue	27/03/2025

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Accredited for compliance with ISO/IEC 17025. Tests not covered by NATA are denoted with *.

Authorisation Details

Results Approved By	Ben Carpenter, Metals Technician Lien Tang, Assistant Operations Manager Lucas Yii, Inorganics Team Leader Michael Mowle, Development Chemist - Inorganics and Metals Sally Rogers, Senior Microbiological Analyst Varsha Ho Wing, Inorganics and Metals Supervisor
Laboratory Manager	Michael Kubiak

Certificate of Analysis PGC1267

Samples in this Report

Envirolab ID	Sample ID	Matrix	Date Sampled	Date Received
PGC1267-01	GW1	Groundwater	18/03/2025	19/03/2025
PGC1267-02	GW2	Groundwater	18/03/2025	19/03/2025
PGC1267-03	GW3	Groundwater	18/03/2025	19/03/2025
PGC1267-04	GW4	Groundwater	18/03/2025	19/03/2025
PGC1267-05	GW5	Groundwater	18/03/2025	19/03/2025
PGC1267-06	GW6	Groundwater	18/03/2025	19/03/2025
PGC1267-07	GW7	Groundwater	18/03/2025	19/03/2025
PGC1267-08	GW8	Groundwater	18/03/2025	19/03/2025
PGC1267-09	GW9	Groundwater	18/03/2025	19/03/2025

Certificate of Analysis PGC1267

Acid Extractable Metals (Groundwater)

Envirolab ID	**Units**	**PQL**	PGC1267-01	PGC1267-02	PGC1267-03	PGC1267-04	PGC1267-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			18/03/2025	18/03/2025	18/03/2025	18/03/2025	18/03/2025
Phosphorus	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050

Envirolab ID	**Units**	**PQL**	PGC1267-06	PGC1267-07	PGC1267-08	PGC1267-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			18/03/2025	18/03/2025	18/03/2025	18/03/2025
Phosphorus	mg/L	0.050	0.13	<0.050	0.087	<0.050

Dissolved Low Level Metals (Groundwater)

Envirolab ID	**Units**	**PQL**	PGC1267-01	PGC1267-02	PGC1267-03	PGC1267-04	PGC1267-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			18/03/2025	18/03/2025	18/03/2025	18/03/2025	18/03/2025
Arsenic	µg/L	1.0	1.1	<1.0	1.0	1.1	1.6
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	<1.0	<1.0	2.0	2.6	2.3
Copper	µg/L	1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	12	<1.0	2.5	6.0	<1.0
Lead	µg/L	1.0	<1.0	<1.0	<1.0	1.0	<1.0
Zinc	µg/L	1.0	1.6	1.6	2.3	7.0	1.0

Envirolab ID	**Units**	**PQL**	PGC1267-06	PGC1267-07	PGC1267-08	PGC1267-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			18/03/2025	18/03/2025	18/03/2025	18/03/2025
Arsenic	µg/L	1.0	2.6	<1.0	<1.0	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	7.1	2.4	3.7	2.8
Copper	µg/L	1.0	3.4	<1.0	<1.0	<1.0
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	4.8	7.0	<1.0	4.8
Lead	µg/L	1.0	24	<1.0	<1.0	2.2
Zinc	µg/L	1.0	19	2.9	5.8	4.1

Inorganics - Ionic Balance and Indexes (Groundwater)

Envirolab ID	Units	PQL	PGC1267-01	PGC1267-02	PGC1267-03	PGC1267-04	PGC1267-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			18/03/2025	18/03/2025	18/03/2025	18/03/2025	18/03/2025
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	5.8
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	5.8

Envirolab ID	Units	PQL	PGC1267-06	PGC1267-07	PGC1267-08	PGC1267-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			18/03/2025	18/03/2025	18/03/2025	18/03/2025
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	13	8.3
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	13	8.3

Certificate of Analysis PGC1267

Inorganics - Nutrients (Groundwater)

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PGC1267-01 GW1 18/03/2025	PGC1267-02 GW2 18/03/2025	PGC1267-03 GW3 18/03/2025	PGC1267-04 GW4 18/03/2025	PGC1267-05 GW5 18/03/2025
Ammonia as N	mg/L	0.0050	0.60	<0.0050	0.16	0.24	0.16
Nitrate as N	mg/L	0.0050	<0.0050	6.2	0.18	<0.050 [3]	<0.0050
Nitrate as NO3 by calculation	mg/L	0.020	<0.020	28	0.81	<0.20 [3]	<0.020
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	<0.050 [3]	<0.050 [3]	<0.0050
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	<0.20 [3]	<0.20 [3]	<0.020
NOx as N	mg/L	0.0050	<0.0050	6.3	0.19	<0.050 [3]	<0.0050
TKN as N by calculation	mg/L	0.10	1.4	0.74	0.63	1.4	0.68
Organic Nitrogen by calc.	mg/L	0.10	0.77	0.74	0.47	1.2	0.52
Total Nitrogen	mg/L	0.10	1.4	7.0	0.82	1.4	0.68
Phosphate as P	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PGC1267-06 GW6 18/03/2025	PGC1267-07 GW7 18/03/2025	PGC1267-08 GW8 18/03/2025	PGC1267-09 GW9 18/03/2025
Ammonia as N	mg/L	0.0050	0.12	0.31	0.14	0.27
Nitrate as N	mg/L	0.0050	<0.0050	<0.0050	0.97	<0.050 [3]
Nitrate as NO3 by calculation	mg/L	0.020	<0.020	<0.020	4.3	<0.20 [3]
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	0.14	0.058
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	0.46	<0.20 [3]
NOx as N	mg/L	0.0050	<0.0050	<0.0050	1.1	0.055
TKN as N by calculation	mg/L	0.10	5.7	0.82	0.80	1.7
Organic Nitrogen by calc.	mg/L	0.10	5.5	0.51	0.66	1.4
Total Nitrogen	mg/L	0.10	5.7	0.82	1.9	1.7
Phosphate as P	mg/L	0.0050	<0.0050	<0.0050	0.034	<0.0050

Certificate of Analysis PGC1267

Microbiological Suite (Groundwater)

Envirolab ID	**Units**	**PQL**	PGC1267-03
Your Reference			GW3
Date Sampled			18/03/2025
Thermotolerant Coliforms	cfu/100mL	1	<10 [1]
E.coli	cfu/100mL	1	<10 [1]

Certificate of Analysis PGC1267

Result Comments

Identifier	Description
[1]	Microbiological testing PQL raised due to high sample turbidity and/or matrix interference.
[3]	PQL(s) has/have been raised due to matrix interference.

Method Summary

Method ID	Methodology Summary
Calc	Calculation
Calc - TKN	TKN determined by calculation (Total Nitrogen - NOx).
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition 2320-B. Solids reported from a 1:5 water extract unless otherwise specified. Total Carbon Dioxide - determined by calculation in accordance with APHA latest edition,4500-CO2 D.
INORG-055	Nitrate/Nitrite/NOx/TKN - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils/solids are analysed following a water extraction.
INORG-057	Ammonia - determined colourimetrically. Water samples are filtered on receipt prior to analysis. Soils and OHS media are analysed following a water extraction. Alternatively, Ammonia can be extracted from soil using 1M KCl.
INORG-060	Phosphate - determined colourimetrically using APHA latest edition 4500 P E. Water samples are filtered on receipt prior to analysis. Soils are analysed from a water extract.
INORG-127	Total Nitrogen by high temperature catalytic combustion with chemiluminescence detection. Organic Carbon forms (inorganic, organic, total) determined using a TOC/NDIR analyser via combustion. Dissolved forms require filtering prior to determination.
METALS-020	Determination of various metals by ICP-OES. Where salts (oxides, chlorides etc.) are calculated from the element concentration stoichiometrically there is no guarantee that the salt form is completely soluble in the acids used in the preparation.
METALS-021	Determination of Mercury by Cold Vapour AAS.
METALS-022	Determination of various metals by ICP-MS. Please note for Bromine and Iodine, any forms of these elements that are present are included together in the one result reported for each of these two elements. Where salts (oxides, chlorides etc.) are calculated from the element concentration stoichiometrically there is no guarantee that the salt form is completely soluble in the acids used in the preparation.
MICRO-001B	E. coli/Thermotolerant coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.5-latest edition). Recommended maximums based on NHMRC Australian Drinking Water Guidelines. Please note that results for this test derived from counts outside of the range 10-100 are considered approximate as per AS4276.1.

Certificate of Analysis PGC1267

Result Definitions

Identifier	Description
NR	Not reported
NEPM	National Environment Protection Measure
NS	Not specified
LCS	Laboratory Control Sample
RPD	Relative Percent Difference
>	Greater than
<	Less than
PQL	Practical Quantitation Limit
INS	Insufficient sample for this test
NA	Test not required
NT	Not tested
DOL	Samples rejected due to particulate overload (air filters only)
RFD	Samples rejected due to filter damage (air filters only)
RUD	Samples rejected due to uneven deposition (air filters only)
##	Indicates a laboratory acceptance criteria outlier, for further details, see Result Comments and/or QC Comments

Quality Control Definitions

Blank

This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, and is determined by processing solvents and reagents in exactly the same manner as for samples.

Surrogate Spike

Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

LCS (Laboratory Control Sample)

This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Matrix Spike

A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

Duplicate

This is the complete duplicate analysis of a sample from the process batch. The sample selected should be one where the analyte concentration is easily measurable.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria. Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction. Spikes for Physical and Aggregate Tests are not applicable. For VOCs in water samples, three vials are required for duplicate or spike analysis.

General Acceptance Criteria (GAC) - Analyte specific criteria applies for some analytes and is reflected in QC recovery tables.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% - see ELN-P05 QAQC tables for details (available on request); <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase. Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was typically insufficient in order to satisfy laboratory QA/QC protocols.

Miscellaneous Information

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached. We have taken the sampling date as being the date received at the laboratory.

Two significant figures are reported for the majority of tests and with a high degree of confidence, for results <10*PQL, the second significant figure may be in doubt i.e. has a relatively high degree of uncertainty and is provided for information only.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS where sediment/solids are included by default.

Urine Analysis - The BEI values listed are taken from the 2022 edition of *TLVs and BEIs Threshold Limits by ACGIH*.

Air volume measurements are not covered by Envirolab's NATA accreditation.

Data Quality Assessment Summary PGC1267

Client Details

Client	Hyd2O
Your Reference	H24009 - Ballajura Monitoring
Date Issued	27/03/2025

Recommended Holding Time Compliance

Recommended holding time exceedances exist - See detailed list below

Quality Control and QC Frequency

QC Type	Compliant	Details
Blank	Yes	No Outliers
LCS	Yes	No Outliers
Duplicates	Yes	No Outliers
Matrix Spike	No	Matrix Spike Outliers Exist - See detailed list below
Surrogates / Extracted Internal Standards	Yes	No Outliers
QC Frequency	Yes	No Outliers

Surrogates/Extracted Internal Standards, Duplicates and/or Matrix Spikes are not always relevant/applicable to certain analyses and matrices. Therefore, said QC measures are deemed compliant in these situations by default. See Laboratory Acceptance Criteria for more information

Data Quality Assessment Summary PGC1267

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
Total Phosphorus | Water	1-9	18/03/2025	24/03/2025	26/03/2025	Yes
Dissolved Metals (LL) | Water	1-9	18/03/2025	24/03/2025	25/03/2025	Yes
Dissolved Metals (LL)-Hg | Water	1-9	18/03/2025	24/03/2025	27/03/2025	Yes
Alkalinity Suite | Water	1-9	18/03/2025	20/03/2025	20/03/2025	Yes
Nitrogen - Ammonia | Water	1-9	18/03/2025	24/03/2025	24/03/2025	Yes
Nitrogen - Nitrate | Water	1-7	18/03/2025	24/03/2025	24/03/2025	Yes
	8-9	18/03/2025	24/03/2025	25/03/2025	Yes
Nitrogen - Nitrite | Water	1-7	18/03/2025	24/03/2025	24/03/2025	No
	8-9	18/03/2025	24/03/2025	25/03/2025	No
Nitrogen - NOx | Water	1-7	18/03/2025	24/03/2025	24/03/2025	No
	8-9	18/03/2025	24/03/2025	25/03/2025	No
Nitrogen - Total N | Water	1-9	18/03/2025	26/03/2025	26/03/2025	Yes
Phosphate as P | Water	1-9	18/03/2025	24/03/2025	24/03/2025	No
TKN as N calc | Water	1-9	18/03/2025	24/03/2025	27/03/2025	Yes
E. coli & T.T.coli | Water	3	18/03/2025	19/03/2025	19/03/2025	Yes

Outliers: Matrix Spike

INORG-055|Inorganics - Nutrients (Water)| Batch BGC3780

Sample ID	Analyte	% Limits	% Recovery
BGC3780-MS2#	Nitrate as N	70 - 130	##[2]
BGC3780-MS1#	NOx as N	70 - 130	##[2]

Quality Control PGC1267

METALS-020 | Acid Extractable Metals (Water) | Batch BGC3997

Analyte	Units	PQL	Blank	DUP1 PGC1267-04 Samp | QC | RPD %	DUP2 BGC3997-DUP2# Samp | QC | RPD %	LCS %	Spike % PGC1267-01
Phosphorus	mg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	102	93.2

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-021 | Dissolved Low Level Metals (Water) | Batch BGC3987

Analyte	Units	PQL	Blank	DUP1 BGC3987-DUP1# Samp | QC | RPD %	DUP2 PGC1267-09 Samp | QC | RPD %	LCS %	Spike % BGC3987-MS1#
Mercury	µg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	106	102

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-022 | Dissolved Low Level Metals (Water) | Batch BGC3991

Analyte	Units	PQL	Blank	DUP1 BGC3991-DUP1# Samp | QC | RPD %	DUP2 PGC1267-09 Samp | QC | RPD %	LCS %	Spike % BGC3991-MS1#
Arsenic	µg/L	1.0	<1.0	56.7 | 55.1 | 2.83	<1.0 | <1.0 | [NA]	103	108
Cadmium	µg/L	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	110	107
Chromium	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	2.79 | 2.73 | [NA]	101	105
Copper	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	103	94.9
Lead	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	2.20 | 2.21 | [NA]	104	99.4
Nickel	µg/L	1.0	<1.0	22.8 | 22.4 | 1.66	4.83 | 4.64 | [NA]	102	97.9
Zinc	µg/L	1.0	<1.0	12.5 | 12.4 | 1.01	4.08 | 4.15 | [NA]	106	103

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-006 | Inorganics - Ionic Balance and Indexes (Water) | Batch BGC3456

Analyte	Units	PQL	Blank	DUP1 BGC3456-DUP1# Samp | QC | RPD %	DUP2 PGC1267-09 Samp | QC | RPD %	LCS %
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	538 | 552 | 2.47	8.30 | 8.05 | [NA]	[NA]
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	538 | 552 | 2.47	8.30 | 8.05 | [NA]	90.1

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-057 | Inorganics - Nutrients (Water) | Batch BGC3780

Analyte	Units	PQL	Blank	DUP1 BGC3780-DUP1# Samp | QC | RPD %	DUP2 PGC1267-01 Samp | QC | RPD %	LCS %	Spike % BGC3780-MS1#
Ammonia as N	mg/L	0.0050	<0.0050	0.325 | 0.310 | 4.61	0.604 | 0.604 | 0.108	117	111
Nitrate as N	mg/L	0.0050	<0.0050	30.8 | 31.8 | 3.15	<0.0050 | <0.0050 | [NA]	108	##[2]
Nitrate as NO3 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
Nitrite as N	mg/L	0.0050	<0.0050	0.0208 | 0.0211 | [NA]	<0.0050 | <0.0050 | [NA]	80.4	116
Nitrite as NO2 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
NOx as N	mg/L	0.0050	<0.0050	30.9 | 31.8 | 3.15	<0.0050 | <0.0050 | [NA]	108	##[2]
Phosphate as P	mg/L	0.0050	<0.0050	0.00610 | 0.00694 | [NA]	<0.0050 | <0.0050 | [NA]	108	114

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-127 | Inorganics - Nutrients (Water) | Batch BGC4342

Analyte	Units	PQL	Blank	DUP1 PGC1267-01 Samp | QC | RPD %	DUP2 BGC4342-DUP2# Samp | QC | RPD %	LCS %	Spike % PGC1267-02
Total Nitrogen	mg/L	0.10	<0.10	1.37 | 1.36 | 0.643	1.67 | 1.66 | [NA]	107	82.8

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PGC1267

MICRO-001B|Microbiological Suite (Water) | Batch BGC3283

Analyte	Units	PQL	Blank	LCS %
Thermotolerant Coliforms	cfu/100mL	1	<1	[NA]
E.coli	cfu/100mL	1	<1	[NA]

QC Comments

Identifier	Description
[2]	Spike recovery is not applicable due to the relatively high analyte background in the sample (>3* spike level). However, the LCS recovery is within acceptance criteria.

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Certificate of Analysis PGF0836

Client Details

Client	Hyd2O
Contact	Andre Righetti
Address	Unit 1 387 Hay Street, SUBIACO, WA, 6008

Sample Details

Your Reference	H24009
Number of Samples	9 Groundwater
Date Samples Received	12/06/2025
Date Instructions Received	12/06/2025

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for soils and on an as received basis for other matrices.

Report Details

Date Final Results Expected	19/06/2025
Date of Issue	19/06/2025

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Authorisation Details

Results Approved By	Ben Carpenter, Metals Technician Jessica Miller, Microbiological Supervisor Lien Tang, Assistant Operations Manager Lucas Yii, Inorganics Team Leader Michael Mowle, Development Chemist - Inorganics and Metals Varsha Ho Wing, Inorganics and Metals Supervisor
Laboratory Manager	Michael Kubiak

Certificate of Analysis PGF0836

Samples in this Report

Envirolab ID	Sample ID	Matrix	Date Sampled	Date Received
PGF0836-01	GW1	Groundwater	11/06/2025	12/06/2025
PGF0836-02	GW2	Groundwater	11/06/2025	12/06/2025
PGF0836-03	GW3	Groundwater	11/06/2025	12/06/2025
PGF0836-04	GW4	Groundwater	11/06/2025	12/06/2025
PGF0836-05	GW5	Groundwater	11/06/2025	12/06/2025
PGF0836-06	GW6	Groundwater	11/06/2025	12/06/2025
PGF0836-07	GW7	Groundwater	11/06/2025	12/06/2025
PGF0836-08	GW8	Groundwater	11/06/2025	12/06/2025
PGF0836-09	GW9	Groundwater	11/06/2025	12/06/2025

Certificate of Analysis PGF0836

Acid Extractable Metals (Groundwater)

Envirolab ID	**Units**	**PQL**	PGF0836-01	PGF0836-02	PGF0836-03	PGF0836-04	PGF0836-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/06/2025	11/06/2025	11/06/2025	11/06/2025	11/06/2025
Phosphorus	mg/L	0.050	<0.050	<0.050	<0.050	0.094	<0.050

Envirolab ID	**Units**	**PQL**	PGF0836-06	PGF0836-07	PGF0836-08	PGF0836-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/06/2025	11/06/2025	11/06/2025	11/06/2025
Phosphorus	mg/L	0.050	<0.050	<0.050	0.085	<0.050

Certificate of Analysis PGF0836

Dissolved Low Level Metals (Groundwater)

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PGF0836-01 GW1 11/06/2025	PGF0836-02 GW2 11/06/2025	PGF0836-03 GW3 11/06/2025	PGF0836-04 GW4 11/06/2025	PGF0836-05 GW5 11/06/2025
Arsenic	µg/L	1.0	1.4	<1.0	<1.0	<1.0	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	<1.0	<1.0	1.4	2.9	1.2
Copper	µg/L	1.0	1.2	<1.0	<1.0	<1.0	<1.0
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	18	<1.0	3.3	4.4	<1.0
Lead	µg/L	1.0	1.3	<1.0	<1.0	<1.0	<1.0
Zinc	µg/L	1.0	4.0	1.1	1.3	4.4	<1.0

Envirolab ID **Your Reference** **Date Sampled**	**Units**	**PQL**	PGF0836-06 GW6 11/06/2025	PGF0836-07 GW7 11/06/2025	PGF0836-08 GW8 11/06/2025	PGF0836-09 GW9 11/06/2025
Arsenic	µg/L	1.0	2.4	<1.0	<1.0	<1.0
Cadmium	µg/L	0.10	<0.10	<0.10	<0.10	<0.10
Chromium	µg/L	1.0	2.4	2.0	4.1	3.0
Copper	µg/L	1.0	<1.0	<1.0	<1.0	<1.0
Mercury	µg/L	0.050	<0.050	<0.050	<0.050	<0.050
Nickel	µg/L	1.0	4.7	5.9	<1.0	4.3
Lead	µg/L	1.0	2.1	<1.0	<1.0	<1.0
Zinc	µg/L	1.0	<1.0	<1.0	1.3	<1.0

Certificate of Analysis PGF0836

Inorganics - Ionic Balance and Indexes (Groundwater)

Envirolab ID	**Units**	**PQL**	PGF0836-01	PGF0836-02	PGF0836-03	PGF0836-04	PGF0836-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/06/2025	11/06/2025	11/06/2025	11/06/2025	11/06/2025
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Envirolab ID	**Units**	**PQL**	PGF0836-06	PGF0836-07	PGF0836-08	PGF0836-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/06/2025	11/06/2025	11/06/2025	11/06/2025
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	5.8	12	<5.0
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0	<5.0	<5.0
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	5.8	12	<5.0

Inorganics - Nutrients (Groundwater)

Envirolab ID	**Units**	**PQL**	PGF0836-01	PGF0836-02	PGF0836-03	PGF0836-04	PGF0836-05
Your Reference			GW1	GW2	GW3	GW4	GW5
Date Sampled			11/06/2025	11/06/2025	11/06/2025	11/06/2025	11/06/2025
Ammonia as N	mg/L	0.0050	0.29	<0.0050	0.14	0.10	0.13
Nitrate as N	mg/L	0.0050	0.19	2.7	0.18	<0.050 [3]	0.41
Nitrate as NO3 by calculation	mg/L	0.020	0.83	12	0.77	<0.20 [3]	1.8
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	<0.0050	<0.050 [3]	<0.0050
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	<0.020	<0.20 [3]	<0.020
NOx as N	mg/L	0.0050	0.19	2.7	0.18	<0.050 [3]	0.41
TKN as N by calculation	mg/L	0.10	0.91	0.42	0.71	2.3	0.18
Organic Nitrogen by calc.	mg/L	0.10	0.62	0.41	0.57	2.2	<0.10
Total Nitrogen	mg/L	0.10	1.1	3.1	0.88	2.3	0.59
Phosphate as P	mg/L	0.0050	0.0086	0.0053	<0.0050	<0.0050	<0.0050

Envirolab ID	**Units**	**PQL**	PGF0836-06	PGF0836-07	PGF0836-08	PGF0836-09
Your Reference			GW6	GW7	GW8	GW9
Date Sampled			11/06/2025	11/06/2025	11/06/2025	11/06/2025
Ammonia as N	mg/L	0.0050	0.15	0.25	0.15	0.11
Nitrate as N	mg/L	0.0050	0.17	0.18	<0.050 [3]	0.19
Nitrate as NO3 by calculation	mg/L	0.020	0.76	0.80	<0.20 [3]	0.83
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050	<0.050 [3]	<0.0050
Nitrite as NO2 by calculation	mg/L	0.020	<0.020	<0.020	<0.20 [3]	<0.020
NOx as N	mg/L	0.0050	0.17	0.18	<0.050 [3]	0.19
TKN as N by calculation	mg/L	0.10	0.73	0.81	1.0	1.6
Organic Nitrogen by calc.	mg/L	0.10	0.58	0.56	0.86	1.5
Total Nitrogen	mg/L	0.10	0.90	1.0	1.0	1.8
Phosphate as P	mg/L	0.0050	<0.0050	<0.0050	0.060	<0.0050

Certificate of Analysis PGF0836

Microbiological Suite (Groundwater)

Envirolab ID	**Units**	**PQL**	PGF0836-03
Your Reference			GW3
Date Sampled			11/06/2025
Thermotolerant Coliforms	cfu/100mL	1	<10 [1]
E.coli	cfu/100mL	1	<10 [1]

Certificate of Analysis PGF0836

Result Comments

Identifier	Description
[1]	Microbiological testing PQL raised due to high sample turbidity and/or matrix interference.
[3]	PQL(s) has/have been raised due to matrix interference.

Method Summary

Method ID	Methodology Summary
Calc	Calculation
Calc - TKN	TKN determined by calculation (Total Nitrogen - NOx).
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition 2320-B. Solids reported from a 1:5 water extract unless otherwise specified. Total Carbon Dioxide - determined by calculation in accordance with APHA latest edition,4500-CO2 D.
INORG-055	Nitrate/Nitrite/NOx/TKN - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils/solids are analysed following a water extraction.
INORG-057	Ammonia - determined colourimetrically. Water samples are filtered on receipt prior to analysis. Soils and OHS media are analysed following a water extraction. Alternatively, Ammonia can be extracted from soil using 1M KCl.
INORG-060	Phosphate - determined colourimetrically using APHA latest edition 4500 P E. Water samples are filtered on receipt prior to analysis. Soils are analysed from a water extract.
INORG-127	Total Nitrogen by high temperature catalytic combustion with chemiluminescence detection. Organic Carbon forms (inorganic, organic, total) determined using a TOC/NDIR analyser via combustion. Dissolved forms require filtering prior to determination.
METALS-020	Determination of various metals by ICP-OES. Where salts (oxides, chlorides etc.) are calculated from the element concentration stoichiometrically there is no guarantee that the salt form is completely soluble in the acids used in the preparation.
METALS-021	Determination of Mercury by Cold Vapour AAS.
METALS-022	Determination of various metals by ICP-MS. Please note for Bromine and Iodine, any forms of these elements that are present are included together in the one result reported for each of these two elements. Where salts (oxides, chlorides etc.) are calculated from the element concentration stoichiometrically there is no guarantee that the salt form is completely soluble in the acids used in the preparation.
MICRO-001B	E. coli/Thermotolerant coliforms: Microbial Water Analysis - in accordance with MICRO-001 (AS4276.5-latest edition). Recommended maximums based on NHMRC Australian Drinking Water Guidelines. Please note that results for this test derived from counts outside of the range 10-80 are considered approximate as per AS4276.1.

Result Definitions

Identifier	Description
NR	Not reported
NEPM	National Environment Protection Measure
NS	Not specified
LCS	Laboratory Control Sample
RPD	Relative Percent Difference
>	Greater than
<	Less than
PQL	Practical Quantitation Limit
INS	Insufficient sample for this test
NA	Test not required
NT	Not tested
DOL	Samples rejected due to particulate overload (air filters only)
RFD	Samples rejected due to filter damage (air filters only)
RUD	Samples rejected due to uneven deposition (air filters only)
##	Indicates a laboratory acceptance criteria outlier, for further details, see Result Comments and/or QC Comments

Quality Control Definitions

Blank

This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, and is determined by processing solvents and reagents in exactly the same manner as for samples.

Surrogate Spike

Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

LCS (Laboratory Control Sample)

This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Matrix Spike

A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

Duplicate

This is the complete duplicate analysis of a sample from the process batch. The sample selected should be one where the analyte concentration is easily measurable.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria. Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction. Spikes for Physical and Aggregate Tests are not applicable. For VOCs in water samples, three vials are required for duplicate or spike analysis.

General Acceptance Criteria (GAC) - Analyte specific criteria applies for some analytes and is reflected in QC recovery tables.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% - see ELN-P05 QAQC tables for details (available on request); <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase. Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was typically insufficient in order to satisfy laboratory QA/QC protocols.

Miscellaneous Information

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached. We have taken the sampling date as being the date received at the laboratory.

Two significant figures are reported for the majority of tests and with a high degree of confidence, for results <10*PQL, the second significant figure may be in doubt i.e. has a relatively high degree of uncertainty and is provided for information only.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, Total Recoverable metals and PFAS where sediment/solids are included by default.

Urine Analysis - The BEI values listed are taken from the 2022 edition of *TLVs and BEIs Threshold Limits by ACGIH*.

Air volumes are typically provided by customers (often as flow rate(s) and sampling time(s) and/or simply volume(s) sampled or exposure times (determines 'volume' passive badges are exposed to)). Hence in such circumstances the volume measurement is inevitably not covered by Envirolab's NATA accreditation. An exception may occur where Envirolab Newcastle does the sampling where accreditation exists for certain types of sampling and hence volume determination(s). Note air volumes are often used to determine concentrations for dust and/or analyses on filters, sorbents and in impingers. For canister sampling, the air volume is covered by Envirolab's NATA accreditation.

Data Quality Assessment Summary PGF0836

Client Details

Client	Hyd2O
Your Reference	H24009
Date Issued	19/06/2025

Recommended Holding Time Compliance

No recommended holding time exceedances

Quality Control and QC Frequency

QC Type	Compliant	Details
Blank	Yes	No Outliers
LCS	Yes	No Outliers
Duplicates	Yes	No Outliers
Matrix Spike	No	Matrix Spike Outliers Exist - See detailed list below
Surrogates / Extracted Internal Standards	Yes	No Outliers
QC Frequency	Yes	No Outliers

Surrogates/Extracted Internal Standards, Duplicates and/or Matrix Spikes are not always relevant/applicable to certain analyses and matrices. Therefore, said QC measures are deemed compliant in these situations by default. See Laboratory Acceptance Criteria for more information

Data Quality Assessment Summary PGF0836

Recommended Holding Time Compliance

Analysis	Sample Number(s)	Date Sampled	Date Extracted	Date Analysed	Compliant
Total Phosphorus | Water	1-9	11/06/2025	13/06/2025	13/06/2025	Yes
Dissolved Metals (LL) | Water	1-9	11/06/2025	16/06/2025	17/06/2025	Yes
Dissolved Metals (LL)-Hg | Water	1-6	11/06/2025	13/06/2025	13/06/2025	Yes
	7-9	11/06/2025	16/06/2025	16/06/2025	Yes
Alkalinity Suite | Water	1-9	11/06/2025	13/06/2025	13/06/2025	Yes
Nitrogen - Ammonia | Water	1-9	11/06/2025	13/06/2025	13/06/2025	Yes
Nitrogen - Nitrate | Water	1-3, 5-7, 9	11/06/2025	13/06/2025	13/06/2025	Yes
	4, 8	11/06/2025	13/06/2025	16/06/2025	Yes
Nitrogen - Nitrite | Water	1-3, 5-7, 9	11/06/2025	13/06/2025	13/06/2025	Yes
	4, 8	11/06/2025	13/06/2025	16/06/2025	Yes
Nitrogen - NOx | Water	1-3, 5, 7	11/06/2025	13/06/2025	13/06/2025	Yes
	6, 9	11/06/2025	13/06/2025	14/06/2025	Yes
	4, 8	11/06/2025	13/06/2025	16/06/2025	Yes
Nitrogen - Total N | Water	1-2	11/06/2025	17/06/2025	17/06/2025	Yes
	3-9	11/06/2025	17/06/2025	18/06/2025	Yes
Phosphate as P | Water	1-9	11/06/2025	13/06/2025	13/06/2025	Yes
TKN as N calc | Water	1-9	11/06/2025	13/06/2025	19/06/2025	Yes
E. coli & T.T.coli | Water	3	11/06/2025	12/06/2025	12/06/2025	Yes

Outliers: Matrix Spike

INORG-055|Inorganics - Nutrients (Water)| Batch BGF2055

Sample ID	Analyte	% Limits	% Recovery
PGF0836-02	Nitrite as N	70 - 130	##[2]

INORG-057|Inorganics - Nutrients (Water)| Batch BGF2189

Sample ID	Analyte	% Limits	% Recovery
BGF2189-MS1#	Ammonia as N	70 - 130	##[2]

Quality Control PGF0836

METALS-020 | Acid Extractable Metals (Water) | Batch BGF2088

Analyte	Units	PQL	Blank	DUP1	DUP2	LCS %	Spike %
				BGF2088-DUP1#	BGF2088-DUP2#		BGF2088-MS1#
				Samp | QC | RPD %	Samp | QC | RPD %		
Phosphorus	mg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	109	101

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-021 | Dissolved Low Level Metals (Water) | Batch BGF2080

Analyte	Units	PQL	Blank	DUP1	DUP2	LCS %	Spike %
				BGF2080-DUP1#	BGF2080-DUP2#		PGF0836-01
				Samp | QC | RPD %	Samp | QC | RPD %		
Mercury	µg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	98.0	96.4

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-022 | Dissolved Low Level Metals (Water) | Batch BGF2352

Analyte	Units	PQL	Blank	DUP1	DUP2	LCS %	Spike %
				BGF2352-DUP1#	PGF0836-09		BGF2352-MS1#
				Samp | QC | RPD %	Samp | QC | RPD %		
Arsenic	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	107	104
Cadmium	µg/L	0.10	<0.10	<0.10 | <0.10 | [NA]	<0.10 | <0.10 | [NA]	104	102
Chromium	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	3.05 | 3.03 | [NA]	107	102
Copper	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	108	104
Lead	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	<1.0 | <1.0 | [NA]	104	101
Nickel	µg/L	1.0	<1.0	<1.0 | <1.0 | [NA]	4.33 | 4.35 | [NA]	107	104
Zinc	µg/L	1.0	<1.0	3.11 | 3.06 | [NA]	<1.0 | <1.0 | [NA]	104	101

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

METALS-021 | Dissolved Low Level Metals (Water) | Batch BGF2356

Analyte	Units	PQL	Blank	DUP1	DUP2	LCS %	Spike %
				PGF0836-07	BGF2356-DUP2#		PGF0836-08
				Samp | QC | RPD %	Samp | QC | RPD %		
Mercury	µg/L	0.050	<0.050	<0.050 | <0.050 | [NA]	<0.050 | <0.050 | [NA]	106	100

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-006 | Inorganics - Ionic Balance and Indexes (Water) | Batch BGF2217

Analyte	Units	PQL	Blank	DUP1	DUP2	LCS %
				PGF0836-01	BGF2217-DUP2#	
				Samp | QC | RPD %	Samp | QC | RPD %	
Bicarbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Carbonate Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Hydroxide OH- as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	[NA]
Total Alkalinity as CaCO3	mg/L as CaCO3	5.0	<5.0	<5.0 | <5.0 | [NA]	<5.0 | <5.0 | [NA]	92.6

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PGF0836

INORG-057 | Inorganics - Nutrients (Water) | Batch BGF2055

Analyte	Units	PQL	Blank	DUP1 PGF0836-01 Samp | QC | RPD %	DUP2 BGF2055-DUP2# Samp | QC | RPD %	LCS %	Spike % PGF0836-02
Ammonia as N	mg/L	0.0050	<0.0050	0.289 | 0.278 | 4.04	<0.050 | <0.050 | [NA]	91.9	88.7
Nitrate as N	mg/L	0.0050	<0.0050	0.188 | 0.150 | 22.4	0.170 | 0.187 | 9.39	105	112
Nitrate as NO3 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
Nitrite as N	mg/L	0.0050	<0.0050	<0.0050 | <0.0050 | [NA]	<0.0050 | <0.0050 | [NA]	[NA]	[NA]
Nitrite as NO2 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
NOx as N	mg/L	0.0050	<0.0050	0.188 | 0.180 | 4.54	0.170 | 0.187 | 9.39	105	112
Phosphate as P	mg/L	0.0050	<0.0050	0.00864 | 0.00879 | [NA]	<0.0050 | <0.0050 | [NA]	112	124

Analyte	Units	PQL	Blank	LCS %	Spike % PGF0836-02
Nitrite as N	mg/L	0.005		112	##[2]

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-057 | Inorganics - Nutrients (Water) | Batch BGF2189

Analyte	Units	PQL	Blank	DUP1 BGF2189-DUP1# Samp | QC | RPD %	DUP2 BGF2189-DUP2# Samp | QC | RPD %	LCS %	Spike % BGF2189-MS1#
Ammonia as N	mg/L	0.0050	<0.0050	0.105 | 0.104 | 1.14	49.4 | 47.8 | 3.14	86.9	##[2]
Nitrate as N	mg/L	0.0050	<0.0050	51.8 | 52.4 | 1.05	<0.050 | <0.050 | [NA]	100	114
Nitrate as NO3 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
Nitrite as N	mg/L	0.0050	<0.0050	0.786 | 0.800 | 1.76	<0.050 | <0.050 | [NA]	120	106
Nitrite as NO2 by calculation	mg/L	0.020	<0.020			[NA]	[NA]
NOx as N	mg/L	0.005		52.6 | 53.2 | 1.06	<0.050 | <0.050 | [NA]	100	113
Phosphate as P	mg/L	0.0050	<0.0050	0.859 | 0.875 | 1.74	6.20 | 6.25 | 0.787	112	127

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

INORG-127 | Inorganics - Nutrients (Water) | Batch BGF2647

Analyte	Units	PQL	Blank	DUP1 PGF0836-01 Samp | QC | RPD %	DUP2 BGF2647-DUP2# Samp | QC | RPD %	LCS %	Spike % PGF0836-02
Total Nitrogen	mg/L	0.10	<0.10	1.09 | 1.07 | 2.59	59.7 | 60.0 | 0.531	100	96.7

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

MICRO-001B | Microbiological Suite (Water) | Batch BGF2091

Analyte	Units	PQL	Blank	DUP1 BGF2091-DUP1# Samp | QC | RPD %	DUP2 BGF2091-DUP2# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1	<1	<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1	<1	<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP3 BGF2091-DUP3# Samp | QC | RPD %	DUP4 BGF2091-DUP4# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	<1 | <1 | [NA]	[NA]

Analyte	Units	PQL	Blank	DUP5 BGF2091-DUP5# Samp | QC | RPD %	LCS %
Thermotolerant Coliforms	cfu/100mL	1		<1 | <1 | [NA]	[NA]
E.coli	cfu/100mL	1		<1 | <1 | [NA]	[NA]

The QC reported was not specifically part of this workorder but formed part of the QC process batch.

Quality Control PGF0836

QC Comments

Identifier	Description
[2]	Spike recovery is outside routine acceptance criteria (70-130%), this may be due to suspected non-homogeneity and/or matrix interference effects. However, an acceptable recovery was achieved for the LCS.

APPENDIX J

CURRV Runoff Calculator

CURRV

Calculator for Urban Runoff Rates & Volumes

11/10/2024

Project: Lakefarm Ballajura DWMS - Catchment 1

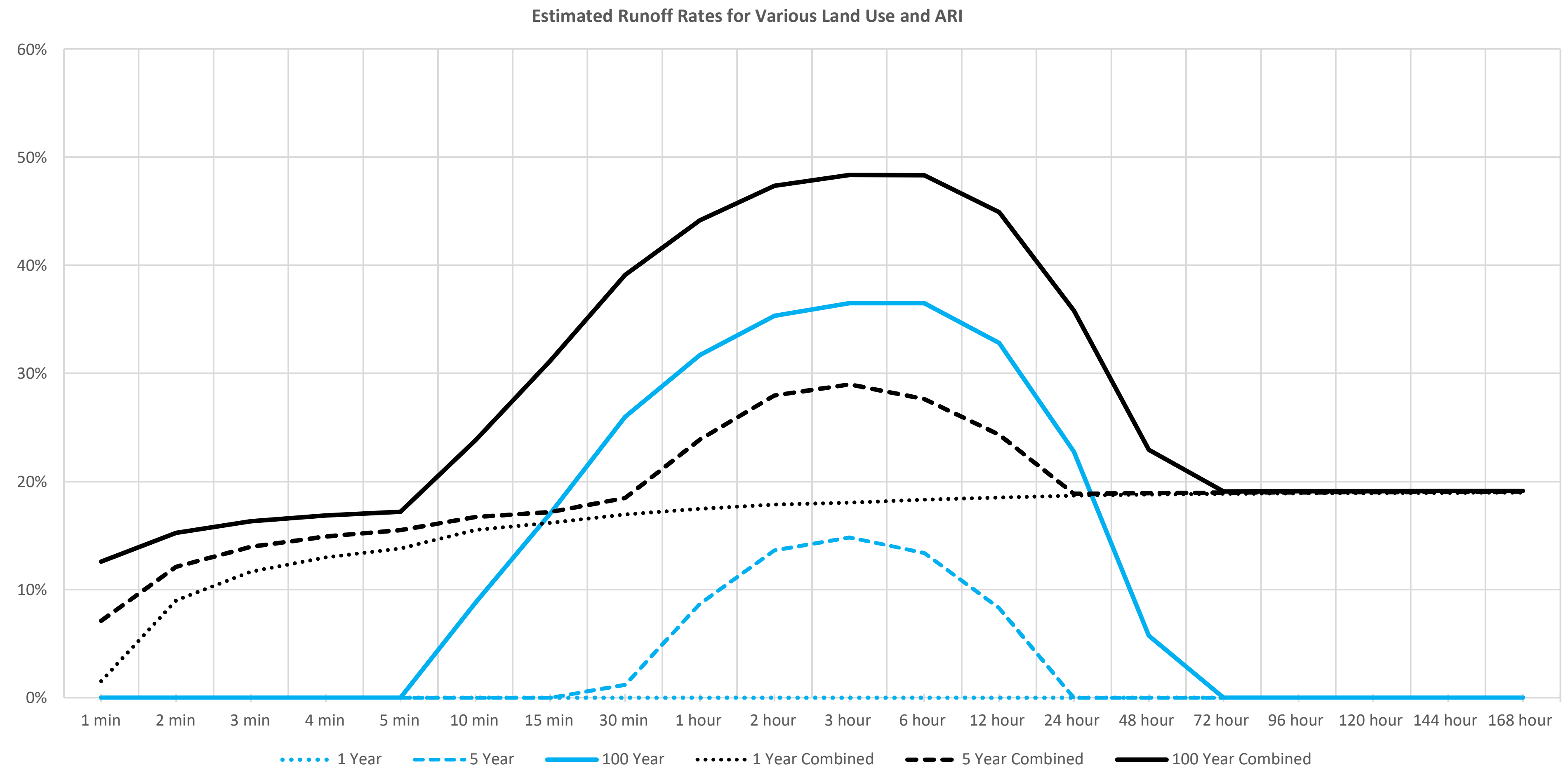
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Residential 300-600m2	12.57	Yes	1.5	20.0	4.0	15.0	0.25	60%	60	20	20	soakwells
2	Local Roads	5.11	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	no soakwells assumed
3	Active POS	0.97	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	assume similar EIA/TIA to rural residential
4				1.5	20.0	4.0		1.00					
5				1.5	20.0	4.0		1.00					
6				1.5	20.0	4.0		1.00					
7				1.5	20.0	4.0		1.00					
8				1.5	20.0	4.0		1.00					
9				1.5	20.0	4.0		1.00					
10				0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector 1

(11 - combined total)

Residential 300-600m2



Rainfall IFD Data

Annual Exceedence Probability

	Duration	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
1	1 min	1.63	1.8	2.38	2.8	3.23	3.84	4.33
2	2 min	2.82	3.11	4.04	4.71	5.4	6.4	7.22
3	3 min	3.8	4.18	5.46	6.38	7.34	8.71	9.85
4	4 min	4.6	5.08	6.66	7.81	9	10.7	12.1
5	5 min	5.29	5.85	7.7	9.04	10.4	12.4	14
6	10 min	7.75	8.59	11.4	13.4	15.5	18.4	20.7
7	15 min	9.37	10.4	13.8	16.2	18.7	22.2	25
8	30 min	12.5	13.8	18.2	21.3	24.6	29.2	32.8
9	1 hour	16.1	17.8	23.2	27.3	31.5	37.5	42.4
10	2 hour	20.6	22.6	29.5	34.7	40.3	48.5	55.4
11	3 hour	23.8	26.1	34	40.2	46.8	56.8	65.3
12	6 hour	30.6	33.5	43.7	51.9	60.9	74.7	86.8
13	12 hour	39.4	43.1	56.2	66.8	78.5	96.4	112
14	24 hour	50.3	55.1	71.6	84.1	97.6	119	136
15	48 hour	63.5	69.6	89.3	103	117	138	155
16	72 hour	72.7	79.7	101	115	129	150	166
17	96 hour	80.3	88	111	126	140	160	176
18	120 hour	87.2	95.5	120	136	151	172	189
19	144 hour	93.8	103	129	147	163	186	203
20	168 hour	100	109	138	157	176	202	221

Estimated Runoff Rates

Annual Exceedence Probability

Maximum of All Events	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
Residential 300-600m2	**0%**	4%	**15%**	**22%**	27%	33%	**36%**
Local Roads	**69%**	69%	**69%**	**74%**	77%	81%	**84%**
Active POS	**1%**	1%	**3%**	**7%**	10%	14%	**16%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
combined total	**19%**	21%	**29%**	**35%**	40%	45%	**48%**

Event Selector	9	1 hour					
Residential 300-600m2	**0%**	0%	**9%**	**16%**	22%	28%	**32%**
Local Roads	**63%**	64%	**65%**	**70%**	74%	78%	**81%**
Active POS	**1%**	1%	**1%**	**5%**	8%	12%	**14%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
combined total	**17%**	18%	**24%**	**30%**	35%	41%	**44%**

CURRV

Calculator for Urban Runoff Rates & Volumes

11/10/2024

Project: Lakefarm Ballajura DWMS - Catchment 2

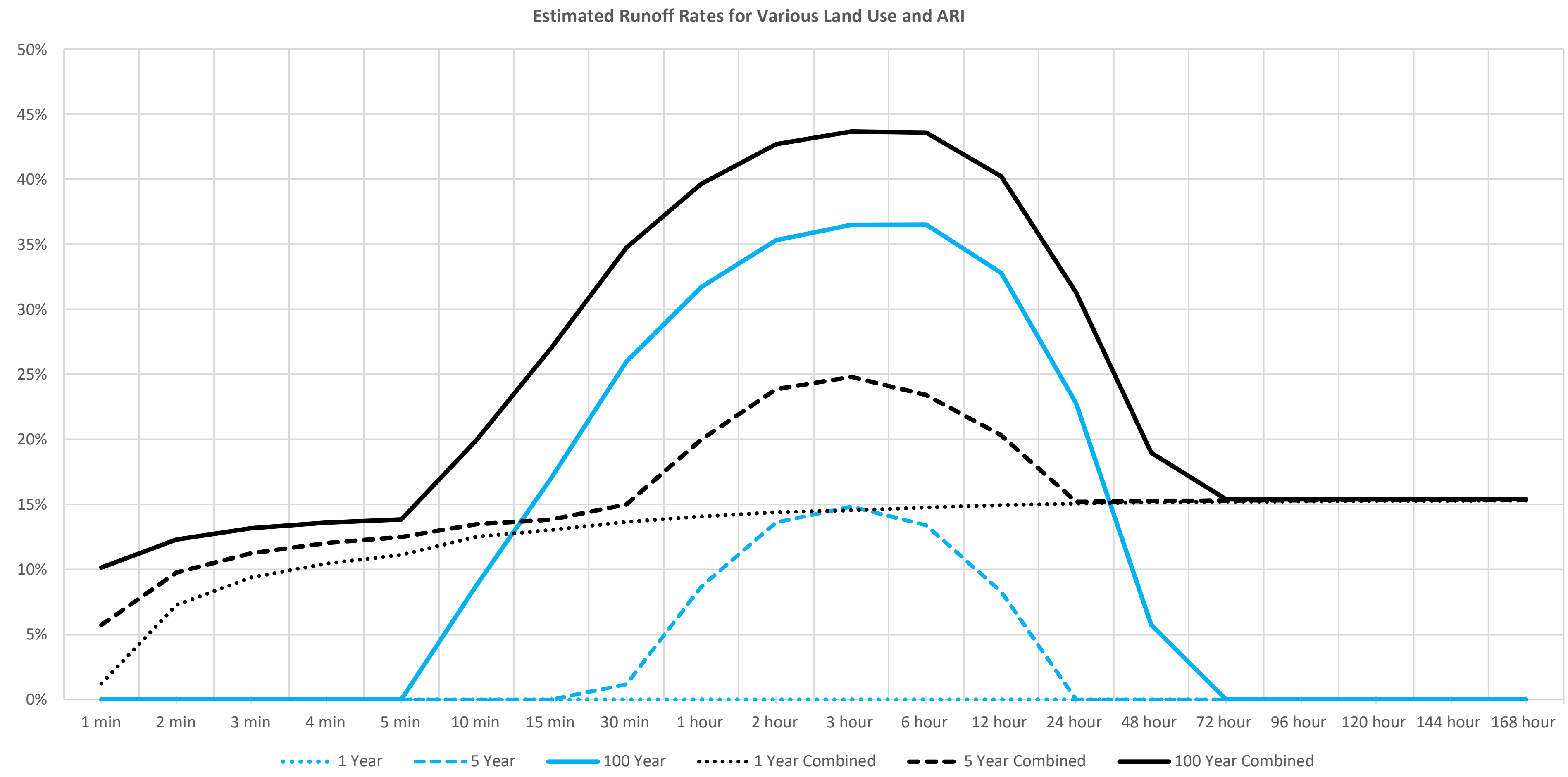
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Residential 300-600m2	6.93	Yes	1.5	20.0	4.0	15.0	0.25	60%	60	20	20	soakwells
2	Local Roads	2.41	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	no soakwells assumed
3	Active POS	1.69	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	assume similar EIA/TIA to rural residential
4				1.5	20.0	4.0		1.00					
5				1.5	20.0	4.0		1.00					
6				1.5	20.0	4.0		1.00					
7				1.5	20.0	4.0		1.00					
8				1.5	20.0	4.0		1.00					
9				1.5	20.0	4.0		1.00					
10				0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	1

(11 - combined total)

Residential 300-600m2



Rainfall IFD Data

Annual Exceedence Probability

	Duration	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
1	1 min	1.63	1.8	2.38	2.8	3.23	3.84	4.33
2	2 min	2.82	3.11	4.04	4.71	5.4	6.4	7.22
3	3 min	3.8	4.18	5.46	6.38	7.34	8.71	9.85
4	4 min	4.6	5.08	6.66	7.81	9	10.7	12.1
5	5 min	5.29	5.85	7.7	9.04	10.4	12.4	14
6	10 min	7.75	8.59	11.4	13.4	15.5	18.4	20.7
7	15 min	9.37	10.4	13.8	16.2	18.7	22.2	25
8	30 min	12.5	13.8	18.2	21.3	24.6	29.2	32.8
9	1 hour	16.1	17.8	23.2	27.3	31.5	37.5	42.4
10	2 hour	20.6	22.6	29.5	34.7	40.3	48.5	55.4
11	3 hour	23.8	26.1	34	40.2	46.8	56.8	65.3
12	6 hour	30.6	33.5	43.7	51.9	60.9	74.7	86.8
13	12 hour	39.4	43.1	56.2	66.8	78.5	96.4	112
14	24 hour	50.3	55.1	71.6	84.1	97.6	119	136
15	48 hour	63.5	69.6	89.3	103	117	138	155
16	72 hour	72.7	79.7	101	115	129	150	166
17	96 hour	80.3	88	111	126	140	160	176
18	120 hour	87.2	95.5	120	136	151	172	189
19	144 hour	93.8	103	129	147	163	186	203
20	168 hour	100	109	138	157	176	202	221

Estimated Runoff Rates

Annual Exceedence Probability

Maximum of All Events	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
Residential 300-600m2	**0%**	4%	**15%**	**22%**	27%	33%	**36%**
Local Roads	**69%**	69%	**69%**	**74%**	77%	81%	**84%**
Active POS	**1%**	1%	**3%**	**7%**	10%	14%	**16%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
combined total	**15%**	17%	**25%**	**31%**	36%	41%	**44%**

Event Selector	9	1 hour					
Residential 300-600m2	**0%**	0%	**9%**	**16%**	22%	28%	**32%**
Local Roads	**63%**	64%	**65%**	**70%**	74%	78%	**81%**
Active POS	**1%**	1%	**1%**	**5%**	8%	12%	**14%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
combined total	**14%**	14%	**20%**	**26%**	31%	36%	**40%**

CURRV

Calculator for Urban Runoff Rates & Volumes

11/10/2024

nya2o HYDROLOGY

Project: Lakefarm Ballajura DWMS - Catchment 3

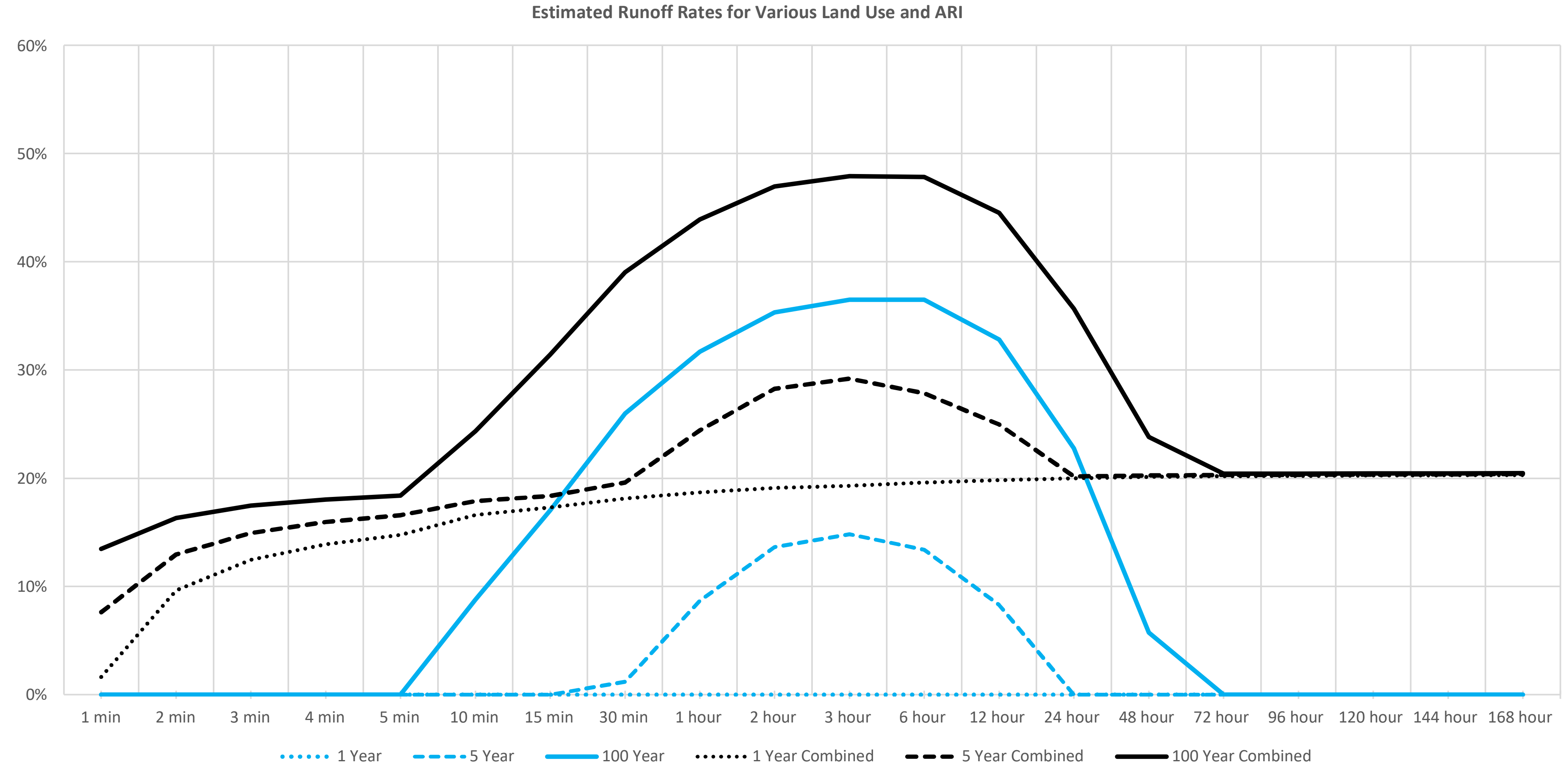
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Residential 300-600m2	4.29	Yes	1.5	20.0	4.0	15.0	0.25	60%	60	20	20	soakwells
2	Local Roads	2.11	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	no soakwells assumed
3	Active POS	0.83	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	assume similar EIA/TIA to rural residential
4				1.5	20.0	4.0		1.00					
5				1.5	20.0	4.0		1.00					
6				1.5	20.0	4.0		1.00					
7				1.5	20.0	4.0		1.00					
8				1.5	20.0	4.0		1.00					
9				1.5	20.0	4.0		1.00					
10				0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	1

(11 - combined total)

Residential 300-600m2



Rainfall IFD Data

Annual Exceedence Probability

	Duration	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
1	1 min	1.63	1.8	2.38	2.8	3.23	3.84	4.33
2	2 min	2.82	3.11	4.04	4.71	5.4	6.4	7.22
3	3 min	3.8	4.18	5.46	6.38	7.34	8.71	9.85
4	4 min	4.6	5.08	6.66	7.81	9	10.7	12.1
5	5 min	5.29	5.85	7.7	9.04	10.4	12.4	14
6	10 min	7.75	8.59	11.4	13.4	15.5	18.4	20.7
7	15 min	9.37	10.4	13.8	16.2	18.7	22.2	25
8	30 min	12.5	13.8	18.2	21.3	24.6	29.2	32.8
9	1 hour	16.1	17.8	23.2	27.3	31.5	37.5	42.4
10	2 hour	20.6	22.6	29.5	34.7	40.3	48.5	55.4
11	3 hour	23.8	26.1	34	40.2	46.8	56.8	65.3
12	6 hour	30.6	33.5	43.7	51.9	60.9	74.7	86.8
13	12 hour	39.4	43.1	56.2	66.8	78.5	96.4	112
14	24 hour	50.3	55.1	71.6	84.1	97.6	119	136
15	48 hour	63.5	69.6	89.3	103	117	138	155
16	72 hour	72.7	79.7	101	115	129	150	166
17	96 hour	80.3	88	111	126	140	160	176
18	120 hour	87.2	95.5	120	136	151	172	189
19	144 hour	93.8	103	129	147	163	186	203
20	168 hour	100	109	138	157	176	202	221

Estimated Runoff Rates

Annual Exceedence Probability

Maximum of All Events	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
Residential 300-600m2	0%	4%	15%	22%	27%	33%	36%
Local Roads	69%	69%	69%	74%	77%	81%	84%
Active POS	1%	1%	3%	7%	10%	14%	16%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**20%**	22%	**29%**	**35%**	40%	45%	**48%**

Event Selector	9	1 hour					
Residential 300-600m2	0%	0%	9%	16%	22%	28%	32%
Local Roads	63%	64%	65%	70%	74%	78%	81%
Active POS	1%	1%	1%	5%	8%	12%	14%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**19%**	19%	**24%**	**30%**	35%	41%	**44%**

CURRV

Calculator for Urban Runoff Rates & Volumes
11/10/2024

Project: Lakefarm Ballajura DWMS - Catchment 4

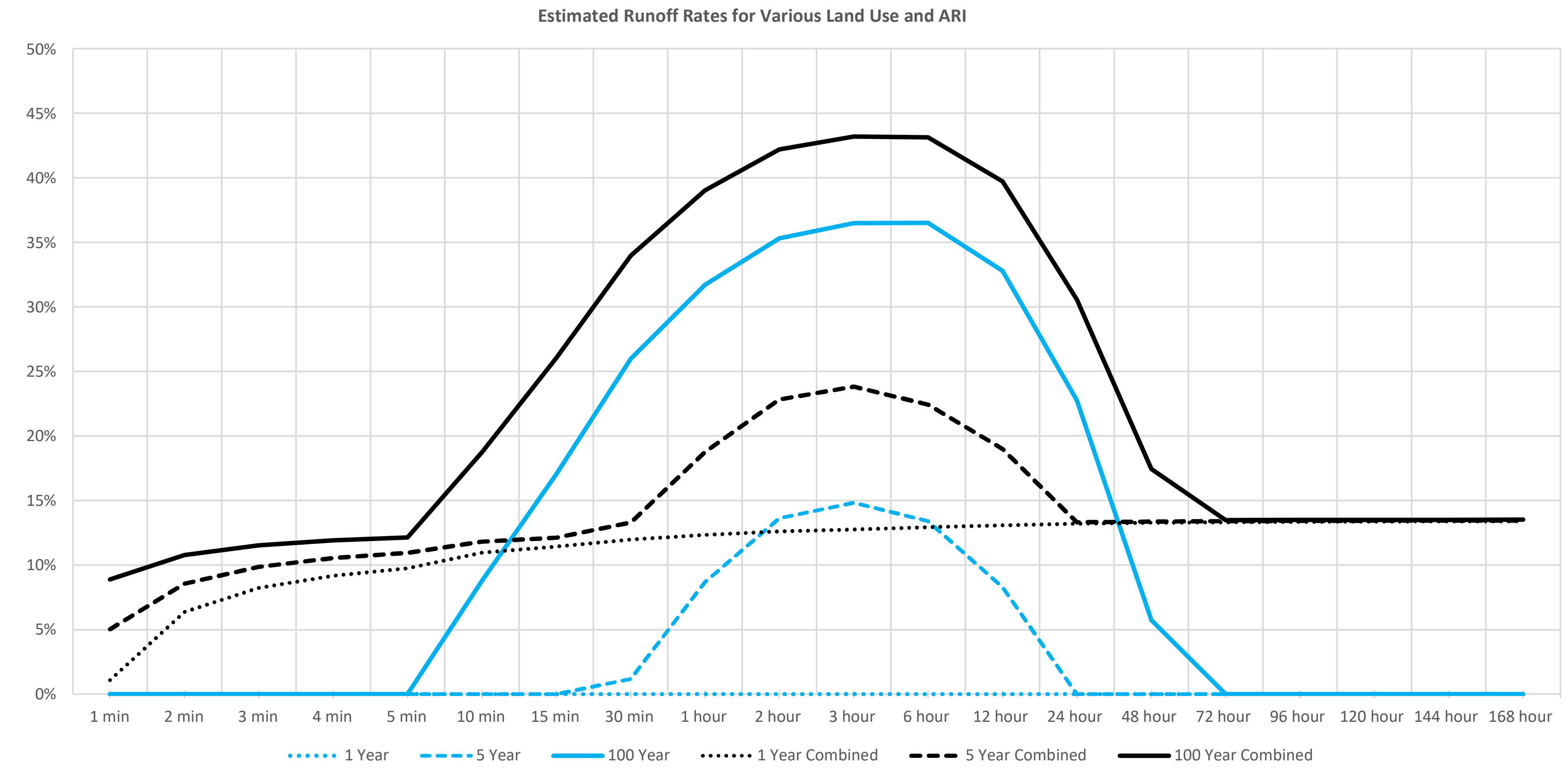
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Residential 300-600m2	3.58	Yes	1.5	20.0	4.0	15.0	0.25	60%	60	20	20	soakwells
2	Local Roads	0.99	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	no soakwells assumed
3	Active POS	0.59	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	assume similar EIA/TIA to rural residential
4				1.5	20.0	4.0		1.00					
5				1.5	20.0	4.0		1.00					
6				1.5	20.0	4.0		1.00					
7				1.5	20.0	4.0		1.00					
8				1.5	20.0	4.0		1.00					
9				1.5	20.0	4.0		1.00					
10				0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	1

(11 - combined total)

Residential 300-600m2



Rainfall IFD Data

Annual Exceedence Probability

		63.2%	50%	20%	10%	5%	2%	1%
	Duration	1.00	1.44	4.48	10	20	50	100
1	1 min	1.63	1.8	2.38	2.8	3.23	3.84	4.33
2	2 min	2.82	3.11	4.04	4.71	5.4	6.4	7.22
3	3 min	3.8	4.18	5.46	6.38	7.34	8.71	9.85
4	4 min	4.6	5.08	6.66	7.81	9	10.7	12.1
5	5 min	5.29	5.85	7.7	9.04	10.4	12.4	14
6	10 min	7.75	8.59	11.4	13.4	15.5	18.4	20.7
7	15 min	9.37	10.4	13.8	16.2	18.7	22.2	25
8	30 min	12.5	13.8	18.2	21.3	24.6	29.2	32.8
9	1 hour	16.1	17.8	23.2	27.3	31.5	37.5	42.4
10	2 hour	20.6	22.6	29.5	34.7	40.3	48.5	55.4
11	3 hour	23.8	26.1	34	40.2	46.8	56.8	65.3
12	6 hour	30.6	33.5	43.7	51.9	60.9	74.7	86.8
13	12 hour	39.4	43.1	56.2	66.8	78.5	96.4	112
14	24 hour	50.3	55.1	71.6	84.1	97.6	119	136
15	48 hour	63.5	69.6	89.3	103	117	138	155
16	72 hour	72.7	79.7	101	115	129	150	166
17	96 hour	80.3	88	111	126	140	160	176
18	120 hour	87.2	95.5	120	136	151	172	189
19	144 hour	93.8	103	129	147	163	186	203
20	168 hour	100	109	138	157	176	202	221

Estimated Runoff Rates

Annual Exceedence Probability

	63.2%	50%	20%	10%	5%	2%	1%
Maximum of All Events	1.00	1.44	4.48	10	20	50	100
Residential 300-600m2	0%	4%	15%	22%	27%	33%	36%
Local Roads	69%	69%	69%	74%	77%	81%	84%
Active POS	1%	1%	3%	7%	10%	14%	16%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	13%	15%	24%	30%	35%	40%	43%

Event Selector	9	1 hour					
Residential 300-600m2	0%	0%	9%	16%	22%	28%	32%
Local Roads	63%	64%	65%	70%	74%	78%	81%
Active POS	1%	1%	1%	5%	8%	12%	14%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	12%	12%	19%	25%	30%	36%	39%

CURRV

Calculator for Urban Runoff Rates & Volumes

11/10/2024

Project: Lakefarm Ballajura DWMS - Catchment 5

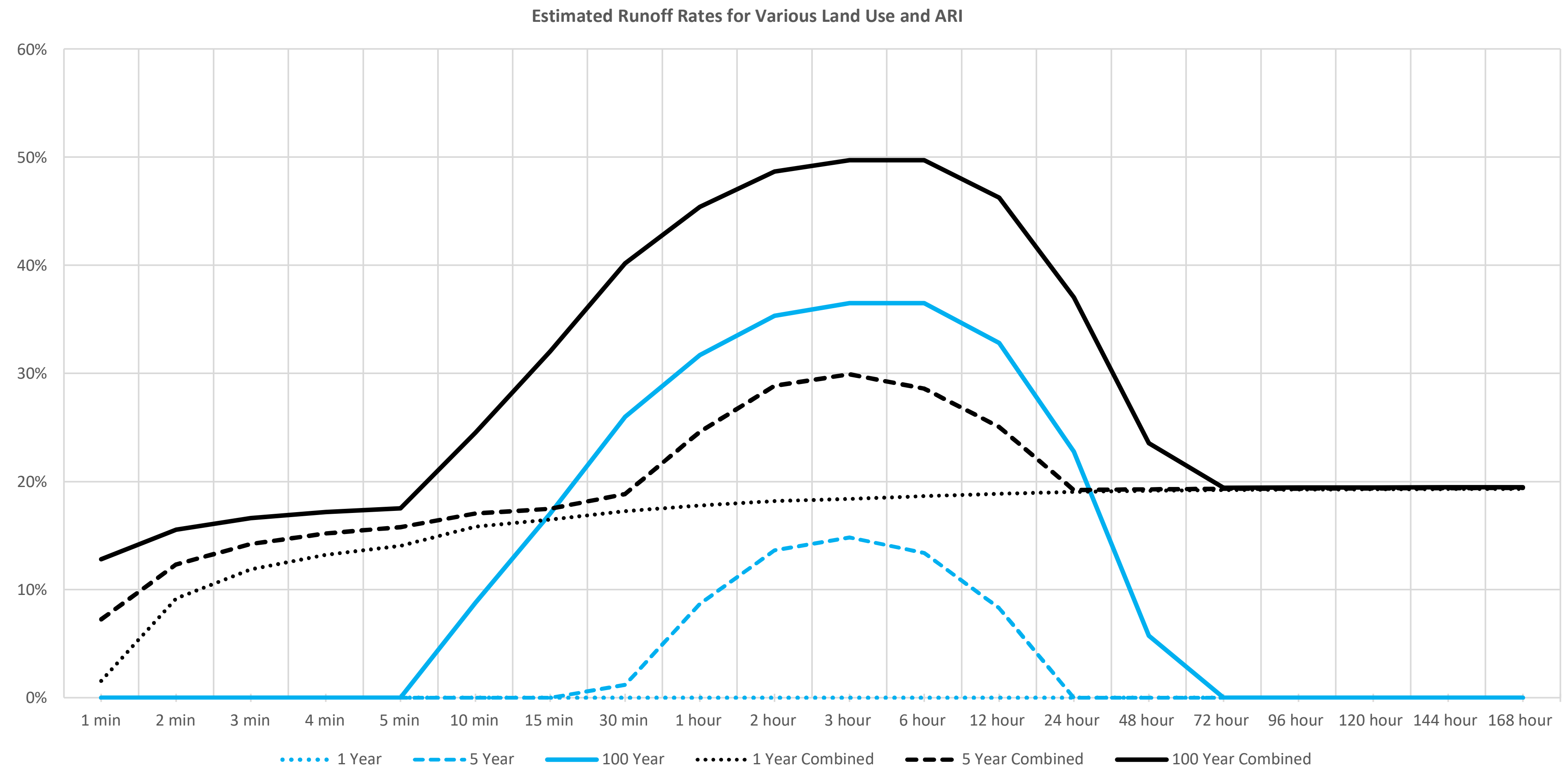
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Residential 300-600m2	3.88	Yes	1.5	20.0	4.0	15.0	0.25	60%	60	20	20	soakwells
2	Local Roads	1.51	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	no soakwells assumed
3	Active POS	0.00	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	assume similar EIA/TIA to rural residential
4				1.5	20.0	4.0		1.00					
5				1.5	20.0	4.0		1.00					
6				1.5	20.0	4.0		1.00					
7				1.5	20.0	4.0		1.00					
8				1.5	20.0	4.0		1.00					
9				1.5	20.0	4.0		1.00					
10				0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	1

(11 - combined total)

Residential 300-600m2


Estimated Runoff Rates for Various Land Use and ARI

Rainfall IFD Data

Annual Exceedence Probability

		63.2%	50%	20%	10%	5%	2%	1%
	Duration	1.00	1.44	4.48	10	20	50	100
1	1 min	1.63	1.8	2.38	2.8	3.23	3.84	4.33
2	2 min	2.82	3.11	4.04	4.71	5.4	6.4	7.22
3	3 min	3.8	4.18	5.46	6.38	7.34	8.71	9.85
4	4 min	4.6	5.08	6.66	7.81	9	10.7	12.1
5	5 min	5.29	5.85	7.7	9.04	10.4	12.4	14
6	10 min	7.75	8.59	11.4	13.4	15.5	18.4	20.7
7	15 min	9.37	10.4	13.8	16.2	18.7	22.2	25
8	30 min	12.5	13.8	18.2	21.3	24.6	29.2	32.8
9	1 hour	16.1	17.8	23.2	27.3	31.5	37.5	42.4
10	2 hour	20.6	22.6	29.5	34.7	40.3	48.5	55.4
11	3 hour	23.8	26.1	34	40.2	46.8	56.8	65.3
12	6 hour	30.6	33.5	43.7	51.9	60.9	74.7	86.8
13	12 hour	39.4	43.1	56.2	66.8	78.5	96.4	112
14	24 hour	50.3	55.1	71.6	84.1	97.6	119	136
15	48 hour	63.5	69.6	89.3	103	117	138	155
16	72 hour	72.7	79.7	101	115	129	150	166
17	96 hour	80.3	88	111	126	140	160	176
18	120 hour	87.2	95.5	120	136	151	172	189
19	144 hour	93.8	103	129	147	163	186	203
20	168 hour	100	109	138	157	176	202	221

Estimated Runoff Rates

Annual Exceedence Probability

	63.2%	50%	20%	10%	5%	2%	1%
Maximum of All Events	1.00	1.44	4.48	10	20	50	100
Residential 300-600m2	**0%**	4%	**15%**	**22%**	27%	33%	**36%**
Local Roads	**69%**	69%	**69%**	**74%**	77%	81%	**84%**
Active POS	**1%**	1%	**3%**	**7%**	10%	14%	**16%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
combined total	**19%**	21%	**30%**	**36%**	41%	46%	**50%**

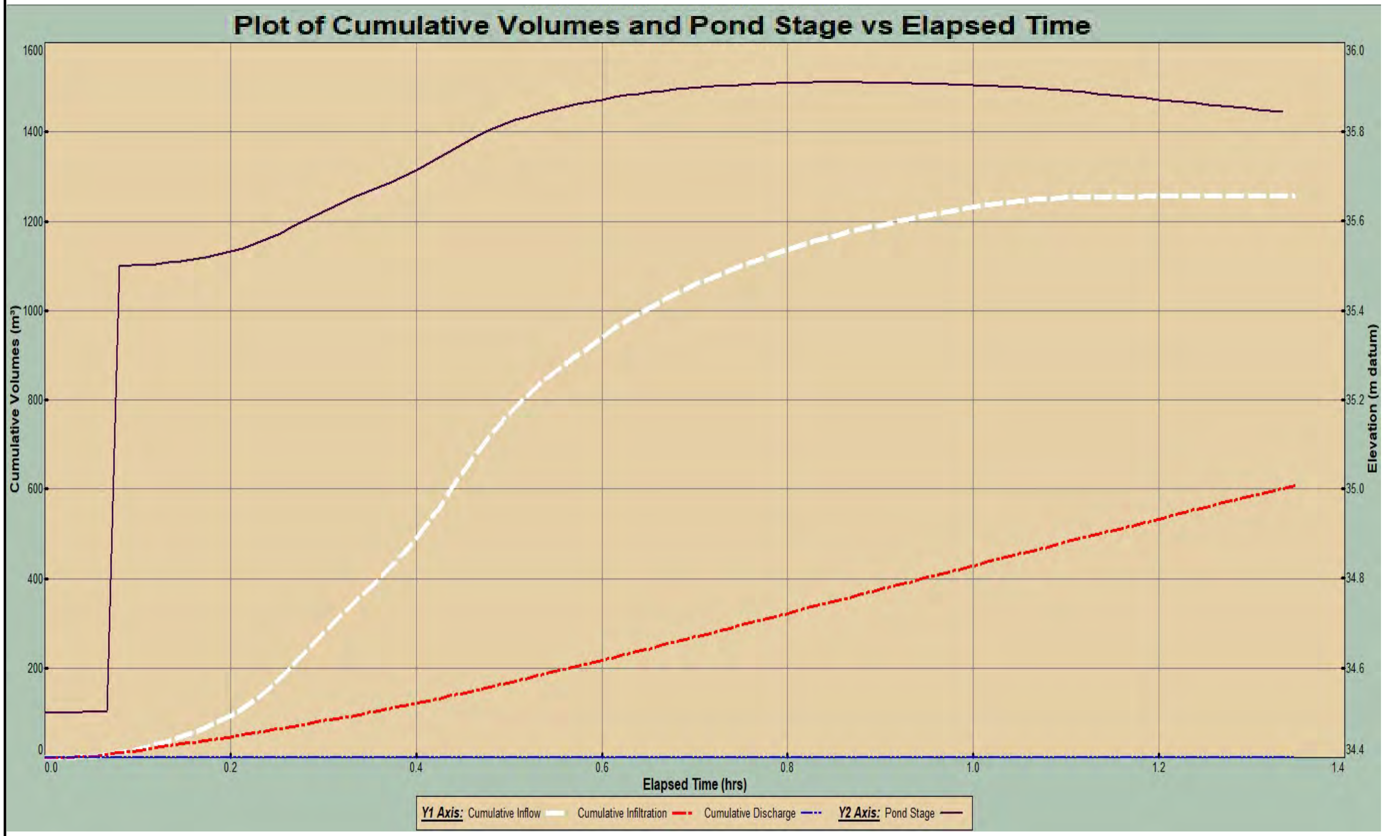
Event Selector	9	1 hour					
Residential 300-600m2	**0%**	0%	**9%**	**16%**	22%	28%	**32%**
Local Roads	**63%**	64%	**65%**	**70%**	74%	78%	**81%**
Active POS	**1%**	1%	**1%**	**5%**	8%	12%	**14%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
0	**0%**	0%	**0%**	**0%**	0%	0%	**0%**
combined total	**18%**	18%	**25%**	**31%**	36%	42%	**45%**

APPENDIX K

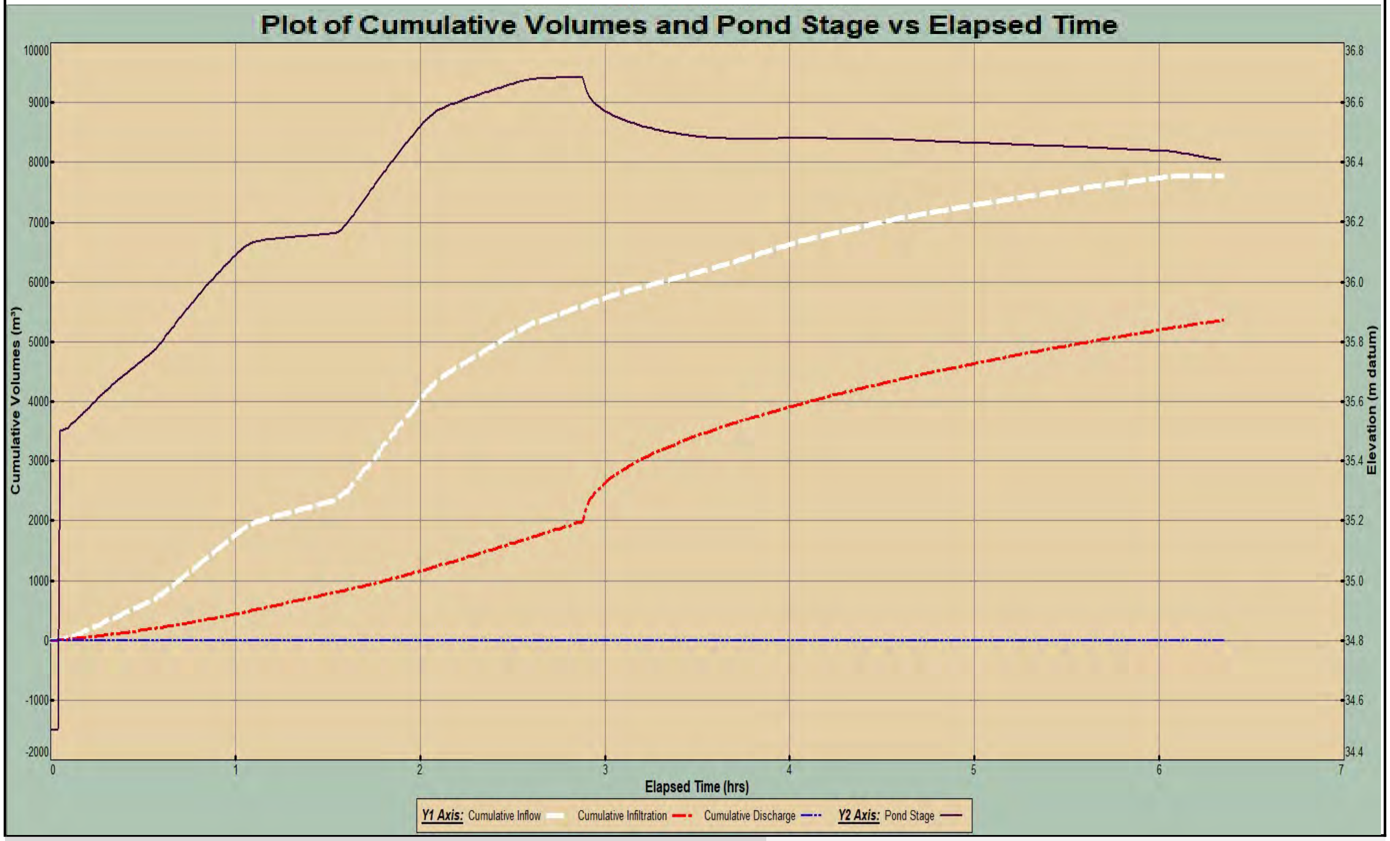
Stormwater Modelling Outputs

Date: 23/10/2024 Job No. H24009

PONDS 20% AEP Results



PONDS 1% AEP Results



hyd2o

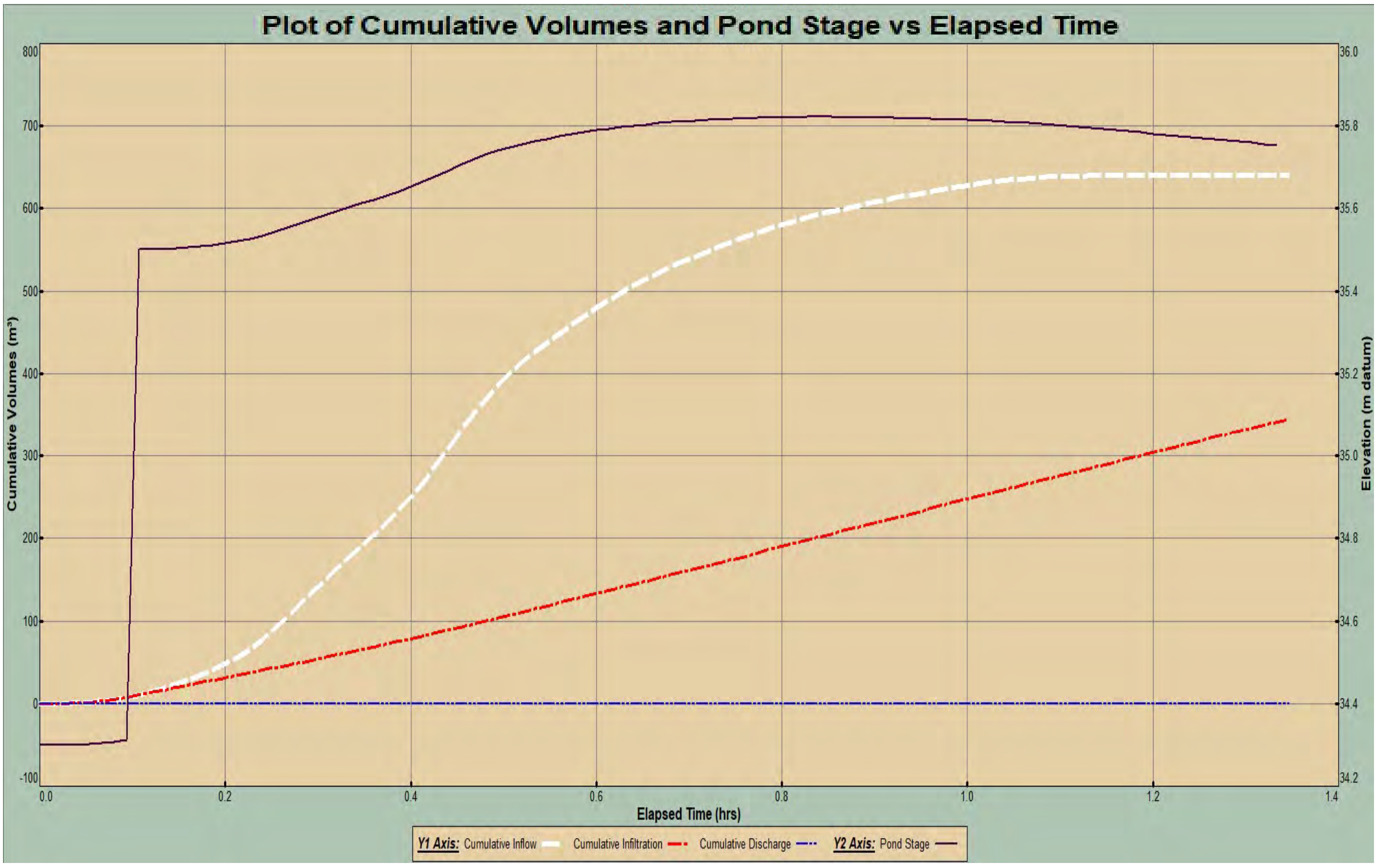
Lakefarm Rereat Ballajura DWMS

Catchment 1 PONDS 1% & 20% AEP Results

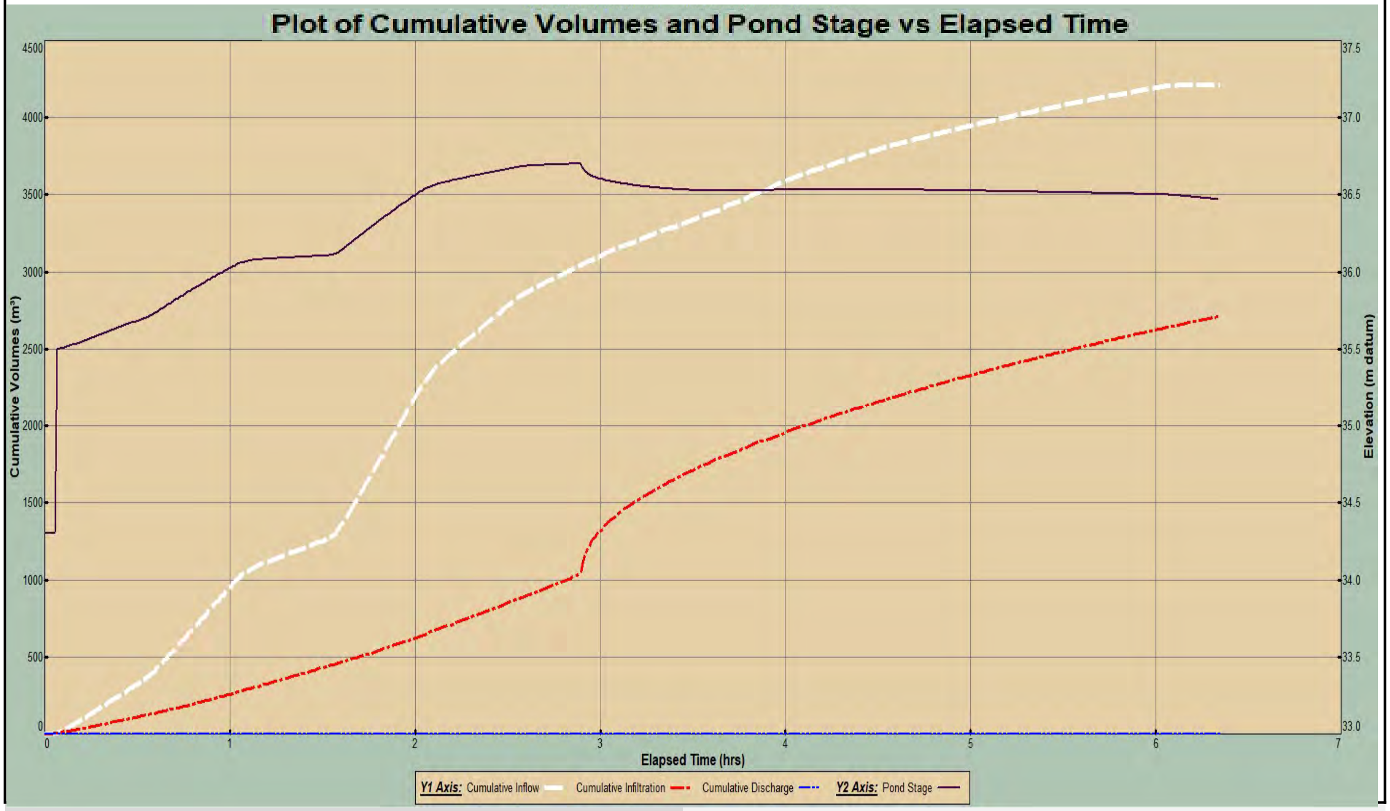
Figure K1

Date: 23/10/2024 Job No. H24009

PONDS 20% AEP Results



PONDS 1% AEP Results



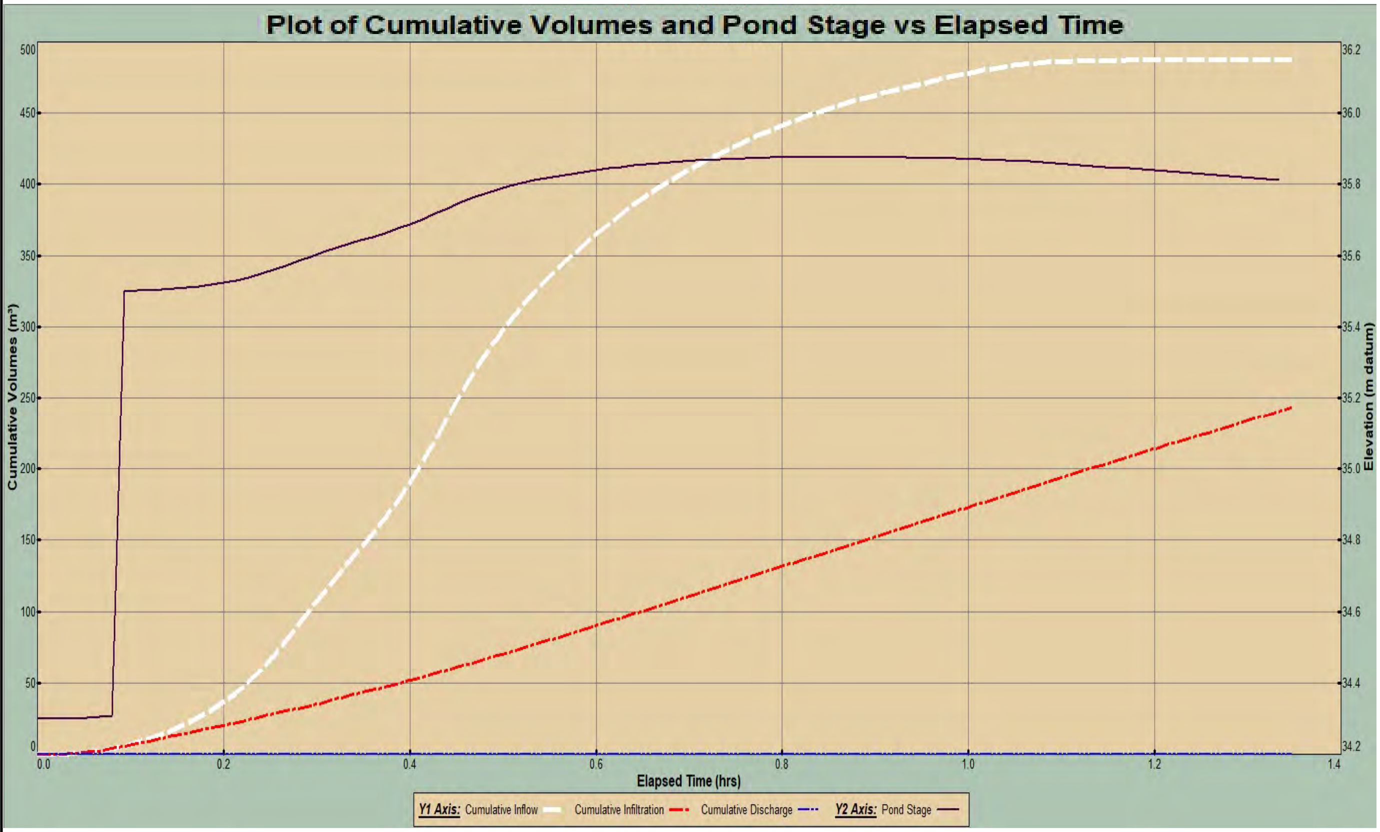
hyd2o

Lakefarm Rereat Ballajura DWMS

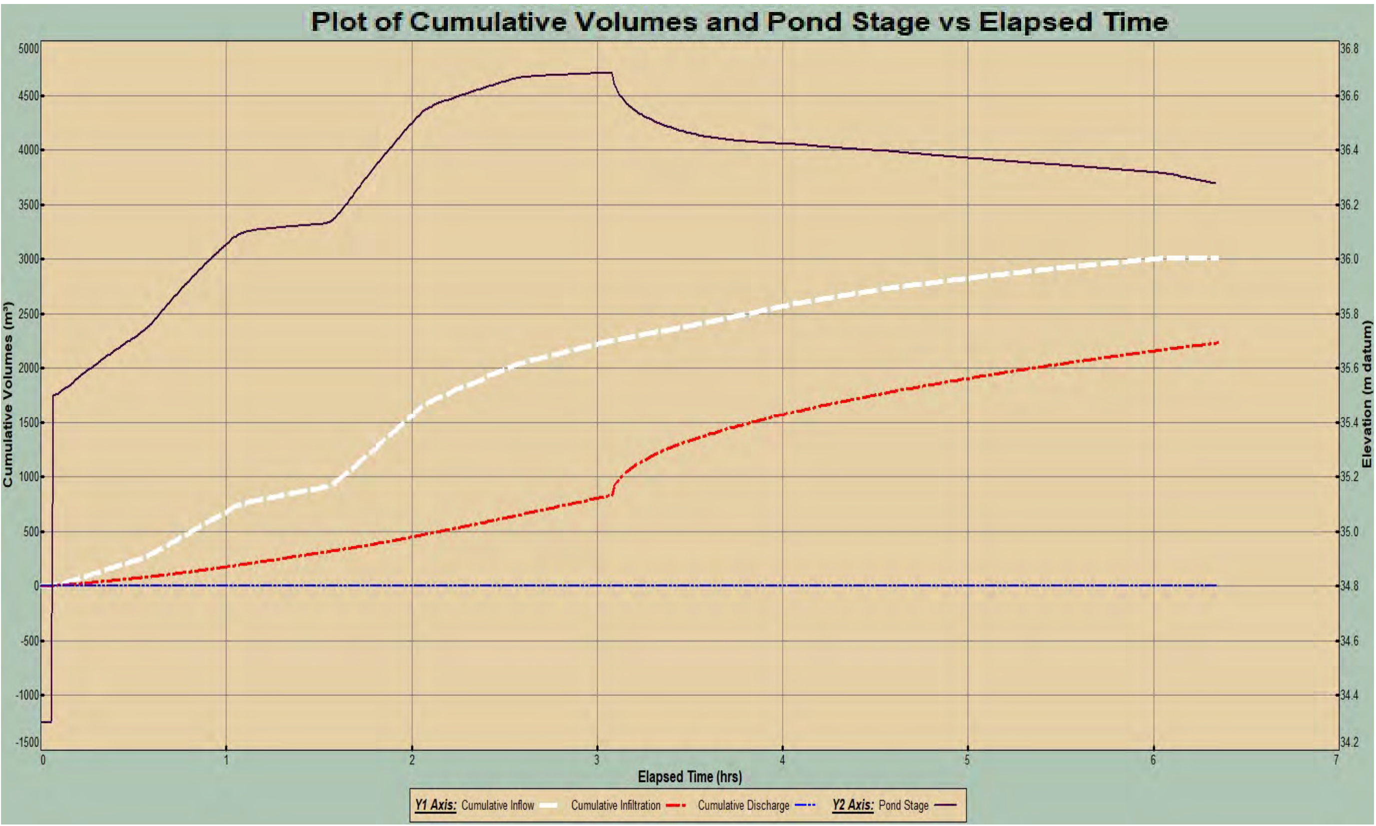
Catchment 2 PONDS 1% & 20% AEP Results

Figure K2

PONDS 20% AEP Results



PONDS 1% AEP Results



hyd$_2$o

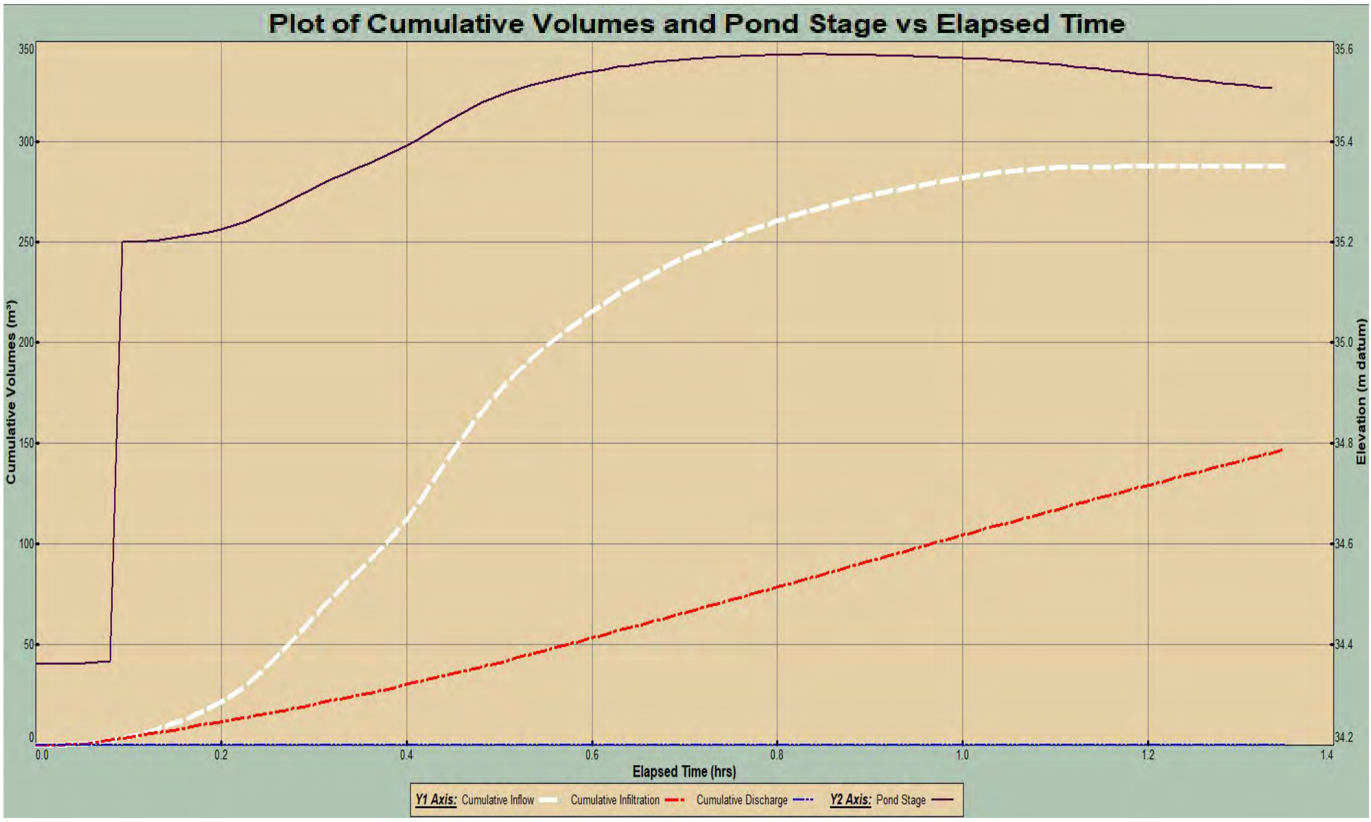
Lakefarm Rereat Ballajura DWMS

Catchment 3 PONDS 1% & 20% AEP Results

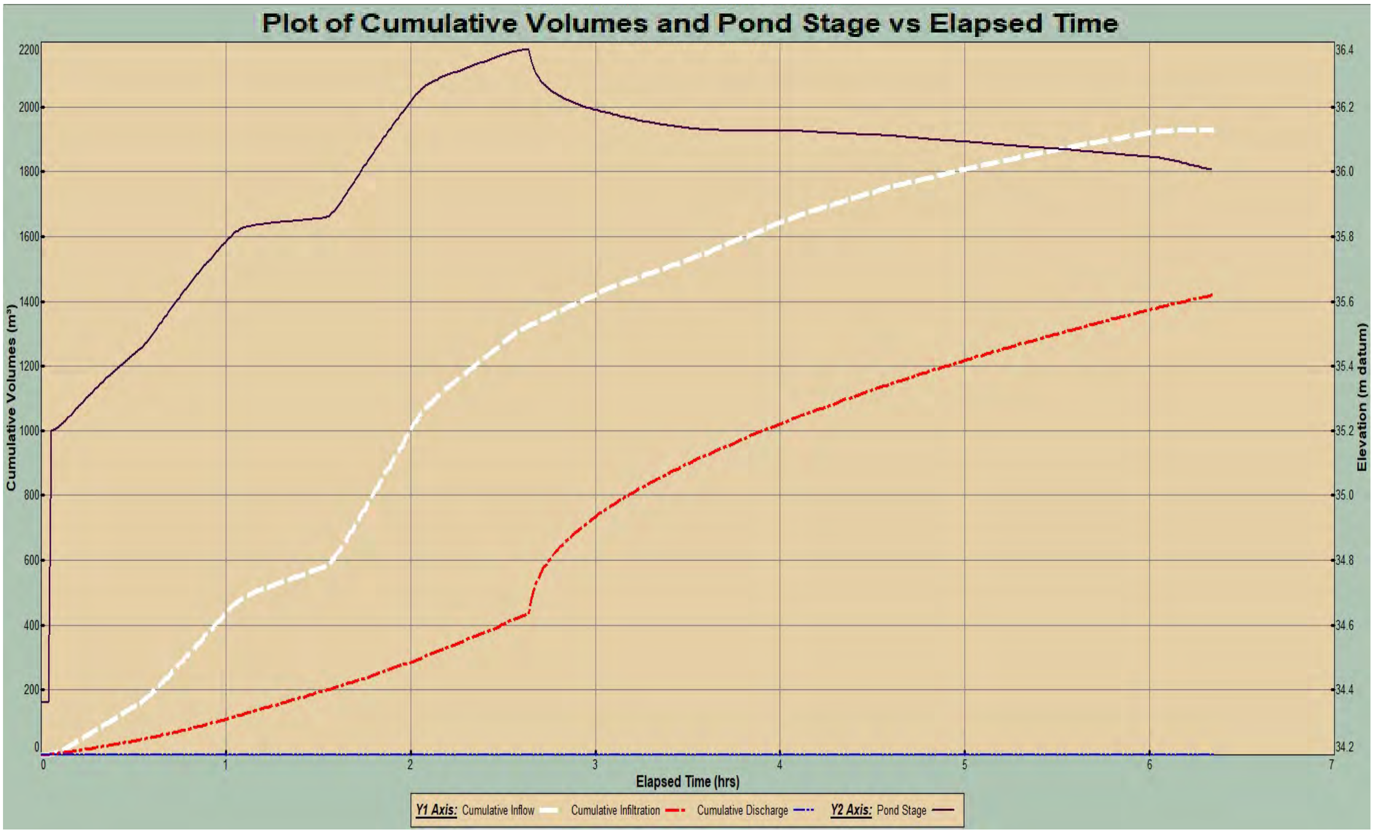
Figure K3

Date: 23/10/2024 Job No. H24009

PONDS 20% AEP Results



PONDS 1% AEP Results



hyd₂o

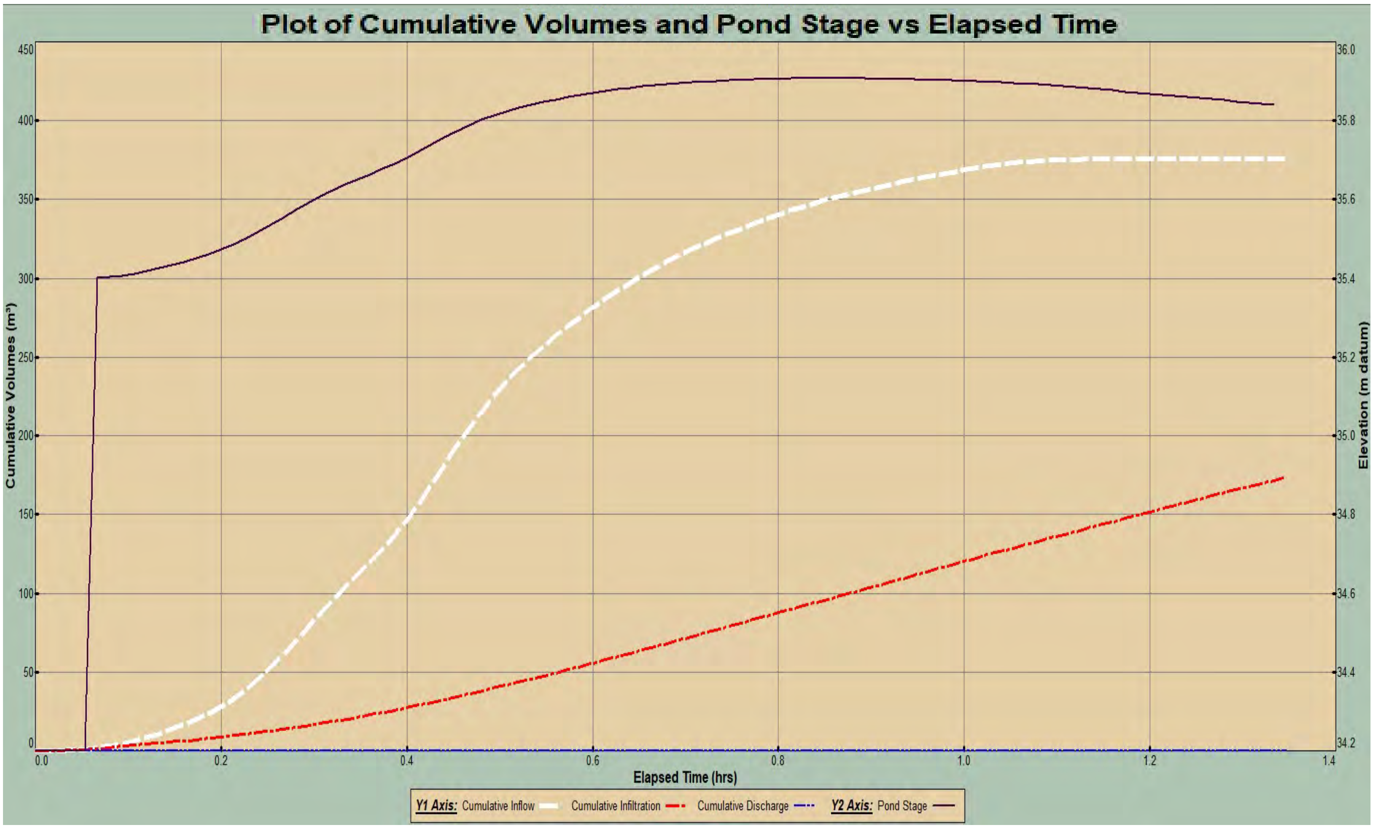
Lakefarm Rereat Ballajura DWMS

Catchment 4 PONDS 1% & 20% AEP Results

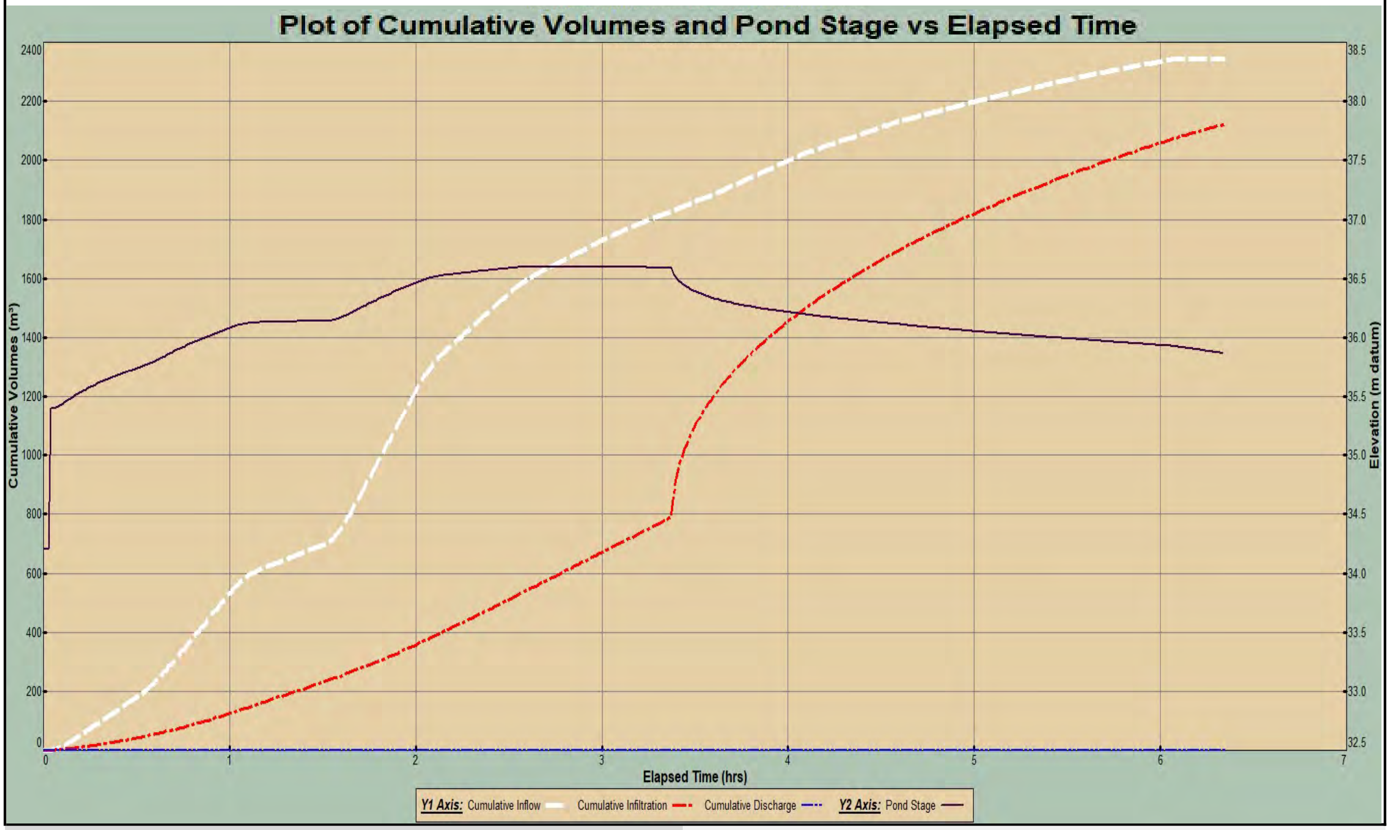
Figure K4

Date: 23/10/2024 Job No. H24009

PONDS 20% AEP Results



PONDS 1% AEP Results



hyd$_2$o

Lakefarm Rereat Ballajura DWMS

Catchment 5 PONDS 1% & 20% AEP Results

Figure K5

APPENDIX L

Engineering Servicing Report

pritchard francis

Albany
Broome
Darwin
Perth

24-213

27 September 2024

Mr Tim Bycroft
Land Group WA
578 Murray St
West Perth WA 6005

Dear Tim

LAKEFARM RETREAT
Desktop Engineering Servicing Assessment

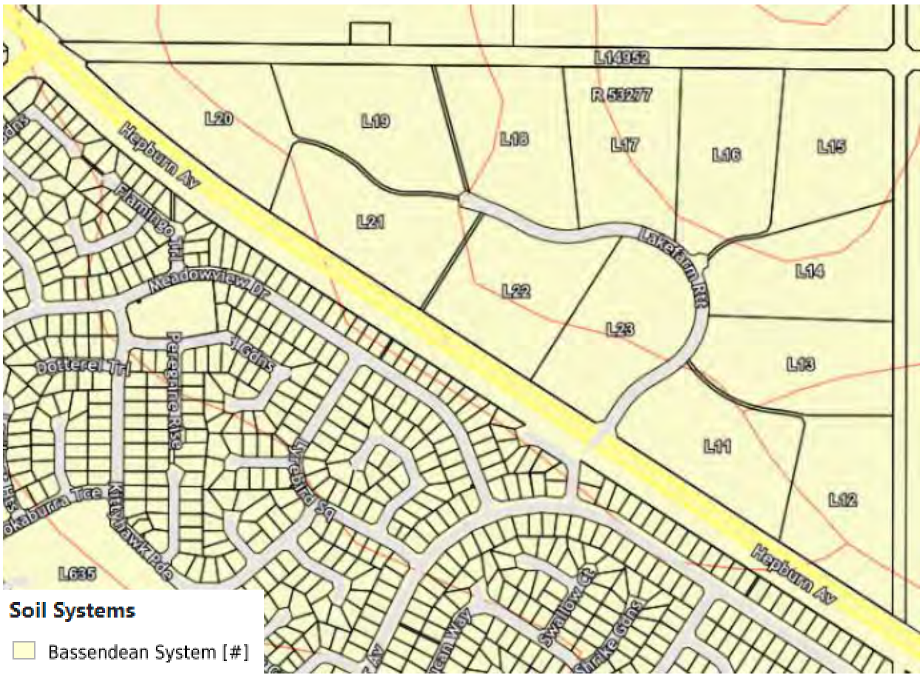
Desktop review of online mapping and consultation with service authorities has determined that urban development of lots 11 – 23 Lakefarm Retreat, Ballajura is technically feasible. Existing site conditions and nearby services provide for swift development with minimal engineering headworks required. Please refer below for a breakdown of the different site components and services which considered approximately 750 lots:

1 Local Government – City of Swans

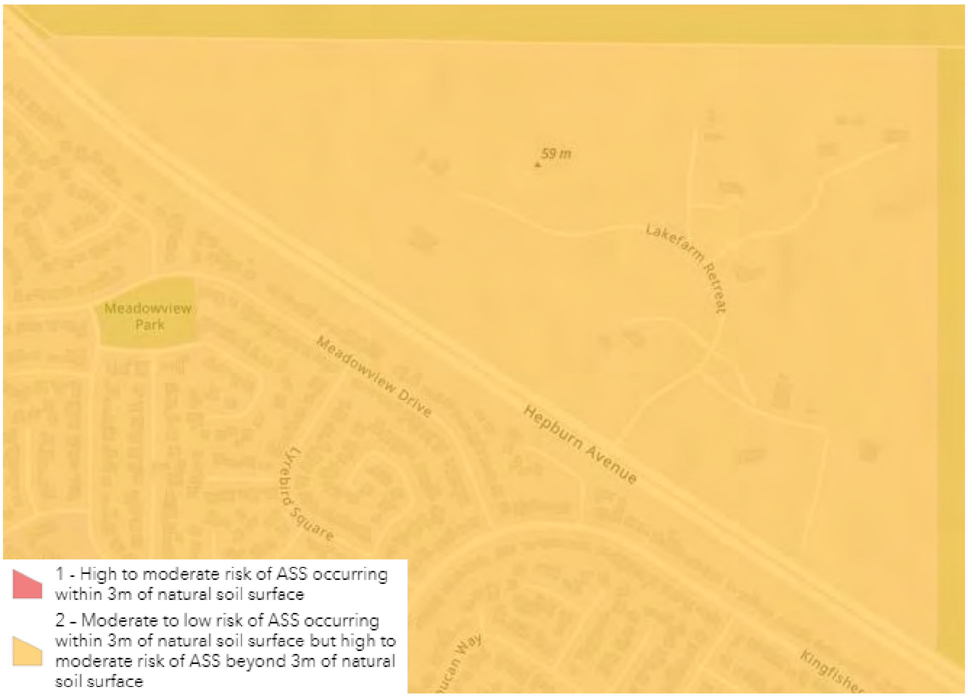
- Lots 12 - 23 Lakefarm Retreat are zoned General Rural under Town Planning Scheme 17.
- MRS Zoning Rural – Water Protection.
- Design of earthworks, roadworks and drainage shall adhere to the City of Swan's specifications and standards.

2 Geotechnical / Environmental

- The Perth 1:50 000 Environmental Geology sheet indicates that the site is part of the Bassendean Sand system meaning free draining and well graded soils.
- Galt Geotechnics have conducted site works and confirmed the site consists of sand to a maximum investigation depth of 3m with a thin lens of coffee rock found at depths between 1-2.5m. Based on these findings, a preliminary site classification as "Class A" has been confirmed.
- No site remediation or significant earthworks are required and therefore the site is immediately ready for development from a geotechnical perspective.



- Acid Sulphate Soils (ASS) mapping categorises the site as Moderate to Low Risk. ASS testing should be conducted on site to aid management through construction.



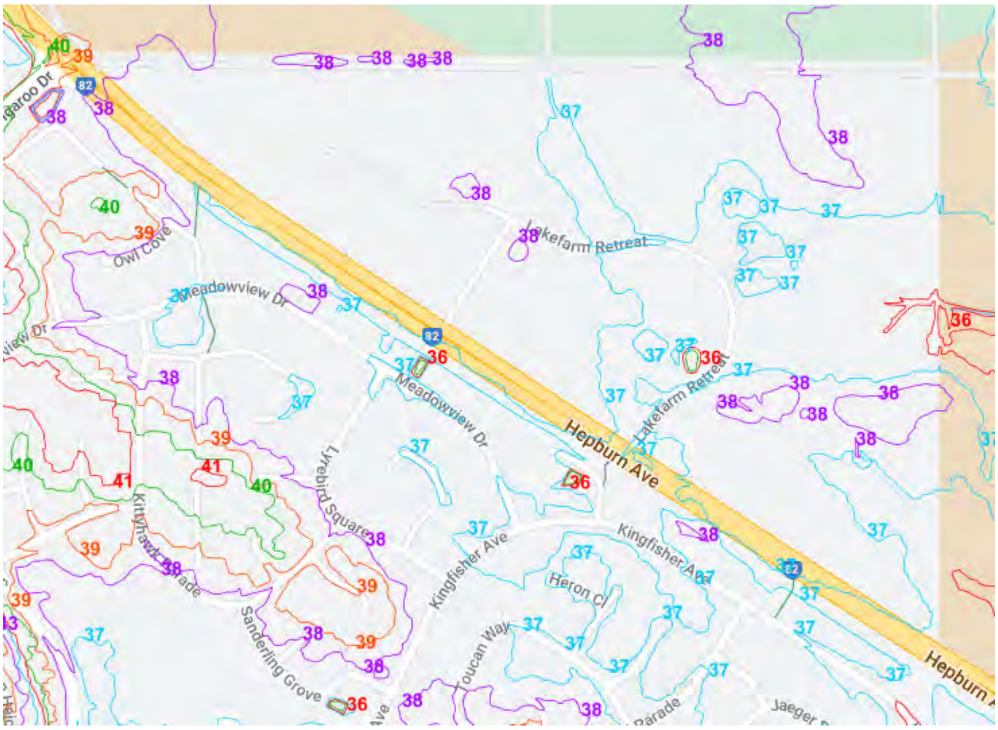
- Multiple Use category wetland bisects the site representing a former waterway however, no surface water is present when reviewing current aerial imagery. This category of wetland can be developed to an urban standard.
- Conservation and Resource Enhancement wetlands are present and cannot be developed. Wetland management advice is to be sought from an environmental consultant.

- Bushfire Prone Areas are found throughout the site and along the northern boundary. Bushfire management plan is to be prepared to assess clearing of vegetation, Bushfire Attack Levels (BAL) to future urban lots and emergency access/egress.

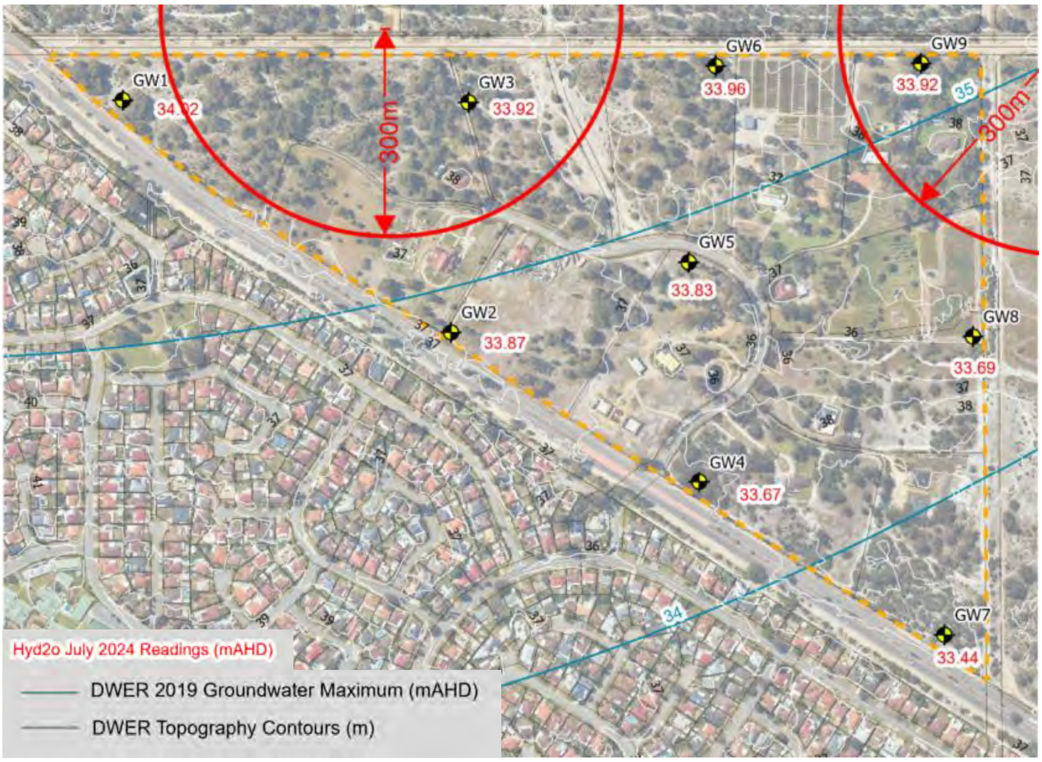
3 Earthworks

- The site areas total to approximately 53ha and comprise of a homesteads, grass cover and trees.

- The site mostly undulates between 38m AHD to 37m AHD with a low trough through the middle of the site that follows the overland drainage path to 36m AHD.



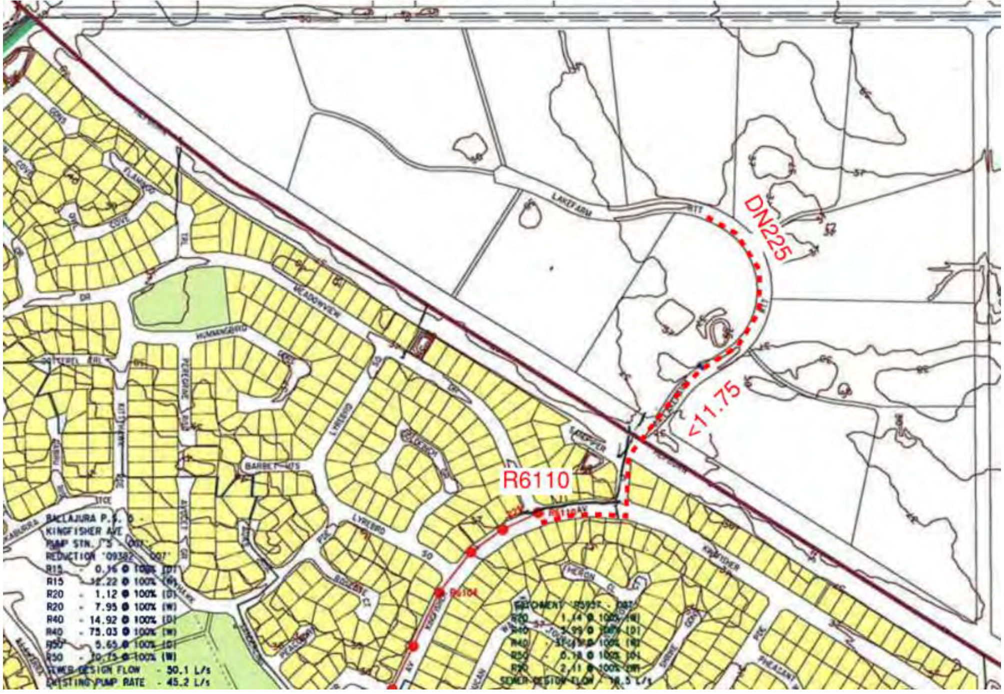
- Maximum groundwater levels range from 36m AHD to 34m AHD (2 – 2.5m below surface level) according to DWER mapping. However, groundwater monitoring bores installed by Hyd2o depicts greater separation from surface to groundwater of greater than 3m.
- Water Corporation have two groundwater bores north of the site, each with 300m wellhead buffer zones. Proximity to these bores results in the site being classified P2 in accordance with DWER.



- Minor earthworks (cut to fill balance) expected for the purposes of overland drainage flow.

4 Sewer

- The proposed development results in an overall wastewater flow rate of approximately 11 L/s suitable for a DN225 pipe.
- Water Corporation initial planning advice confirmed the nearby Ballajura wastewater network had spare capacity. Existing access chamber R6110, approximately 200m from Lakefarm Retreat, is deemed the connection point.
- Mechanical and electrical upgrades may be required for Kingfisher Avenue Pump Station as flow rates increase through the development timeline. Water Corporation are yet to quantify this information.



5 Water

- Probable Simultaneous Demand for the proposed development equals a flow rate of approximately 51 L/s
- Water Corporation initial planning advice shows the existing DN200 reticulation mains can be extended from Marangaroo Drive and Kingfisher Avenue to create a loop to service the site.

6 Drainage

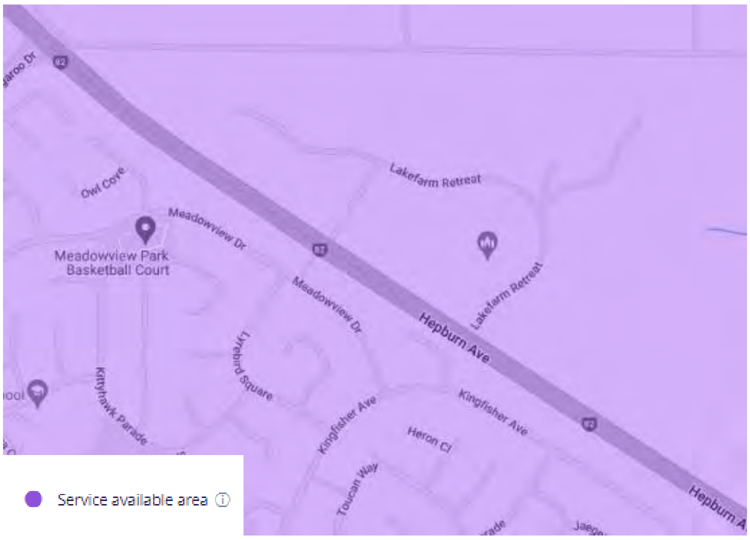
- An open drain extends flows in from the north and out to the east via two drainage easements. There is no standing water in this drain due to the groundwater levels and sandy soils.
- The first flush and minor storm (5% AEP) event shall navigate to drainage basins within POS via a pit and pipe system. The roads shall be graded such that the major storm event (1% AEP) is conveyed the POS via overland flow. Basin sizing shall occur at the LWMS stage.
- Initial conversations with DWER indicate that given the dry nature of the existing water course, the area could be used to fully detain 100year ARI event and that Water Sensitive Urban Design should apply.

7 Power

- The development is expected to draw approximately 4MVA from Western Power.
- Although the Western Power Network Capacity Tool 2023 pictured below indicates there is between 5 - 10 MVA available, its more than likely network reinforcement is required.
- A Design Information Package has been lodged with Western Power to commence master planning.
- 132kV overhead line traverse the eastern and western sides of the site and will constrain the site development layout if relocation is to be avoided due to time and cost.
- HV power is present to the west, north and south and offer possible connection points. Overhead powerline will need to be undergrounded as part of development.

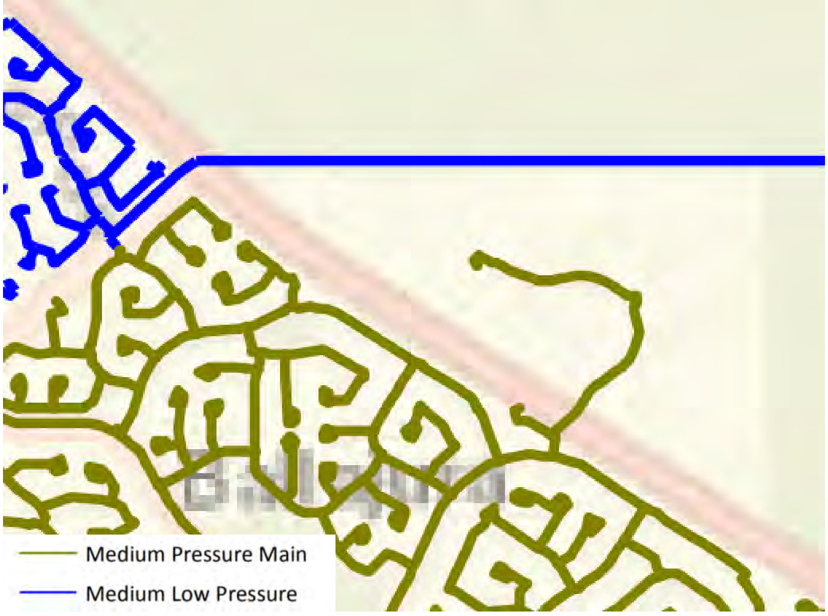
8 Communications

- NBN Co mapping depicts Fixed Line service is available to Lakefarm Retreat.
- The nearest NBN FTTP estate is approximately 2km northwest (Darling Rise, Lansdale)



9 Gas

- DN80 PVC medium pressure gas main services the existing Lakefarm Retreat dwellings and a DN80 PVC medium low pressure main spans the northern boundary.
- ATCO Gas Asset Planning have confirmed the existing network is sufficient for the proposed development.



10 Traffic & Acoustic

- Vehicle noise generate by Hepburn Avenue exceeds allowable residential noise limits therefore an acoustic noise wall plus quiet homes are required to abate sound.
- Traffic Impact Assessment has been completed by Transcore. The traffic modelling suggests the ultimate development will operate efficiently with a roundabout at the intersection of Lake Farm Retreat and Hepburn Ave and a secondary access/egress point will suffice as Left In/Left Out.

The information contained in this letter is compiled using the following sources:

- Before You Dig Australia
- 1:50 000 Environmental Geology
- City of Swan Intramaps
- Perth Groundwater Atlas
- Water Corporation ESInet
- Western Power Network Capacity Tool
- NBN Co Rollout Map

Yours sincerely

Chris Clay
Associate - Civil
Perth

APPENDIX M

UNDO Nutrient Modelling
Post Development

Government of **Western Australia**
Department of Water and Environmental Regulation

Project:	Lakefarm Ballajura DWMS Post Development	Date:	7/10/2024
		Version:	Version 1.2.0.19289

Subregion name: Lots & POS

			Input load	
Landuse	**Percent (%)**	**Area (ha)**	**Nitrogen (kg)**	**Phosphorus (kg)**
Residential	72	31.23	733.70	214.94
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	28	12.15	228.94	8.68
Road reserve	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
43.38	**81**
Nitrogen input (kg/yr)	**Phosphorus input (kg/yr)**
1189.49	**230.13**
Nitrogen export (kg/yr)	**Phosphorus (kg/yr)**
112.70	**8.00**

Residential

			Input load	
Size (m²)	Percent (%)	Area (ha)	Nitrogen (kg)	Phosphorus (kg)
<400	100	31.23	733.70	214.94
400-500 m²	0	0.00	0.00	0.00
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
31.23036	**72**
Nitrogen input (kg)	**Phosphorus input (kg)**
733.70	**214.94**

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	35	4.25
Non-native gardens	0	0.00
Not fertilised	0	0.00
Nature	50	6.07
Sport	5	0.61
Recreation	5	0.61
Golf course	0	0.00
Bowling green	0	0.00
Impervious	5	0.61
Water body	0	0.00

Total area (ha)	Total percent (%)
12.15	**28**

Nitrogen input (kg)	Phosphorus input (kg)
228.94	**8.68**

Soil and drainage information

Type of drainage **Infiltration**

Soil type **Bassendean**

Depth to groundwater (m) **2**

Groundwater slope (%) **0.5**

Soil PRI **5.0**

Does it contain imported fill? **No**

Does subregion contain onsite sewage diposal system? **No**

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

Subregion name: **Roads**

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	0	0.00	0.00	0.00
Road reserve	100	10.17	242.15	30.98

Total area (ha)	Total percent (%)
10.17	**19**

Nitrogen input (kg/yr)	Phosphorus input (kg/yr)
295.37	**32.51**

Nitrogen export (kg/yr)	Phosphorus (kg/yr)
18.86	**1.68**

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	40	4.07
Road reserve - impervious	30	3.05
Road reserve - native garden	5	0.51
Road reserve - non-native garden	0	0.00
Road reserve - turf	20	2.03
Road reserve - not fertilised	5	0.51

Total area (ha)	Total percent (%)
10.1745	**100**

Nitrogen input (kg)	Phosphorus input (kg)
242.15	**242.15**

Soil and drainage information

Type of drainage	**Piped drainage**
Soil type	**Bassendean**
Depth to groundwater (m)	**2**
Groundwater slope (%)	**0.5**
Soil PRI	**5.0**

Does it contain imported fill? **No**

Does subregion contain onsite sewage diposal system? **No**

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

Summary: Nutrient stripping devices

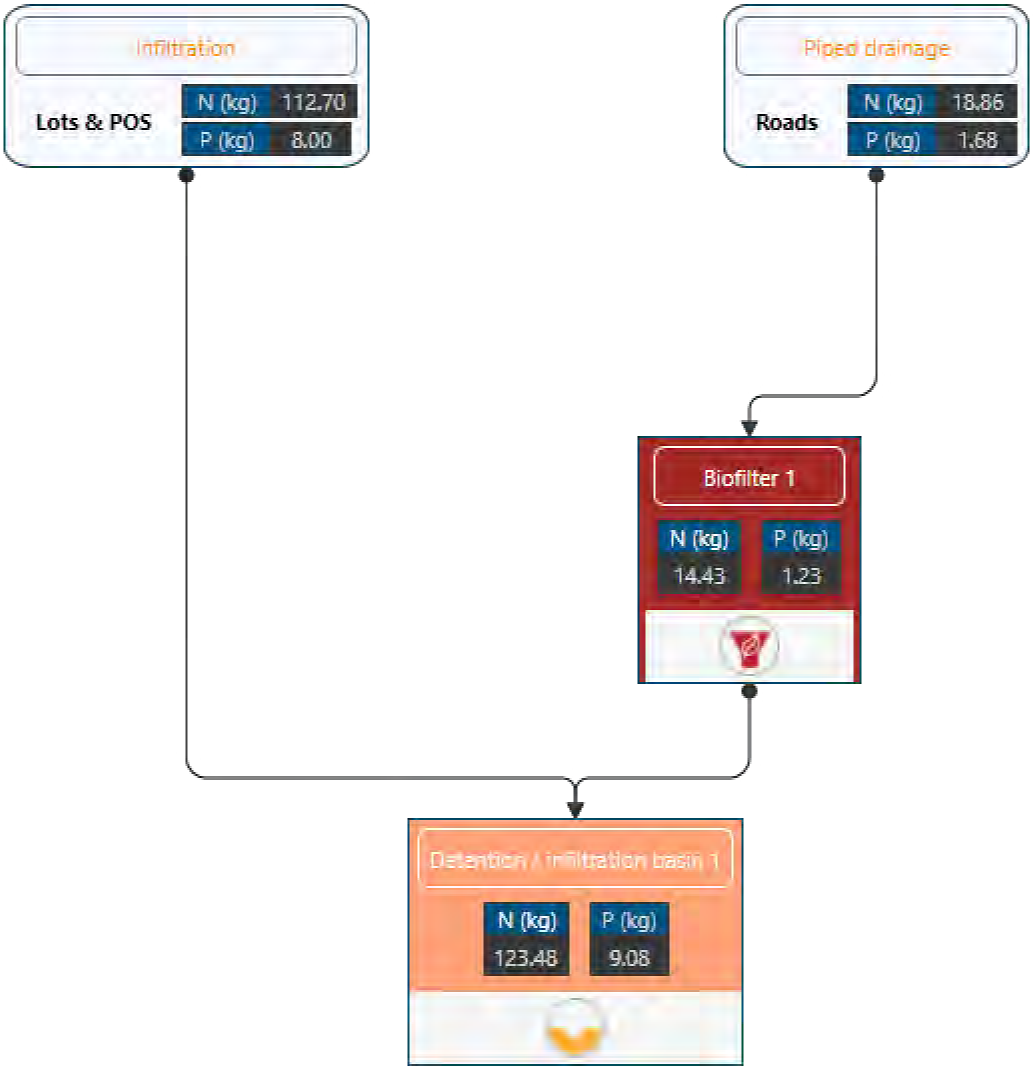
Treatment	Name	Size (m²)	Treated area (ha)	Treating	N removed (kg/yr)	P removed (kg/yr)
Biofilter	Biofilter 1	3984.00	10.17	Sandy soils – Runoff only (infiltration on lots)	4.43	0.45
Detention / infiltration basin	Detention / infiltration basin 1	11372.00	53.55	Sandy soils – Runoff only (infiltration on lots)	3.65	0.15
Load removed					**8.08**	**0.60**
Net export					**123.48**	**9.08**

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/yr)	N export (kg/yr)
Lots & POS	43.38	8.00	112.70
Roads	10.17	1.68	18.86

PRE-TREATMENT LOAD (kg/yr)		LOAD REMOVED (kg/yr)		NET LOAD EXPORT (kg/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
131.56	**9.68**	**8.08**	**0.60**	**123.48**	**9.08**

Treatment diagram



APPENDIX N

Risk Assessment

Appendix N Risk Assessment

Proposed Land Use: Urban Residential (assessment based on an indicative concept plan only)
Existing Land Use: Rural Residential (35+ years) with septic tanks. Current uses include nursery, place of worship & associated parking areas, orchards, historically some livestock/sheep. Adjacent to existing urban development (35+ years)
Given the brownfield nature of the site, the following risk assessment is performed in relation to considering the increase of risk posed by the proposal compared to existing land use and existing controls.

* DWER WQPN77 Default Consequences are shown in the table below for reference purposes only. WQPN 77 states that these values may not accurately represent a sites situation, and site-specific information is recommended to be applied where available, as provided below.

**** Hyd2o Site Assessed Consequence of Minor is assessed on the basis of DWER WQPN77's definition of a minor consequence being "Minor impact for a small population, some manageable operation disruption. some increase in operating cost".**
This is considered the most appropriate reflection of consequence should any of the two WC bores adjacent to the site be unable to continue their use as a minor contribution to the Integration Water Supply Scheme for Perth.

Land Use/Activity	Hazard	Hazardous Event	Likelihood Consideration Quantity	Likelihood Consideration Travel Time/Distance	Likelihood	DWER WQPN 77 Default Consequence	DWER WQPN 77 Default Maximum Risk	Hyd2o Site Assessed Consequence	Hyd2o Site Assessed Maximum Risk	Preventative Strategies	Effectiveness	Residual Likelihood	Hyd2o Site Assessed Residual Risk	Additional Comment
Construction														
Construction Activity All earthworks are carried out in accordance with AS 3798-2007 Earthworks Residential and Commercial Developments.	Nutrients	Leakage during Septic tank decommissioning	Minor	200 – 700 m GW flow away from WC bores	Rare	Major *	High *	**Minor ****	**Low**	Decommissioning to be conducted by appropriate qualified contractors in accordance with existing Department of Health septic tank regulations.	Controlled	Rare	**Low**	Historical existing septic tank use under existing land use
	Hydrocarbons	Spill	Unknown	>300m GW flow away from WC bores	Rare	Major *	High *	**Minor ****	**Low**	Maintain existing groundwater flow direction post development away from WC production bores. Establish site compound at distance from WHPZ's. Use bunding and spill management systems within site compounds if necessary for storage of any required materials. Ensure use of fit for purpose construction vehicles. Construction activities to be conducted in accordance with wellhead protection zone requirements in consultation with Water Corporation. This will include construction timing near WHPZ's to consider bore operating schedules. Erosion control measures such as temporary sediment ponds, and soil stabilisation (where necessary) to control stormwater runoff during the construction process. Minimise shallow groundwater exposure. Contingency plan to be established at later stages of planning for construction management.	Controlled	Rare	**Low**	
		Vehicle Use	Minor	50 – 900 m GW flow away from WC bores	Unlikely	Major *	High *	**Minor ****	**Low**		Adequate	Rare	**Low**	
	Chemical	Leakage during Septic tank decommissioning	Minor	200 – 700 m GW flow away from WC bores	Rare	Major *	High *	**Minor ****	**Low**	Decommissioning to be conducted by appropriate qualified contractors in accordance with existing Department of Health septic tank regulations.	Controlled	Rare	**Low**	Historical existing septic tank use under existing land use

Land Use/Activity	**Hazard**	**Hazardous Event**	**Likelihood Consideration Quantity**	**Likelihood Consideration Travel Time/Distance**	**Likelihood**	**DWER WQPN 77 Default Consequence**	**DWER WQPN 77 Default Maximum Risk**	**Hyd2o Site Assessed Consequence**	**Hyd2o Site Assessed Maximum Risk**	**Preventative Strategies**	**Effectiveness**	**Residual Likelihood**	**Hyd2o Site Assessed Residual Risk**	**Additional Comment**
		Spill	Unknown	>300m GW flow away from WC bores	Rare	Major *	High *	**Minor ****	**Low**	Maintain existing groundwater flow direction post development away from WC production bores. Establish site compound at distance from WHPZ's. Use bunding and spill management systems within site compounds if necessary for storage of any required materials. Construction activities to be conducted in accordance with wellhead protection zone requirements in consultation with Water Corporation. This will include construction timing near WHPZ's to consider bore operating schedules. Erosion control measures such as temporary sediment ponds, and soil stabilisation (where necessary) to control stormwater runoff during the construction process. Minimise shallow groundwater exposure. Contingency plan to be established at later stages of planning for construction management.	Controlled	Rare	**Low**	
	Pathogens	Leakage during Septic tank decommissioning	Minor	200 – 700 m GW flow away from WC bores	Rare	Catastrophic *	High *	**Minor ****	**Low**	Decommissioning to be conducted by appropriate qualified contractors in accordance with existing Department of Health septic tank regulations.	Controlled	Rare	**Low**	Historical existing septic tank use under existing land use
	Heavy Metals	Spill	Unknown	>300m GW flow away from WC bores	Rare	Major *	High *	**Minor ****	**Low**	Maintain existing groundwater flow direction post development away from WC production bores. Establish site compound at distance from WHPZ's. Use bunding and spill management systems within site compounds if necessary for storage of any required materials. Ensure use of fit for purpose construction vehicles. Construction activities to be conducted in accordance with wellhead protection zone requirements in consultation with Water Corporation. This will include construction timing near WHPZ's to consider bore operating schedules. Erosion control measures such as temporary sediment ponds, and soil stabilisation (where necessary) to control stormwater runoff during the construction process. Minimise shallow groundwater exposure. Contingency plan to be established at later stages of planning for construction management.	Controlled	Rare	**Low**	
		Vehicle Use	Minor	50 – 900 m GW flow away from WC bores	Unlikely	Major *	High *	**Minor ****	**Low**		Adequate	Rare	**Low**	

Land Use/Activity	Hazard	Hazardous Event	Likelihood Consideration Quantity	Likelihood Consideration Travel Time/Distance	Likelihood	DWER WQPN 77 Default Consequence	DWER WQPN 77 Default Maximum Risk	Hyd2o Site Assessed Consequence	Hyd2o Site Assessed Maximum Risk	Preventative Strategies	Effectiveness	Residual Likelihood	Hyd2o Site Assessed Residual Risk	Additional Comment
Proposed Urban Land Use														
Urban Development Land use undertaken in compliance with WQPN 38 (DWER,2018)	Nutrients	Wastewater	Minor	50 - 1100 m GW flow away from WC bores	Rare	Major *	High *	**Minor ****	**Low**	Urban development is subject to reticulated sewer system provided by a licenced water service provider (see Government Sewerage Policy 2019). Post development groundwater monitoring program to be assessed against predevelopment monitoring data to identify trends and triggers for any contingency actions if required.	Controlled	Rare	**Low**	
		Fertiliser: POS	Variable	250-800 m GW flow away from WC bores	Unlikely	Major *	High *	**Minor ****	**Low**	Maintain existing groundwater flow direction post development away from WC production bores. POS locations to be predominately outside of WHPZ's. Retention of existing vegetation in conservation reserves to minimise POS nutrient application. Reduce fertiliser use in POS areas via retention of existing vegetation, native plantings, and POS landscape design. Extraction bores for POS irrigation to be located considering existing Water Corporation bore locations and outside WHPZ's. Post development groundwater monitoring program to be assessed against predevelopment monitoring data to identify trends and triggers for any contingency actions if required.	Controlled	**Rare**	**Low**	Nutrient application for proposed urban land use expected to be significantly reduced compared to existing rural use including stock, orchards, and commercial nursery
		Fertiliser: Lots	Variable	50-1100 m GW flow away from WC bores	Possible	Major *	Very High *	**Minor ****	**Moderate**	Maintain existing groundwater flow direction post development away from WC production bores. Use of higher density land use to reduce nutrient input (refer DWER UNDO Model, Rural v Urban Land Use application rates). Provide public awareness information regarding fertiliser use and WHPZ's. Ongoing groundwater level and quality monitoring program to define local conditions.	Controlled	**Rare**	**Low**	

Land Use/Activity	Hazard	Hazardous Event	Likelihood Consideration Quantity	Likelihood Consideration Travel Time/Distance	Likelihood	DWER WQPN 77 Default Consequence	DWER WQPN 77 Default Maximum Risk	Hyd2o Site Assessed Consequence	Hyd2o Site Assessed Maximum Risk	Preventative Strategies	Effectiveness	Residual Likelihood	Hyd2o Site Assessed Residual Risk	Additional Comment
		Mobilisation via stormwater runoff from roads & hardstand area	Seasonal Typical Swan Coastal Plain Stormwater quality prior to treatment (Martens et al 2005) TN : 1.1 mg/l TP : 0.21 mg/l	300 m – 900m (from infiltration storage locations) GW flow away from WC bores	Unlikely	Major *	High *	**Minor ****	**Low**	Adopt best management practice in accordance with Stormwater Management Manual for WA (DWER, 2022). Implement stormwater treatment measures such as biofiltration swales, and infiltration/detention basins. Ensure use of high performance bio media in biofiltration systems. Biofiltration design and construction will be consistent with DWER best practice for PDWSAs. Locate water quality treatment areas for stormwater (and subsoil if required) outside of WHPZ's were possible. Consideration of groundwater flow direction in the design/location of stormwater management areas. Design of stormwater system to be based on site specific investigations. Kerbs and piped systems to direct and control stormwater flow to biofiltration treatment areas. Regular checks on system performance during monitoring to ensure proper maintenance of stormwater treatment and infiltration systems and initiate maintenance actions if required. Contingency planning to be established at later stages of planning (LSP stage).	Controlled	**Rare**	**Low**	Existing stormwater runoff expected to have considerably lower TN than existing groundwater quality prior to treatment under current land use
	Hydrocarbons	Vehicle Spills/leak	Minor	50 – 1100 m GW flow away from WC bores	Unlikely	Major *	High *	**Minor ****	**Low**	Adopt best management practice in accordance with Stormwater Management Manual for WA (DWER, 2022). Implement stormwater treatment measures such as biofiltration swales, and infiltration/detention basins. Ensure use of high performance bio media in biofiltration systems. Biofiltration design and construction will be consistent with DWER best practice for PDWSAs. Kerbs and piped systems to direct and control stormwater flow to biofiltration treatment areas. Ongoing regular maintenance and monitoring to maintain performance. Regular checks on system performance during monitoring to ensure proper maintenance of stormwater treatment and infiltration systems and initiate maintenance actions if required. Contingency planning to be established at later stages of planning (LSP stage).	Controlled	**Rare**	**Low**	

Land Use/Activity	Hazard	Hazardous Event	Likelihood Consideration Quantity	Likelihood Consideration Travel Time/Distance	Likelihood	DWER WQPN 77 Default Consequence	DWER WQPN 77 Default Maximum Risk	Hyd2o Site Assessed Consequence	Hyd2o Site Assessed Maximum Risk	Preventative Strategies	Effectiveness	Residual Likelihood	Hyd2o Site Assessed Residual Risk	Additional Comment
		Mobilisation via stormwater runoff from roads & hardstand area	Seasonal	300 m – 900m (from infiltration storage locations) GW flow away from WC bores	Unlikely	Major *	High *	**Minor ****	**Low**	Adopt best management practice in accordance with Stormwater Management Manual for WA (DWER, 2022). Implement stormwater treatment measures such as biofiltration swales, and infiltration/detention basins. Ensure use of high performance bio media in biofiltration systems. Biofiltration design and construction will be consistent with DWER best practice for PDWSAs. Locate water quality treatment areas for stormwater (and subsoil if required) outside of WHPZ's were possible. Consideration of groundwater flow direction in the design/location of stormwater management areas. Design of stormwater system to be based on site specific investigations. Kerbs and piped systems to direct and control stormwater flow to biofiltration treatment areas. Ongoing regular maintenance and monitoring to maintain performance. Regular checks on system performance during monitoring to ensure proper maintenance of stormwater treatment and infiltration systems and initiate maintenance actions if required. Contingency planning to be established at later stages of planning (LSP stage).	Controlled	**Rare**	**Low**	
	Chemical	Wastewater	Minor	50 - 1100 m GW flow away from WC bores	Rare	Major *	High *	**Minor ****	**Low**	Urban development is subject to reticulated sewer system provided by a licenced water service provider (see Government Sewerage Policy 2019). Post development groundwater monitoring program to be assessed against predevelopment monitoring data to identify trends and triggers for any contingency actions if required. Maintain existing groundwater flow direction post development away from WC production bores.	Controlled	**Rare**	**Low**	
		Spill on Lots	Minor	50-1100 m GW flow away from WC bores	Possible	Major *	Very High *	**Minor ****	**Moderate**	Maintain existing groundwater flow direction post development away from WC production bores. Higher density land use with increase hardstand to reduce spill leakage opportunities Community and council education and awareness. Ongoing groundwater level and quality monitoring program to define local conditions.	Adequate	**Unlikely**	**Low**	

Land Use/Activity	**Hazard**	**Hazardous Event**	**Likelihood Consideration Quantity**	**Likelihood Consideration Travel Time/Distance**	**Likelihood**	DWER WQPN 77 Default Consequence	DWER WQPN 77 Default Maximum Risk	**Hyd2o Site Assessed Consequence**	**Hyd2o Site Assessed Maximum Risk**	**Preventative Strategies**	**Effectiveness**	**Residual Likelihood**	**Hyd2o Site Assessed Residual Risk**	**Additional Comment**
		Pesticide Application	Variable	50-1100 m GW flow away from WC bores	Possible	Major *	Very High *	**Minor ****	**Moderate**	Maintain existing groundwater flow direction post development away from WC production bores. Use of higher density land use to increase hardstand and reduce garden areas to minimise application opportunities. Community and council education and awareness.	Adequate	**Unlikely**	**Low**	
	Pathogens	Wastewater	Minor	50 - 900 m GW flow away from WC bores	Rare	Catastrophic*	High*	**Minor ****	**Low**	Urban development is subject to reticulated sewer system provided by a licenced water service provider (see Government Sewerage Policy 2019). Post development groundwater monitoring program to be assessed against predevelopment monitoring data to identify trends and triggers for any contingency actions if required. Maintain existing groundwater flow direction post development away from WC production bores.	Controlled	**Rare**	**Low**	
		Animal Waste	Minor	50-1100 m GW flow away from WC bores	Possible	Catastrophic*	Very High *	**Minor ****	**Moderate**	Maintain existing groundwater flow direction post development away from WC production bores. Use of higher density land use to reduce pet numbers/size and increase hardstand areas to minimise nutrient input opportunity. Placement of pet "poo pouch" stations at POS areas. Community education and awareness program.	Adequate	**Unlikely**	**Low**	
		Manures & Fertilisers	Variable	50-1100 m GW flow away from WC bores	Possible	Catastrophic*	Very High *	**Minor ****	**Moderate**	Maintain existing groundwater flow direction post development away from WC production bores. Use of higher density land use to increase hardstand and reduce garden areas to minimise nutrient input opportunities. Use of native planting in POS areas. Community and council education and awareness.	Adequate	**Rare**	**Low**	

Land Use/Activity	Hazard	Hazardous Event	Likelihood Consideration Quantity	Likelihood Consideration Travel Time/Distance	Likelihood	DWER WQPN 77 Default Consequence	DWER WQPN 77 Default Maximum Risk	Hyd2o Site Assessed Consequence	Hyd2o Site Assessed Maximum Risk	Preventative Strategies	Effectiveness	Residual Likelihood	Hyd2o Site Assessed Residual Risk	Additional Comment
	Heavy Metals	Mobilisation via Stormwater runoff from roads & hardstand area	Seasonal	300 m – 900m (from infiltration storage locations) GW flow away from WC bores	Possible	Major*	Very High *	**Minor ****	**Moderate**	Adopt best management practice in accordance with Stormwater Management Manual for WA (DWER, 2022). Implement stormwater treatment measures such as biofiltration swales, and infiltration/detention basins. Ensure use of high performance bio media in biofiltration systems. Biofiltration design and construction will be consistent with DWER best practice for PDWSAs. Locate water quality treatment areas for stormwater (and subsoil if required) outside of WHPZ's were possible. Design of stormwater system to be based on site specific investigations. Consideration of groundwater flow direction in the design/location of stormwater management areas. Kerbs and piped systems to direct and control stormwater flow to biofiltration treatment areas. Ongoing regular maintenance and monitoring to maintain performance. Regular checks on system performance during monitoring to ensure proper maintenance of stormwater treatment and infiltration systems and initiate maintenance actions if required. Contingency planning to be established at later stages of planning (LSP stage).	Controlled	**Rare**	**Low**	