Appendix D **Geotechnical Report**

VA & MP Wright & Son

LOT 564 GARVEY ROAD

GEOTECHNICAL INVESTIGATION CROOKED BROOK WA

June 2024
11207-G-R-002 Rev1

WML
Consulting Engineers

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WML Consultants Pty Ltd

Aleksandra Gorczynska

Senior Geotechnical Engineer

Author

Raphael Hyde

Senior Geotechnical Engineer

Reviewer

For and on behalf of WML Consultants Pty Ltd

WML Consultants Pty Ltd
ABN 36 092 471 531
Level 3
1 Prowse Street West Perth WA 6005
(08) 9722 3566 wml@wml.com.au
wml.com.au

EXECUTIVE SUMMARY

WML Consultants have undertaken geotechnical investigations (two stages, May 2023 and November 2023) and installed groundwater monitoring wells (May 2023) at Lot 564 Garvey Road to support the proposed residential development of the site (subdivision).

This report presents the findings of the geotechnical investigation, along with geotechnical information that may be used to inform civil design and earthworks.

Several subsurface profiles have been identified on-site and are detailed in Table 10, Table 11 and Table 12. These profiles have been used to divide the Lot into three Zones (1, 2 and 3) based on the similarity of borehole profiles across the site. Areas have been defined based on investigation findings and site landform to develop preliminary site classifications and remedial works across the entire Lot. These areas are presented on a site map drawing, 10207-G1-DG-002, along with the location of borehole excavations. The geotechnical investigation identified that the majority of the site gets locally inundated during the wet seasons.

Based on the in-situ conditions, the soils encountered on site are not considered suitable in their current state, and require remediation prior to construction. Remediation is required due to:

- Zone 1 – loose sands to a depth of 1.5 m
- Zones 2 and 3 – Shallow/surface groundwater

For these reasons, site classification has been based on post-remediation works as recommended in Section 6 and is presented in Section 5.2.

Typically, separation between peak groundwater levels and the base of footings of 1.2 m to 1.5 m is required. This can be achieved by importing clean sand fill or suitable site-won material, as discussed in Section 6. Should the building envelope be located on the loose sands identified in the sand ridges, compaction to a deeper suitable depth is stressed.

Site classifications should be reassessed for each lot following the completion of earthworks, and the recommendations within this report should be reassessed based on updated findings during earthworks and groundwater monitoring.

The monitoring well data indicated shallow or surface groundwater in some low-lying areas during the wet season, as shown in Table 9. Thus, special consideration should be made to avoid earthworks during the winter/wet months. The expected high groundwater/ponding surface water should be considered when designing civil works to meet design codes for groundwater separation to footings and for environmental requirements for on-site effluent disposal (see additional Site and Soil evaluation report 11207-G-R-003 Rev1). This report has only considered the geotechnical condition of the site when assessing recommendations for site improvement, and therefore the requirements for civil and/or environmental requirements may exceed those detailed within this report.

This report should not be used as an earthwork specification and only be used as a guide following prior communication with WML.

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1 INTRODUCTION

Ross Wright (the client) engaged WML Consulting Engineers (WML) on behalf of VA & MP Wright & Son to undertake a geotechnical investigation at Lot 564 Garvey Road, Crooked Brook, Western Australia, to support the proposed residential development. WML was initially engaged in May 2023 to install and monitor 10 groundwater monitoring wells across the site to determine peak groundwater levels through the wet season.

A second geotechnical investigation was completed at the end of November 2023, with additional boreholes and monitoring wells installed to complete a preliminary geotechnical and Site and Soil Evaluation (SSE) report. This preliminary geotechnical report presents the findings of the both stages of geotechnical investigations, including the details of the fieldwork performed, the results of in-situ and laboratory testing, a preliminary site classification to AS2870:2017 and recommendations for site preparation.

1.1 Site description

The proposed subdivision is located approximately 12 km southeast of Bunbury, Western Australia and is located within the Shire of Dardanup. The site has an area of 40.52 ha and is typically flat, with a few slightly elevated sand ridges located mostly in the northern area of the site. The sand ridge is elevated approximately 1–3 m above the surrounding land with approximately a 3-5% slope. Based on the provided contour map, the site ranges in elevation from 24 m AHD to 30 m AHD. A man-made pond approximately 50 m x 20 m has been constructed in the middle of the site. An open drain runs through the western boundary on Lot 13 and diagonally runs mid-way through Lots 15 and 16.

The land is currently used for cattle grazing and is typically covered with grass. The site is generally cleared land with an increased density of medium to large trees located mostly within Lots 10-12, and Lots 19-20 as per Concept Plan Option C 23585-02C by Harley Dykstra, and a couple of trees sporadically spread through the paddocks.

Based on a desktop review and groundwater data collected from monitoring wells during the wet season, the site is susceptible to local inundation, with elevated groundwater around the sand ridge (which typically remains free from perched water).

1.2 Client supplied information

The following information was made available by the client for the purpose of this report.

- “Concept Plan” drawing No 23585-02C by Harley Dykstra
- Landgate Map showing the investigation area
- ‘23858-01A Contour Survey’ by Harley Dykstra

1.3 Objectives of this report

The objectives of the geotechnical investigation were to:

- Assess the sub-surface soil conditions across the site
- Provide a preliminary site classification(s) in accordance with AS 2870-2011 “Residential Slabs and Footings” and a site subsoil class in accordance with AS 1170.4-2007,
- Provide recommendations for design CBR values and drainage conditions,
- Provide a preliminary acid sulphate soils (ASS) assessment.
- Provide geotechnical advice that could affect the design.

2 FIELD PROGRAMME

2.1 Fieldwork

The first stage of fieldwork was carried out in May 2023 with the intent of groundwater observation; the report is appended to this report (Appendix A). The 10 boreholes were logged in general accordance with AS 1726 to collect additional subsurface information. The information from this first stage ground investigation has been presented and interpreted within this report.

The second stage of fieldwork was carried out on 27th and 28th Nov 2023 by a qualified WML geotechnical engineer and comprised:

- A site walkover to observe existing site features and to take record photographs.
- Five (5) solid auger boreholes were drilled using a ute-mounted mechanical auger drill rig, extending to depths of 2.65 m, designated BH11 to BH15.
- Installation of two groundwater monitoring wells with steel monuments at BH 12 and BH 13.
- Five (5) dynamic cone penetrometer (DCP) tests adjacent to each borehole.
- Three (3) in-situ permeability tests using the Talsma-Hallam method.
- Collection of representative soil samples from boreholes for laboratory testing.

The site investigation was undertaken in general accordance with Australian Standard AS 1726:2017 '*Geotechnical Site Investigations*'. A qualified geotechnical engineer from WML completed the fieldwork, logged the materials encountered in the boreholes, carried out in-situ testing, collected soil samples, and took record photographs. All boreholes were backfilled as close to the original conditions as possible. The approximate test locations are presented on the site map, 10207-G1-DG-002 B attached to the end of this report under the 'Drawings' Appendix.

Each location for intrusive ground investigation was checked for underground services against Dial-Before-You-Dig plans before any excavation works were completed.

Table 1: Summary of the first and second stages of fieldwork

Location ID	Equipment	Elevation	Coordinates (MGA94 Zone 50)		Termination Depth (m)	Reason for termination	Date Completed
		RL (m)	Easting	Northing			
BH1	Drill rig	24.14	382410.17	6302150.52	2.50	TD	31/05/2023
BH2	Drill rig	24.77	382727.38	6301952.25	2.50	TD	31/05/2023
BH3	Drill rig	23.27	382356.09	6301931.66	5.50	TD	01/06/2023
BH4	Drill rig	24.92	382512.74	6302000.96	2.50	TD	31/05/2023
BH5	Drill rig	25.10	382403.59	6301770.52	2.50	TD	31/05/2023
BH6	Drill rig	25.78	382940.61	6301826.99	5.50	TD	01/06/2023
BH7	Drill rig	28.44	382935.41	6302144.71	2.50	TD	31/05/2023
BH8	Drill rig	26.12	382890.18	6302072.28	2.50	TD	31/05/2023
BH9	Drill rig	24.70	382775.09	6301792.46	2.50	TD	01/06/2023
BH10	Drill rig	24.51	382608.81	6302111.11	2.50	TD	01/06/2023
BH11	Drill rig	24.8	382367.97	6302077.72	2.65	TD	28/11/2023
BH12	Drill rig	24.8	382562.92	6301823.00	1.00	Refusal	28/11/2023
BH13	Drill rig	25.8	382772.09	6302125.07	2.65	TD	28/11/2023
BH14	Drill rig	25.25	382813.26	6301888.48	2.00	Refusal	28/11/2023
BH15	Drill rig	25.25	382916.11	6301966.97	2.65	TD	28/11/2023

Notes: All depths are relative to the existing ground surface
TD = Target Depth

2.2 In-situ permeability tests

Three in-situ permeability tests were undertaken adjacent to BH11, BH14, and BH15 using the constant head Talsma-Hallam method in accordance with AS/NZS 1547:2012. Boreholes 110 mm in diameter and 600 mm deep were excavated and filled with water to saturate the surrounding soil. A constant head of water was then applied, and a known volume of water was timed to dissipate.

The permeability tests focused on the material layer at the expected depth for on-site effluent treatment systems. A response zone of 250 mm from the base of the boreholes was applied at each test location. Testing was conducted at each location until a consistent flow rate of water through the soils was measured. A summary of the test results is presented below in Table 2.

Table 2: In-situ permeability test results

Location ID	Test soil	In-situ Permeability Test	
		m/s	m/day
BH11	SAND with clay (SP)	2.54×10^{-5}	2.20
BH14	Silty SAND (SM)	1.92×10^{-6}	0.17
BH15	SAND trace silt (SP)	7.30×10^{-5}	4.50[1]

Note: 1- conservative conversion

2.3 Dynamic cone penetrometer (DCP) testing

The dynamic cone penetrometer (DCP) test is an in-situ, manual penetration test that measures the penetration resistance of the soil. The test is conducted by driving a cone-tipped rod into the ground surface using a 9 kg weight dropped from a standard height. The number of drops (called blows) is recorded for each 150 mm depth, and the process continues till the target depth is achieved. The DCP tests were completed in accordance with AS 1289.6.3.3-1997. DCP blow counts are included on the borehole log profiles, which are appended to this report (Appendix B) and a summary of the results is presented in Table 3 and Table 4 below.

Table 3: Summary of DCP results BH1 (DCP1) - BH10 (DCP10)

Depth (m below existing ground level)	DCP1	DCP2	DCP3	DCP4	DCP5	DCP6	DCP7	DCP8	DCP9	DCP10
0.05 – 0.20	2	4	4	2	2	4	3	3	5	4
0.20 – 0.35	3	5	5	5	3	5	2	6	6	9
0.35 – 0.50	3	3	3	2	2	4	3	7	6	12
0.50 – 0.65	4	3	2	6	2	5	2	5	7	9
0.65 – 0.80	7	2	2	7	4	6	1	2	9	7
0.80 – 0.95	8	3	3	6	5	9	1	2	9	4
0.95 – 1.10	16	7	6	6	5	11	0	3	15	5
1.10 – 1.25	23	10	7	25	5	10	1	4	19	2
1.25 – 1.40	3	14	9	25	6	13	1	6	19	1
1.40 – 1.55	4	10	8	-	7	21	2	7	14	2
1.55 – 1.70	4	11	10	-	16	24	3	14	15	5
1.70 – 1.85	6	13	15	-	22	21	4	25	16	11
1.85 – 2.00	20	17	25	-	10	4	7	-	16	19
2.00 – 2.15	-	-	15	-	8	5	9	-	16	-

Note: Red highlights indicate loose soils

Table 4: Summary of DCP results BH11 (DCP11) - BH15 (DCP15)

Depth (m below existing ground level)	DCP11	DCP12	DCP13	DCP14	DCP15
0.05 – 0.20	12	10	4	6	4
0.20 – 0.35	10	28	8	4	12
0.35 – 0.50	5	9	8	2	11
0.50 – 0.65	4	4	6	2	5
0.65 – 0.80	3	50	5	1	6
0.80 – 0.95	4	-	4	2	6
0.95 – 1.10	6	-	4	4	3
1.10 – 1.25	6	-	6	4	5
1.25 – 1.40	10	-	19	5	6
1.40 – 1.55	12	-	15	7	Refusal
1.55 – 1.70	16	-	7	8	-
1.70 – 1.85	20	-	15	8	-
1.85 – 2.00	16	-	9	17	-
2.00 – 2.15	-	-	11	15	-

3 LABORATORY TESTING

To assist in the evaluation of geotechnical design parameters and for confirmation of the visual classification of the soils, laboratory testing was carried out by NATA-accredited laboratories Construction Science and Environmental and Agricultural Testing Services (EATS). The testing comprised the following:

- Particle size distribution on 4 samples (AS 1289 3.6.1)
- Atterberg limits and linear shrinkage on 4 samples (AS 1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)
- Modified maximum dry density (MMDD) on 1 sample (AS 1289.5.2.1)
- 4-day Soaked California bearing ratio (CBR) on 1 sample (AS 1289 6.1.1)
- Phosphorous retention index (PRI) on 4 samples.
- Emersion class on 4 samples.

The results of the testing are presented in the tables below, and the laboratory test certificates are presented in Appendix C.

Table 5: Summary of soil classification testing

Location ID	Depth (m)	PSD			Atterberg Limits				[1]Soil Classification (USCS)
		Fines (%)	Sand (%)	Gravel (%)	LL (%)	PL (%)	PI (%)	LS (%)	
BH11	1.25	43	47	10	50	17	33	12	CL
BH12	0.3	17	87	5	NO	NP	NP	0	SP
BH14	0.3	13	87	0	NO	NP	NP	1	SP
BH11	0.5	18	80	2	NO	NP	NP	0.5	SP

Notes:

Terminology - PSD = Particle Size Distribution; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index; LS = Linear Shrinkage; NO = Not Obtainable; NP = Non-Plastic

[1]Soil classifications based on the classification of fine and coarse grained soils presented in Table 9 and Table 10 of AS1726:2017

Table 6: Summary of the CBR Testing

Location	Depth (m)	Strength			Swell (%)
		OMC [1)] (%)	MDD (t/m3)	CBR [2)] (%)	
BH12	0.3	7.3	2.034	70	0

Notes: All depths are relative to the existing ground surface.

OMC – Optimum Moisture Content; MDD – Maximum Dry Density; CBR – California Bearing Ratio

[1)] Tested at 95% laboratory dry density ratio.

[2)] Soaked CBR value quoted at 2.5 mm penetrate

Table 7: Summary of Emersion and PRI laboratory testing

Location ID	Depth (m)	Emersion Class	Description	PRI (mL/g)	Classification	USCS
BH13	0.5	3	Slakes. Dispersion after remoulding	611	Very Strongly Absorbing	SP
BH11	1.25	5	Slakes. Flocculation in soil/water suspension	108	Very Strongly Absorbing	CL
BH14	0.75	6	Slakes. Flocculation in soil/water suspension	1225	Very Strongly Absorbing	SC
BH15	1.5	3	Slakes. Dispersion after remoulding	33	Moderate to Strongly Absorbing	SP

Note: PRI – phosphorous retention index

The phosphorous retention index (PRI) can be defined as the ratio of phosphorus absorbed to the phosphorus remaining when the soil is left in contact with a standard phosphorus solution under standard conditions. It is generally used as a measure of a soil's ability to strip an applied effluent of phosphorus and, hence, prevent leaching or contamination into the groundwater. In sandy soils, the phosphorus retention index is usually less than 5. Very strongly absorbing soils include lateritic loams, iron-rich peats, Karri loams with PRI >70.

3.1 Acid sulphate soil testing

Laboratory testing was conducted as part of a preliminary acid sulphate soils (ASS) investigation to determine the potential need for further confirmatory testing and subsequent ASS and dewatering management plans. Sampling was conducted at 0.5 m intervals from five boreholes, placed on ice inside an esky, and delivered to EATS, a NATA-accredited laboratory, for acid sulphate soil field testing. The testing results are presented below, and the laboratory test certificates are attached in Appendix C.

Table 8: Summary of ASS field testings

Location ID	Depth (m)	pH_F	pH_{FOX}	ΔpH	Reaction
BH11	0.5	6.21	3.91	2.30	None
BH11	1.0	6.62	4.96	1.66	None
BH11	1.5	6.79	5.11	1.68	None
BH11	2.0	7.29	5.35	1.94	None
BH11	2.5	7.18	5.36	1.82	None
BH12	0.5	6.98	5.24	1.74	None
BH12	1.0	6.77	4.33	2.44	Low
BH13	0.5	4.91	3.59	1.32	None
BH13	1.0	5.26	3.41	1.85	None
BH13	1.5	5.65	3.15	2.50	Low
BH13	2.0	5.93	3.07	2.86	Low
BH13	2.5	6.24	3.22	3.02	None
BH14	0.5	5.35	4.34	1.01	None
BH14	1.0	5.64	4.57	1.07	None
BH14	1.5	5.52	4.24	1.28	None
BH14	2.0	5.12	3.77	1.35	None
BH15	0.5	5.86	4.52	1.34	None
BH15	1.0	5.34	4.28	1.06	None
BH15	1.5	6.13	3.76	2.37	None
BH15	2.0	5.80	4.02	1.78	Low
BH15	2.5	5.96	4.49	1.47	Low

Notes: pH_f – pH field test; pH_{fox} – pH field peroxide test
Highlighted results in red indicate potential ASS (PASS).

Acid sulphate soils (ASS) can be described as naturally occurring soils that contain sulphide minerals, commonly pyrite and iron sulphide. These soils form in wet, anaerobic conditions typically associated with wetlands and inundated areas. Where undisturbed, ASS is stable and does not pose an environmental risk. However, following a disturbance (e.g., excavation, dewatering, or installation of underground services), pyrite may oxidise, producing a variety of iron compounds and sulfuric acid.

ASS that has already oxidised, producing acidic conditions, is termed Actual ASS (AASS). ASS that has not oxidised is referred to as Potential ASS (PASS). Undisturbed PASS remaining in anaerobic conditions, for example, below the water table, does not generally pose a risk to the environment, as while they are undisturbed, their potential to generate environmentally hazardous acids is minimised. Non-ASS (NASS) is when actual (previously oxidised) or potential acidity is at concentrations not considered an environmental hazard or which do not require management.

4 SUBSURFACE CONDITIONS

4.1 Published geology

Based on the 1:50,000 Geological Series map sheet 'Bunbury', the near-surface geology consists of:

- 'Q_{pa}'-Guildford Formation: Mainly alluvial sandy clay
- 'Q_{pb}'-Bassendean sand: Low rounded dunes. Isolated low dunes with loose sands.
- 'Q_{pb}/ Q_{pa}'- Thin Bassendean sand over Guildford formation

The Bassendean sand is represented by the ridge and had varying thickness of sand often overlaying with Guildford formation. The soils encountered during the investigation are generally consistent with the geological map ground profile.

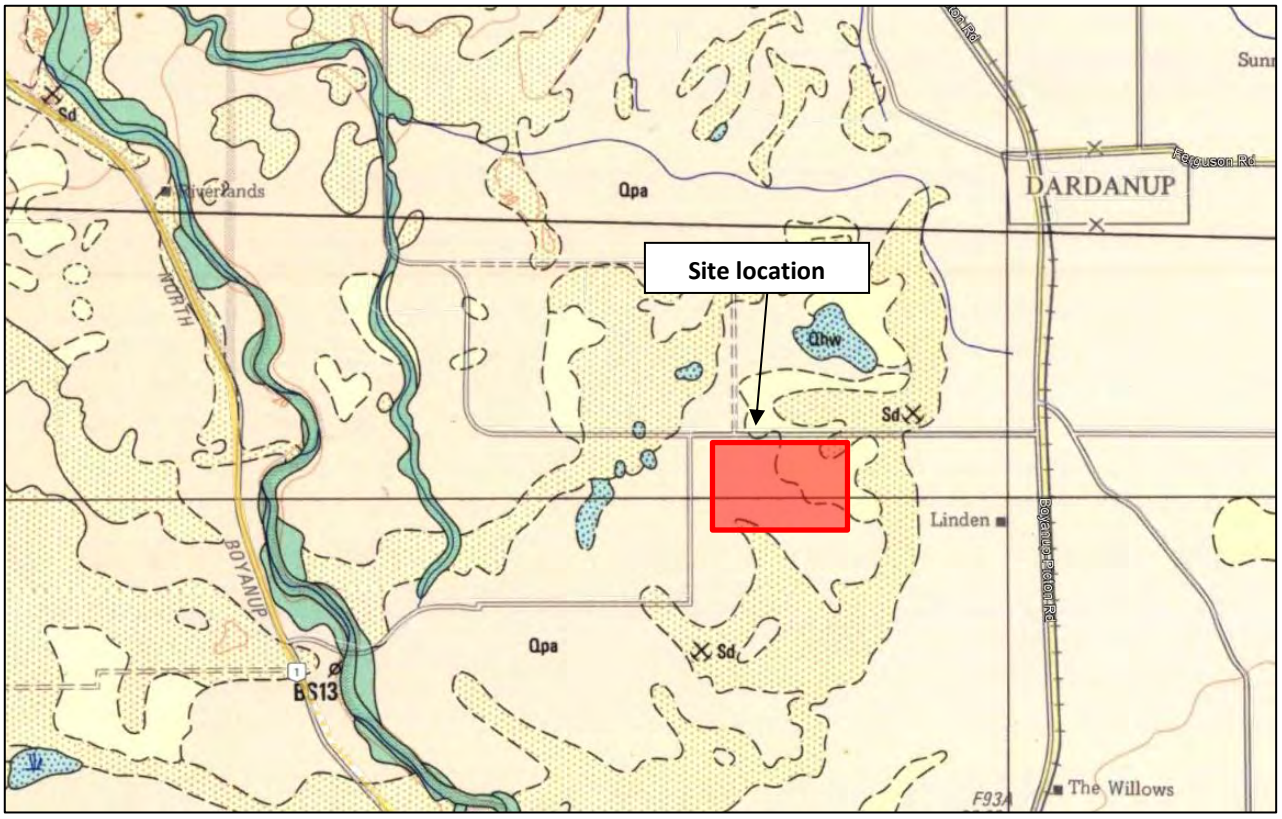

Figure 1: Extract from 1:50,000 Geological Map 'Bunbury'

4.2 Groundwater

During initial fieldwork in May 2023, ten monitoring wells were installed. Readings and measurements throughout winter indicated either shallow water table generally within 0.6 m or local inundation. The detailed summary of groundwater recorded during four different inspections during wet and dry seasons is presented below in Table 9.

Table 9: Summary of groundwater depths

Test ID	Depth of Groundwater (m)				[2]Expected peak groundwater level range (m ADH)
	Observed 1/06/2023	Observed 10/8/2023	Observed 15/9/2023	Observed 31/10/2023	
BH1	1.4	0.76	0.71	1.3	23.43
BH2	GNE	0.18	0.04	1.05	24.73
BH3	3.8	-0.10 (above ground)	-0.20 (above ground)	GNE	23.47
BH4	1.2	0.63	0.63	1.22	24.29
BH5	1.8	0.80	0.89	1.29	24.21
BH6	GNE	0.00[1]	0.00[1]	GNE	25.78
BH7	GNE	GNE	GNE	GNE	-
BH8	1.0	0.00	0.00	GNE	26.12
BH9	GNE	0.00	0.00	1.19	24.70
BH10	2.3	0.60	0.35	0.99	24.16

Notes: All depths are relative to the existing ground surface. Green cells highlight peak groundwater values for each location.
GNE = Groundwater not encountered,
[1]Groundwater not encountered in the borehole, but ponding was present in the area around the monitoring well.
[2] Based off RL of well location picked up by Thompson surveyor minus observed peak water table

4.3 Interpreted subsurface profile

The subsurface profile is typically consistent across the site, with layer thickness variations due to the deposition history and natural topography of the site. Three subsurface profiles have been identified on-site with similar material compositions but varying sand thicknesses. The site has been divided into three subsurface profiles, denoted by Zones 1-3, with an excerpt from drawing 11207-G1-DG-002 B (attached in the Drawings) shown below. The encountered soil profiles for each zone are summarised below in Table 10, Table 11 and Table 12.

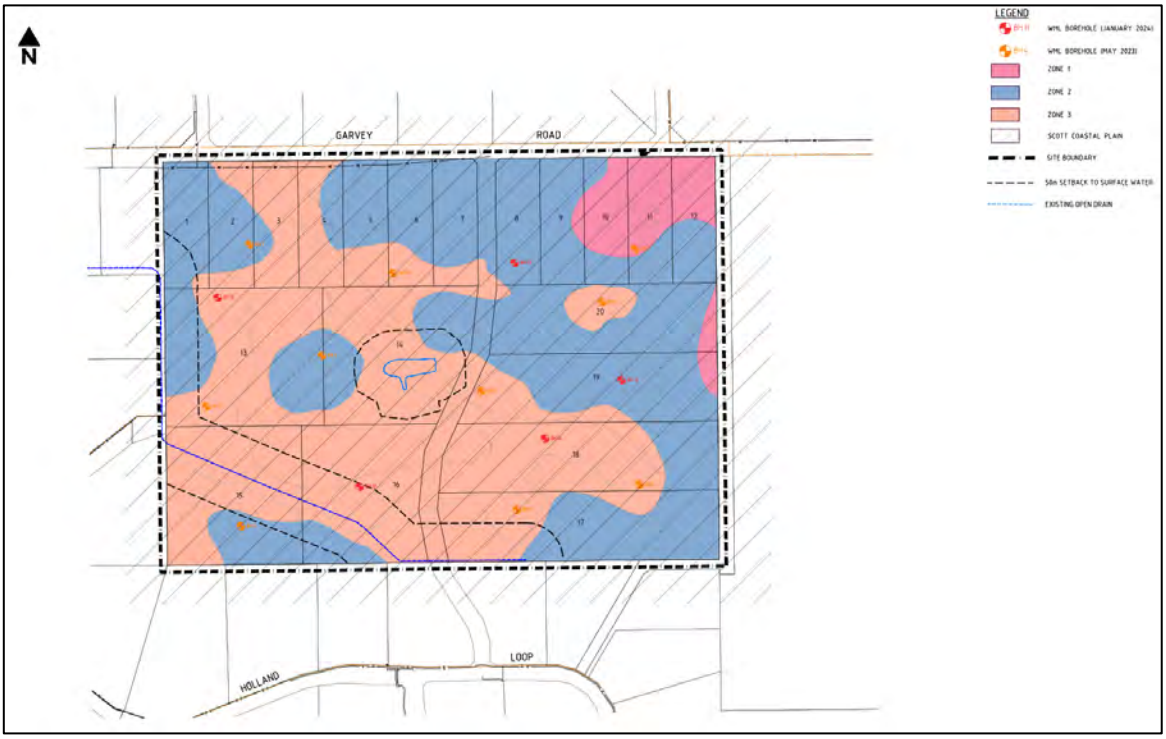

Figure 2: Soil profile zoning map

The top 100 mm across the site is typical topsoil consisting of:
Silty SAND, fine to medium-grained, dark grey; silt is low plasticity; trace roots; moist; loose.

Table 10: Generalised sub-surface soil profile for Zone 1

Depth (m)	Unit	Description
0.1 – 2.5	A	**SAND**/silty **SAND:** fine to medium-grained, moist, pale grey to dark orange, and loose to medium dense.

Table 11: Generalised sub-surface soil profile for Zone 2

Depth (m)	Unit	Description
0.1 – 1.0	A	**SAND**/silty **SAND:** fine to medium-grained, varying colour including pale to dark grey and brown-orange, moist, loose to medium dense. Some areas have slightly cemented lateritic sand.
1.0 – 2.6	B	Sandy **CLAY**/**CLAY**: medium to high plasticity, varying colour including yellow and brown/grey mottled red, trace medium-grained subrounded to subangular gravel, trace to some slightly cemented lateritic gravel, moist to wet, generally stiff to very stiff.

Table 12: Generalised sub-surface soil profile for Zone 3

Depth (m)	Unit	Description
0.1– 0.7	A	**SAND**/silty **SAND**: fine to medium-grained, pale grey to brown, with silt/clay, moist, loose to medium-dense. BH12 had shallow sands to the depths of 0.25 m. BH14 consisted of silty SAND with low to medium plastic clay to the depths of 1.25 m.
0.7 – 5.5	B	Sandy **CLAY**/**CLAY:** medium plasticity, varying colour including orange-brown and grey mottled orange; sand is fine to medium-grained, moist, generally stiff. Traces of lateritic orange sand clumps are occasionally present. BH3 and BH6 drilled from 2.6-5.5 m identified some gravel was identified within the stiff sandy clays.

5 GEOTECHNICAL DISCUSSION

5.1 Geotechnical design parameters

Based on laboratory test results, in-situ test results, and observations made in the field, Table 13 below presents the geotechnical parameters for the soil profile referenced in Section 4.3.

Table 13: Geotechnical design parameters for assessed ground profile and imported sand.

Depth (m)	Unit	Layer	Friction angle (Φ°)	Cohesion (C_u kPa)	Youngs Modulus (E MPa)	Dry unit weight (γ kN/m^3)	Undrained Shear Strength (S_u kPa)	Design permeability (K m/day)
0.1 – 1.0	A	SAND, some fines.	33	0	50	18.0	N/A	2.0
1.0 – 2.6	B	Sandy CLAY	27	3	15	18.5	70-90	-
-	-	Imported SAND fill, trace to some fines, dense	36	0	60	19	N/A	3.5

Field observations and in-situ tests (DCP / field permeability)

5.2 Site classification

Based on the site investigation results, the site may be classified in accordance with AS 2870:2011 - "Residential Slabs and Footings", which requires an estimation of the expected surface movement due to the wetting and drying of a foundation. The site classification assessment assumes that a topsoil strip has been undertaken to remove unsuitable material (typically 100 mm). Due to the varying thickness of SAND across the site, the impact of shrink-swell of the underlying clayey SANDS and sandy CLAYS are expected to vary for each proposed lot. Therefore, different site classifications for each proposed zone would be appropriate.

Based on the soil conditions encountered, the site can be classified as Class 'P' due to the high groundwater and loose sands throughout the lot. The site classification has been assessed at each borehole location, and an improved site classification has been provided based on the remedial works detailed in this report. Note that the actual level of fill should be controlled by the designer to meet the considerations in Table 16 and other site constraints, such as groundwater levels and for effluent disposal.

CLASSIFICATION BY CHARACTERISTIC SURFACE MOVEMENT (y_s)

Characteristic surface movement (y_s) mm	Site classification in accordance with Table 2.1
$0 < y_s \leq 20$	S
$20 < y_s \leq 40$	M
$40 < y_s \leq 60$	H1
$60 < y_s \leq 75$	H2
$y_s > 75$	E

Figure 3: Extract from AS2870:2011 (Table 2.3)

Sites with inadequate bearing strength or where ground movement may be significantly affected by factors other than reactive soil movements due to normal moisture conditions shall be classified as Class P. Class P sites include: the site contains uncontrolled or controlled fill as identified in AS 2870 Clause 2.5.3, soft or unstable foundations such as soft clay or silt or loose sands, landslip, mine subsidence, collapsing soils and soils subject to erosion, reactive sites subject to abnormal moisture conditions and sites that cannot be classified in accordance with AS 2870 Clause 2.1.2.

5.3 Site improvement

Provided the site preparation recommendations are adhered to in Section 6, the site classification for each zone may be improved based on the following recommendations.

Table 14: Site classification

Zone	[1)]Improvement Works	Site Classification at Completion of Remediation Works
1	Compaction to the depth of loose sands, typically to around 1.5 m. The material would be required to achieve a medium dense state, around 50% of relative density	A
2	If adequate groundwater management can be implemented (no sand pad placed)	S
	Placement and compaction of a minimum of 700 mm of suitable fill.	A
3	If adequate groundwater management can be implemented (no sand pad placed)	M
	Placement and compaction of a minimum of 700 mm of suitable fill.	S
	Placement and compaction of a minimum of 1200 mm of suitable fill.	A

Remedial works based on geotechnical assessment only. Remedial works may be exceeded if consideration of environmental (separation of on-site effluent disposal to groundwater) or civil (to achieve foundation-groundwater separation) requirements is made.

5.4 Earthquake classification

Based on available information, we have assessed the site subsoil class in accordance with AS 1170.4 – 2007 "Earthquake Actions in Australia". We consider the subsoil class of "Ce" appropriate for the site. A site hazard factor of 0.09 should be considered appropriate.

5.5 Preliminary allowable bearing pressure

Based on the subsurface profile and ground model determined above, a bearing capacity and settlement analysis have been undertaken. A footing design has not been undertaken, and as such, loads, sizes and embedment depths are approximated for the proposed development.

This analysis has been undertaken with the following assumptions:

- Footings and slabs are assumed to be rigid for calculation simplicity and worst-case scenarios with regard to maximum deflection.
- It is also assumed that footings for the proposed structure will not be carrying significant eccentric loading, such as below retaining walls. Foundations with significant eccentric loading or those designed to resist lateral forces must be assessed separately.
- A minimum footing embedment depth of 0.5 m has been assumed.
- A geotechnical strength reduction factor of 0.35 was used in the analysis in accordance with Tables 5.3.3.3 (A) and 5.3.3.3 (B) of AS 5100.3 (2017).
- The footing system of shallow strip/pad footing widths between 0.5 m and 2.0 m

The above assumptions must be checked once final site levels and additional geotechnical information are available. WML must be notified immediately if any of these assumptions are incorrect.

Based on visual assessment and laboratory testing of borehole materials, and assuming that the preparation measures recommended in Section 6 are adopted, and assumptions above are noted, a preliminary allowable bearing pressure, as shown below in Table 15 may be used.

It should be noted that zones 2 and 3 in the current in-situ state may have an allowable bearing capacity of less than 100 kPa due to shallow or surface groundwater. The recommendations in Section 6 are considered essential to improve the preliminary allowable bearing capacity to 100 kPa.

Table 15: Preliminary allowable bearing pressure post site preparation

Zone	Preliminary Allowable Bearing Pressure (kPa)	Settlement (mm)
1	100	10-20
2	100	10-20
3	100	10-20

Notes: These allowable bearing pressures are valid should the recommendations in Section 6 be followed. If the groundwater isn't maintained at least 500 mm beneath the base of the footing, the bearing capacity should be reassessed for remediated site conditions.

5.6 Drainage

High groundwater levels are expected within the site, particularly during and after rainfall events and during the wet season. Therefore, appropriate drainage and dewatering may be required during any excavation work (pipelines, etc.).

High transient groundwater and perched water can be expected during the wet season and should be considered by the civil engineer when designing surface and subsurface drainage. The designer should be aware that the peak groundwater was found at the surface at many of the monitoring wells, as shown above in Table 9.

Adequate depth of free-draining sand shall be present above the annual average mean groundwater level (AAMGL) if soak wells are to be used. Should soak wells be considered, a recommended design permeability of k = 4 m/day can be adopted for imported, clean sand. For site-won sand material (trace to some fines), a design permeability of k = 2 m/day can be adopted, and for site-won silty sand material, a design permeability of 0.17 m/day may be used.

In zones 2 and 3, where generally 0.7-1.0 m of sand over low permeability sandy clay material was identified, soak wells may not be an appropriate stormwater management solution without allowance for additional fill to separate the base of the soak wells from groundwater and the low permeability soils. For zone 1, sands with fines were identified to the depths of 2.5 m; however, high peak ground waters may cause stormwater management issues.

The design engineer should take into account any variability of foundation conditions around the perimeter of the building structures. The importance of avoiding leakage from underground services and drains near the proposed buildings is stressed. Drainage around the buildings should be adequate to redirect excess surface water away from the buildings. The areas adjacent to the buildings should have a slope away from the structures of not less than 1 in 20, then be directed to the stormwater system to prevent ponding of water adjacent to the building.

Soak wells, if adopted in the drainage design, should not be placed within 5 m of footings without engineering assessment. Discharge from soak wells has been known to cause densification of sandy soils, leading to the settlement of footings and slabs. Where soak wells are placed close to footings, they must be carefully wrapped in geotextile to prevent the migration of sand and fines into the soak well.

There is no prescribed minimum separation from groundwater required by regulatory authorities. Typically, this will be around 1.2-1.5m. The subdivision designer should allow their design to maintain a suitable separation to groundwater.

5.7 Earth retaining structures

No details about any potential retaining structures were known at the time of the preparation of this report.

If retaining structures are required, they must be designed in accordance with AS4678 (2002) “Earth-Retaining Structures”. We recommend that temporary retaining walls be designed using the soil parameters provided in Table 16.

Table 16: Retaining wall design parameters

Soil Type	Soil Unit Weight Above Water Table (t/m^3)	Soil Unit Weight Below Water Table (t/m^3)	Soil Friction Angle ($\phi°$)	Undrained Shear Strength (kPa)	Coefficient of At Rest Earth Pressure, K_o	Coefficient of Active Earth Pressure K_a	Coefficient of Passive Earth Pressure K_p
SAND, some fines, dense	18	8.0	33	N/A	0.455	0.295	3.389
SAND (FILL), dense	19	9.0	36	N/A	0.412	0.259	3.861

Notes:

1. *Alternative design values of K_o may need to be assessed, depending on the wall construction method*
2. *Earth pressure coefficients are provided in the table of conditions of zero friction between the wall and soil. A horizontal ground surface behind the wall has been assumed.*

6 RECOMMENDATIONS

6.1 General site preparation

At the time of the preparation of this report, no information regarding the proposed bulk earthworks strategy for the development was available. The measures outlined below are aimed at improving the site in preparation for the construction of on-ground slabs, shallow footings and low-height retaining walls.

The majority of the site is expected to contain shallow groundwater or surface waters during the wet season and, therefore, is a major consideration for site preparation recommendations. For zones 2 and 3, the placement of imported or site-won engineered fill within the building envelope or adequate drainage controls are required to maintain suitable clearance to groundwater and achieve the preliminary bearing capacity listed in Table 15. The minimum requirements are detailed as follows:

- For zone 2, sand fill **or** drainage is utilised to maintain groundwater at least 500 mm beneath the base of the footing.
- For zone 3, a combination of sand fill **and** drainage is utilised to maintain groundwater at least 500 mm beneath the base of the footing.

Import of suitable fill materials further allows the following:

- Increase groundwater separation from shallow footings.
- Increase separation from reactive soil materials, decreasing characteristic surface movement experienced due to shrink-swell of the soils.
- Additionally: Due to the site lying within a sewerage sensitive area, a minimum groundwater separation of 1.5 m from the base of any on-site effluent disposal system is required. Further details regarding this condition can be found within WML Consultants site and soil evaluation report, document number 11207-G-R-003 Rev1.

The following items should be considered when designing the earthwork levels and tendering the construction:

- Temporary slope angles such as trenches (open for no longer than 2 weeks) in the sand should be no steeper than 1V:2H, provided groundwater is below the base of the trench and the slope is no more than 3 m high. If groundwater is present, additional geotechnical advice should be sought.
- Permanent embankment slope angles in the sand should be no greater than 1V:3H, provided groundwater is below the toe of the embankment. For slopes higher than 3 m, additional slope stability analysis may be required.

The earthworks should be constructed in accordance with AS 3798:2007 – *"Earthworks for Residential and Commercial Developments"*. Additionally, the following site preparation recommendations shall include, but are not limited to, the following actions for the footprint of all building structures and other development infrastructure.

- Remove trees, vegetation, topsoil, and organic material from the construction footprint. Topsoil containing organic material and roots was encountered across the site to a typical depth of 100 mm. The actual stripping depth may vary across the site, and the entire root zone shall be removed.
- If trees are removed within the building footprint, we recommend that the root ball and all large roots up to 50 mm in diameter be grubbed out. The root ball should be backfilled in lifts, recompacted and tested to the full depth of the disturbance zone, achieving the minimum compaction compliance stated below.
- Moisture condition exposed subgrade (if required) to optimum moisture content (OMC) and compact the exposed surface using suitable compaction equipment to achieve a dry density ratio (DDR) of at least 95% modified maximum dry density (MMDD) to a depth of at least 300 mm beneath the underside of proposed footings and slabs.
- Any loose areas identified should be removed and recompacted to the levels provided in Section 6.2.
- BH7 in zone 1 indicates loose soils to an approximate depth of 1.5 m. Sands beneath building footprints within zone 1 should be compacted to a medium-dense state (around 50% of relative density) and tested to a depth of 1050 mm to achieve the compaction compliance detailed in section 6.2 (PSP testing can be used). This may

require excavation, replacement and recompaction in lifts to achieve the required densities. The in-situ sandy soil with some fines can be utilised as a source of fill material.

- Any areas with shallow clay (or sandy clay) identified in the footprint of the building should be topped up with suitable fill materials to suitable depths. BH12 was identified to have sandy/silty clay at depths of 0.25 m.
- Confirm adequate compaction of the subgrade has been achieved on-site (by on-site testing as mentioned below in Section 6.2).
- Place and compact approved granular fill material on the prepared and certified subgrade (if required). Any structural free-draining sand fill should be placed in compacted horizontal layers not greater than 300 mm and compacted in accordance with Section 6.2.
- Construct footings and slabs in accordance with structural engineers' design drawings and documents. Any imported fill material used should be free-draining sand or granular material with a fine (<75 microns) and organic content no greater than 5% and 2%, respectively.
- It is recommended that the foundation construction works be planned for a period of dry weather and that any excavations remain open for the shortest possible duration to prevent ground softening and the possible deterioration of the subgrade. Any areas of the subgrade that have softened or been exposed to erosion by surface water must be excavated and replaced with approved granular fill.

Loose soils in Zone 1

The DCP test at these areas identified loose soils to the depths of 1.5 m in BH7 as indicated in Table 3. Large rollers and dynamic compaction may be considered for better compaction to deeper depths as an alternative to excavation and recompaction

Open Drains on Lots 15 and 16

An open drain runs through the western boundary of Lot 13 and diagonally runs midway through Lots 15 and 16. It is expected that the drain will have surface water during the wet weather. Should the building envelope be closer to the drain channel, suitable surface and subsurface drainage should be considered.

6.2 Compaction

Any exposed subgrade must be compacted using suitable plant and equipment to a DDR of at least 95% MDD (standard compaction for clays, modified compaction for sands) and within 2% variation from OMC as determined in accordance with AS 1289 5.1.1 or 5.2.1.

Approved granular fill and in-situ sands beneath footings, slabs and flexible pavement areas must be compacted using suitable plant and equipment to a DDR of at least 95% MMDD as determined in accordance with AS 1289 5.2.1. Field density tests shall be used to check the compliance of the compacted material. The tests shall be carried out at the frequency detailed in Table 8.1 of AS3798:2007 ***Type 1***.

- Method 5.3.1 of AS 1289 (Sand replacement method using a sand-cone pouring apparatus);
- Method 5.8.1 of AS 1289 (Nuclear surface moisture-density gauge).

For clean in-situ sand and imported clean sand fill, alternatively to the above methods, a Perth Sand Penetrometer (PSP) may be used for compaction control with a minimum number of blows count per 300 mm as indicated below in Table 17 to achieve the minimum compaction of 95% of MDD. Lesser blow counts are required for areas in Zone 1 that will be compacted to a medium-dense state.

Table 17: Minimum PSP blow counts

Depth	Blow count/300mm
150 – 450mm	8
450mm – 750mm	10
750mm – 1050mm	12
1050mm – 1350mm	12+

Over excavation and replacement of loose materials may be required where the minimum dry density ratios cannot be achieved.

6.3 Excavatability

The excavatability of the natural strata on site (to a depth of at least 3 m) should cause no problems for excavation using conventional plant, with the encountered sands/clays being within the excavation limits of a smaller dozer (e.g. Cat D6 or similar) in bulk excavations or medium size excavator (e.g. CAT 303 or similar) in trench excavations.

If any variation from the material outlined in the attached borehole logs is encountered, WML should be contacted immediately to assess the nature of the strata.

6.4 Subgrade design CBR

Where the design of flexible pavements is undertaken, a preliminary subgrade California Bearing Ratio (CBR) of 10% may be assumed for the natural sand materials at the site and 6% for silty/clayey SAND. This CBR value assumes that the site preparation measures outlined in this document have been completed on all pavement subgrades and that adequate drainage will be included in future pavement designs.

6.5 In-situ material quality

Material won from excavation work carried out within the sand dune/ridges is expected to comprise fine to medium-grained SAND (SP), which is considered to be a good quality fill material. Any materials comprising deleterious inclusions such as clay lumps, roots, and any large cobbles/boulders (if encountered) should be removed.

Sandy CLAYS and clayey SANDS encountered at the site at depths generally lower than 0.7 m within low-lying areas must not be used as structural fill.

6.6 Structural fill

All imported granular fill materials used on this project must conform to the material requirements of AS3798-2007 "*Guidelines for Earthworks for Commercial and Residential Developments*".

6.7 Batter slopes

The sides of any excavations must be battered back to a suitably stable angle to allow the works to be completed safely. For initial site preparation works, previous experience has indicated that the following maximum cut/fill batter slopes for batter heights not exceeding 4 m may be adopted:

Table 18: Maximum unprotected batter slopes

Material	Short Term (maximum) Height <4m[a)]	Long Term (maximum) Height <4m[a)]
Compacted FILL (SAND)	1V:2.5H	1V:3H[b]
Medium Dense to Dense SAND, Clayey SAND	1V:2.5H	1V:3H [b]
Stiff to Hard Sandy CLAY, CLAY	1V:2 H	1V:2.5H

Notes:

[a)] For batter slopes higher than 4 m, a further assessment shall be carried out

[b)] Surface protection required

All confined excavations or trenches deeper than 1.5 m shall be fully supported or battered in accordance with occupational health and safety regulations.

It should be noted that groundwater levels and water seepage through permeable sand layers are likely to affect the stability of excavation batters in low-lying areas.

If the area within H to 2H of the excavation (where H is the depth of excavation) is subject to a surcharge or is sensitive to vertical or lateral movement, the use of artificial support is required, and this should be designed prior to the commencement of bulk excavation works. Further investigation regarding the existing roads and structures within this zone should be carried out to ensure that any excavation does not undermine or create instability in the existing pavements/building footings within the adjoining road corridors/facilities.

6.8 Preliminary acid sulfate soil (ASS) assessment

The Department of Water and Environment Regulation (DWER) provides broad-scale mapping indicating areas of potential ASS risk (DWER 2018). A review of the DWER mapping indicates that the site is classified as having a moderate to low risk of ASS occurring within 3 m of the natural soil surface and a high to moderate risk of ASS beyond 3 m of the natural ground surface. The results of the ASS field tests are presented in Table 8 and have been compared against the following criteria, established from the DWER guidelines to determine if a soil is an actual acid sulphate soil (AASS) or potential acid sulphate soil (PASS):

- pH_f less than 4
- $pH_{f\,ox}$ less than 3 and/or
- The change in pH was greater than 2 (where the $pH_{f\,ox}$ was less than 3) and/or
- There was a strong reaction following the addition of hydrogen peroxide.

Samples from five boreholes (BH11-15) indicated that PASS might exist within this area, as indicated in Table 8. It is therefore recommended to carry out confirmatory laboratory testing on those samples (Chromium Reducible Sulphur suite) to confirm if AASS is present and if an ASS management plan is required.

6.9 Site and soil evaluation

Recommendations within this report may be exceeded by those in a separate site and soil evaluation report based on environmental requirements for residential development. All recommendations should be considered to assess the limiting design factors for proposed land development.

7 FUTURE INVESTIGATIONS

The spacing of the investigation locations and the quantity of geotechnical testing performed can be considered suitable for a preliminary investigation. If these sites are to be developed, we recommend further geotechnical investigations are to be undertaken within the proposed building envelopes on a lot-by-lot basis to gather data suitable for detailed site classification, design and recommendations.

8 CLOSURE

We trust that the information provided within this report satisfies your present requirements and meets with your approval. Should you have any queries, please do not hesitate to contact the author of this report.

We draw your attention to the attached "*Report Limitations*" included with this report. This information sheet is intended to provide additional information about this report and the information included within it. This information is provided not to reduce the level of responsibility accepted by WML but to ensure that all parties that rely on this report, and the information contained herein, are aware of the responsibilities that each assumes in so doing.

9 REFERENCES

1. Geological Series Map 1:50,000 Scale 'Bunbury'
2. Standards Australia/New Zealand. 2007. *Structural Design Actions Part 4: Earthquake Actions in Australia*. AS 1170.4:2007. SAI Global.
3. Standards Australia. 2017. *Geotechnical Site Investigations*. AS 1726:2017. SAI Global.
4. Standards Australia. 2011. *Residential Slabs and Footings*. AS 2870:2011. SAI Global.
5. Standards Australia. 2007. Earthworks for Residential and Commercial Developments. AS 3798:2007. SAI Global.
6. Standards Australia. 2007. Earth Retaining Structures. AS 4678:2002. SAI Global.
7. Standards Australia. 2017. Bridge Design Part 3: Foundation and soil-supporting structures. AS 5100.3:2017. SAI Global.

LIMITATIONS

REPORT LIMITATIONS

This geotechnical report is provided for the sole use by the Client. This report must not be applied for any other purpose or project except the one originally contemplated without written authorisation from WML. WML accepts no responsibility for the use of this report / document, in whole or in part, in other contexts or for any other purpose.

WML have undertaken investigations, performed consulting services, and prepared this report based on the Client's specific requirements, documents and information supplied, and previous experience. If changes occur in the nature or design of the project, however minor, it is recommended WML review this report to assess their impacts and provide additional recommendations, if any. WML does not assume any responsibility or liability for problems that arise due to developments on site of which we were not informed.

This report utilises data and information provided by third parties, including, but not limited to sub-consultants, published data, and the Client. This information has been assumed to be correct unless otherwise stated. WML assumes no responsibility for assessments made partly or entirely based on information provided by third parties or for the adequacy, incompleteness, inaccuracies, or reliability of any data provided by third parties.

It is the responsibility of the Client to transmit the information, recommendations, and limitations of this report to the appropriate organisations or people involved in design of the project, including, but not limited to developers, builders, owners, buyers, architects, engineers, and designers.

WML's opinions are based on upon information that existed at the time of the production of this report and ground conditions encountered at the time the site study was performed. This geotechnical report should not be relied upon if its adequacy has been affected by: the passage of time, by man-made events, such as construction on or adjacent to the site, or by natural events, such as floods, earthquakes, or groundwater fluctuations. In the event of the above changes, WML should be contacted to determine if this report is still reliable or whether additional testing is required.

The subsurface conditions identified within this report are based only upon investigation locations where subsurface tests have been conducted and / or samples obtained, which are explicitly representative of the specific sample or test location. Interpretation of conditions between such points cannot be assumed to represent actual subsurface information and unknowns or variations in ground conditions between test locations that cannot be inferred or predicted. Actual subsurface conditions may differ significantly from those indicated in this report. Specific warning is also given that many factors, either natural or artificial, may render ground conditions different from those which pertained at the time of the investigation. WML does not accept any responsibility for any variance in the ground conditions that may exist across the site. If unexpected subsurface conditions are encountered, WML shall be notified immediately to review those conditions and provide additional and/or modified recommendations, as necessary.

This geotechnical assessment is based upon judgment of the investigation data, visual observations of the site and materials encountered, along with the proposed land use and project specifications. The findings and recommendations presented within this report represent professional opinions and estimates and should not be taken as fact unless explicitally stated. In general, statements of fact are are limited to what was done and / or what was observed on site.

The recommendations provided in this report are preliminary only; final recommendations can only be given after observing the actual subsurface conditions revealed during construction. WML does not assume responsibility or liability for the recommendations in this report if construction observation has not been performed by a WML geotechnical engineer.

Our services did not include any contamination or environmental assessment of the site or adjacent sites. The equipment and techniques used to perform a geoenvironmental study differ from those used to perform a geotechnical investigation. If you require any geoenvironmental information for your project, WML can advise on further steps to be undertaken.

REPORT LIMITATIONS

WML have performed our professional services in accordance with generally accepted geotechnical engineering principles and practices currently employed in the area; no warranty, expressed or implied, is made as to the professional advice included in this report.

DRAWINGS

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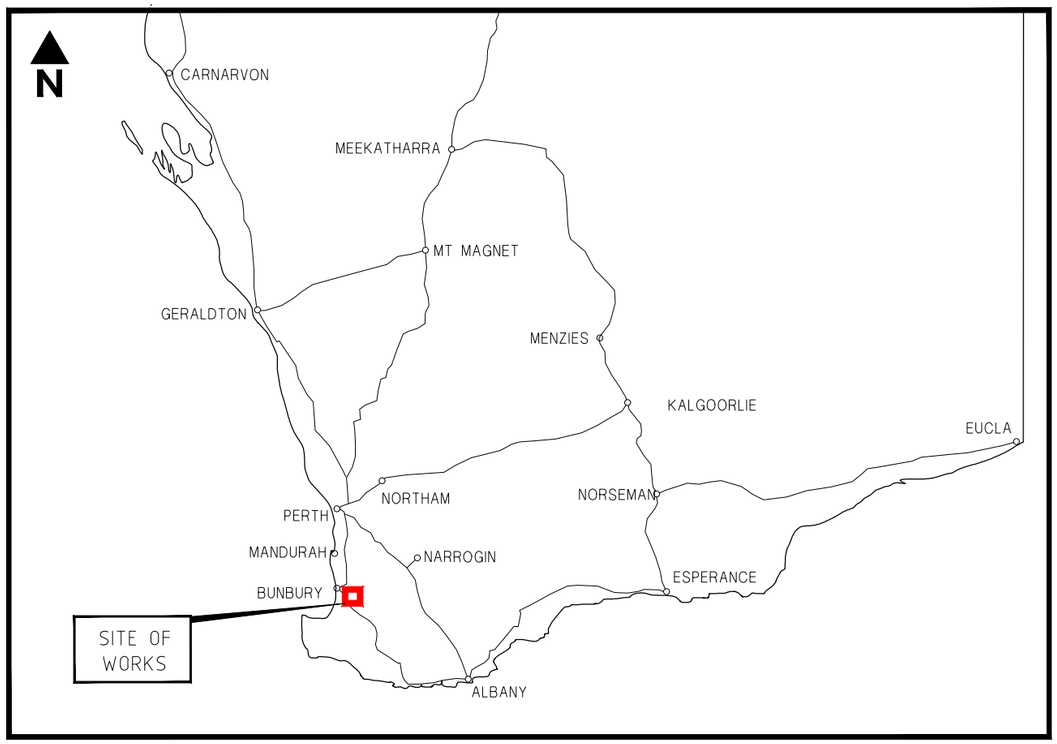

MAP
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SITE PLAN
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PRELIMINARY DRAWING
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DRAWN	C. HICK	FEB 2024
VERIFIED		
APPROVED		

CLIENT
VA & MP WRIGHT & SON

PROJECT
LOT 564 GARVEY ROAD
GEOTECHNICAL INVESTIGATION

DRAWING TITLE
LOT 564 GARVEY ROAD
SUBDIVISION
LOCALITY PLAN

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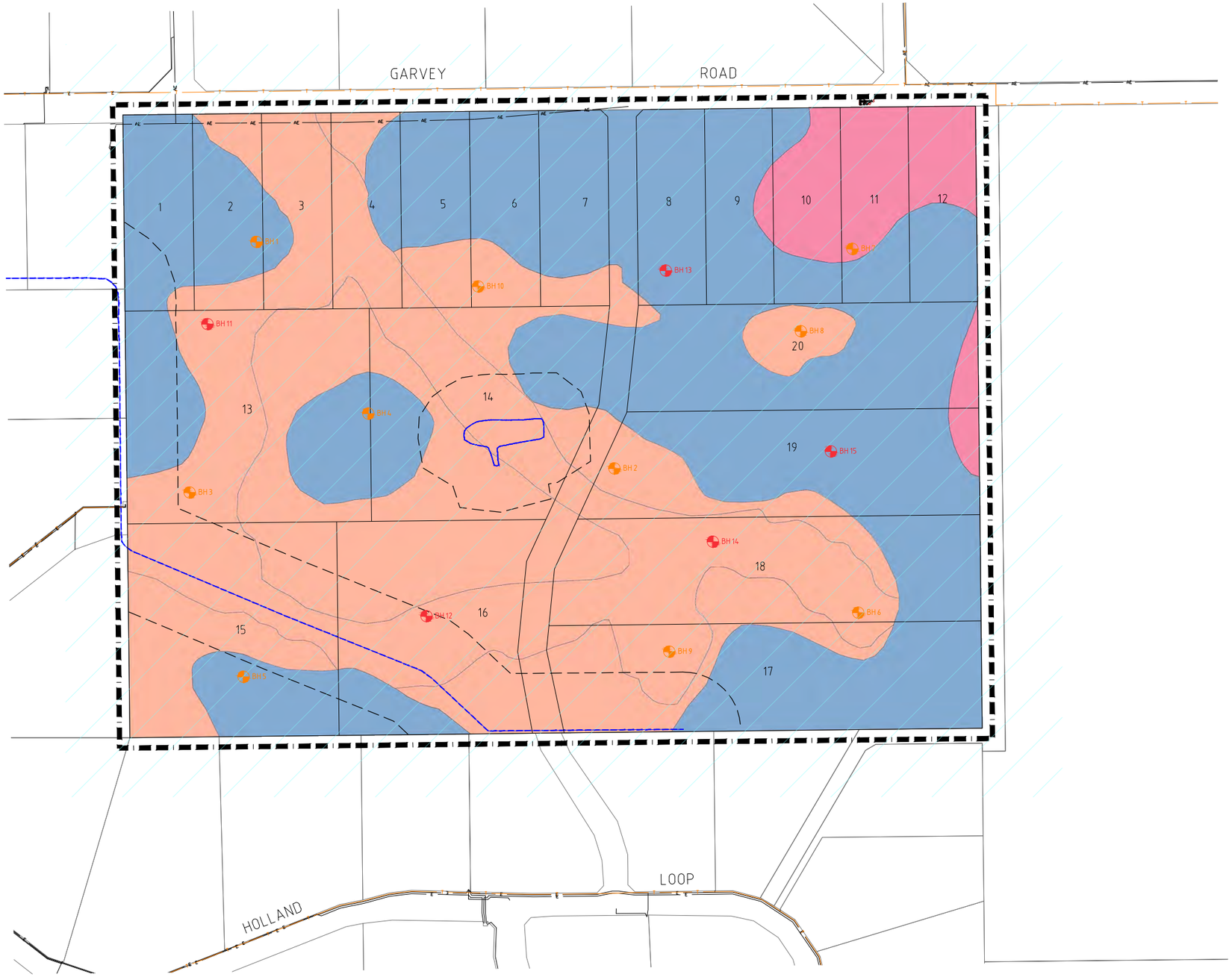

LEGEND

- BH 11 — WML BOREHOLE (JANUARY 2024)
- BH 4 — WML BOREHOLE (MAY 2023)
- ZONE 1
- ZONE 2
- ZONE 3
- SCOTT COASTAL PLAIN
- SITE BOUNDARY
- 50m SETBACK TO SURFACE WATER
- EXISTING OPEN DRAIN

PLAN

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CLIENT: VA & MP WRIGHT & SON

PROJECT: LOT 564 GARVEY ROAD GEOTECHNICAL INVESTIGATION

DRAWING TITLE: LOT 564 GARVEY ROAD SUBDIVISION SOIL SURVEY AND ANALYSIS AREAS

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REVISION: B

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CLIENT
VA & MP WRIGHT & SON

PROJECT
LOT 564 GARVEY ROAD
GEOTECHNICAL INVESTIGATION

DRAWING TITLE
LOT 564 GARVEY ROAD
SUBDIVISION
PREFERRED LAND APPLICATION AREAS

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REVISION B

APPENDIX A

GROUNDWATER MONITORING REPORT

11207-G-R-001-1

VA & MP Wright & Son

GROUNDWATER MONITORING PROGRAM

LOT 564 GARVEY ROAD
DARDANUP WEST
WA

October 2023
11207-G-R-001-1

WML
Consulting Engineers

Document History and Status				
Revision	**Prepared By**	**Reviewed By**	**Purpose of Issue**	**Date**
0	J.Ellis	A. Gorczynska	Issue to Client	26/06/2023
1	Z. Christian	A. Gorczynska	Groundwater monitoring readings added	31/10/2023

Issued to:	Ross Wright
WML Project Number:	11207
Document Name:	11207-G-R-001-1

WML Consultants Pty Ltd

Jack Ellis
Undergraduate Geotechnical Engineer
Author

Aleksandra Gorczynska
Senior Geotechnical Engineer
Reviewer

For and on behalf of WML Consultants Pty Ltd

WML Consultants Pty Ltd
ABN 36 092 471 531
Level 3
1 Prowse Street West Perth WA 6005
(08) 9722 3566 wml@wml.com.au
wml.com.au

CONTENTS

TABLES

APPENDICES

1 INTRODUCTION

Ross Wright (the client) engaged WML Consulting Engineers (WML) on behalf of VA & MP Wright & Son to undertake a groundwater monitoring program at Lot 564 Garvey Road, West Dardanup, WA. This report presents a summary of the installation of the bores and the results of the 3 groundwater monitoring events. The works were completed to assist with the rezoning of the site.

A generalised soil profile has been provided in this report. If laboratory testing and in-depth logs of all materials encountered are required, please contact WML to assist with providing this information in a detailed geotechnical investigation report.

This report and the information presented herein must be read in conjunction with the attached "Report Limitations".

1.1 Site description

The proposed site is located on Lot 564 Garvey Road, West Dardanup, WA, in the South-West region of Western Australia, approximately 12 km southeast of Bunbury. The site is bounded by Garvey Road to the north and adjacent lots along each of the three other boundaries. The site is a typical farmland used for grazing cows, with a shed structure located along the Garvey Road edge of the site positioned centrally between the east and west boundaries. The ground surface is covered predominantly by grass, free from trees for much of the site, with some isolated trees to the northeast corner of the site. A man-made drainage swale was observed running from east to west through the site, with a small stone arch bridge used to access the southwest corner of the property. A small man-made dam was observed in the centre of the lot.

The site is generally flat, with a maximum variation of 6 metres between the low-lying areas and the small mound at the northeast corner of the lot. Photographs depicting typical site conditions at the time of the investigation are presented in the Appendix attached to this report.

1.2 Client supplied information

The following information was made available by the client for the purpose of this report.

- Site map – Services.pdf
- 11052023104911-0001.pdf

1.3 Objectives of this report

The objectives of this investigation and report were to:

- Install groundwater monitoring wells across the site,
- Carry out a survey of the groundwater monitoring bores to provide accurate bore coordinates and levels.
- Review the available information from the groundwater well installation fieldwork and complete 3 groundwater monitoring events following the fieldwork.
- Provide a generalised soil profile encountered during the installation of groundwater monitoring wells.

2 FIELD PROGRAMME

2.1 Fieldwork

The fieldwork was carried out on the 31st of May and the 1st of June by two geotechnical engineers from WML and comprised:

- A site walkover to observe existing site features and to take record photographs.
- Drilling eight (10) solid auger boreholes using a mechanical auger drill rig. Each borehole was converted into a groundwater monitoring well (MW), designated BH1 – BH10, to depths of either 2.5 m or 5.5 m.

The geotechnical engineers from WML completed the drilling, installation of groundwater monitoring wells, and backfilling of each borehole appropriately with gravel and bentonite plug to ensure the accuracy of the groundwater monitoring wells. The surveyed test locations are presented in Table 1, with coordinates and RL levels recorded by a licensed surveying contractor.

Each location for intrusive ground investigation was checked for underground services against Dial-Before-You-Dig plans prior to any excavation works.

Table 1: Summary of fieldwork

Location ID	Coordinates (MGA94 Zone 50)		Elevation (TOC) RL (m)	Upstand (m)	Termination Depth (m)	Date Completed
	Easting	Northing				
BH1	382410.17	6302150.52	24.30	0.16	2.5	31/05/2023
BH2	382727.38	6301952.25	25.00	0.23	2.5	31/05/2023
BH3	382356.09	6301931.66	23.50	0.23	5.5	1/06/2023
BH4	382512.74	6302000.96	25.30	0.38	2.5	31/05/2023
BH5	382403.59	6301770.52	25.35	0.25	2.5	31/05/2023
BH6	382940.61	6301826.99	26.18	0.40	5.5	1/06/2023
BH7	382935.41	6302144.71	28.72	0.28	2.5	31/05/2023
BH8	382890.18	6302072.28	26.32	0.20	2.5	31/05/2023
BH9	382775.09	6301792.46	24.86	0.16	2.5	1/06/2023
BH10	382608.81	6302111.11	24.84	0.33	2.5	1/06/2023

Notes: All depths are relative to the existing ground surface
TOC – Top of Casing

2.2 Monitoring well installation

The monitoring wells were installed across the site to provide an indication of the static groundwater levels for the proposed subdivision and allow for ongoing monitoring. The monitoring wells were installed by drilling a 110 mm diameter borehole and inserting a 40 mm diameter PVC pipe consisting of a screen and casing. A gravel response zone was placed around the section of the slotted pipe, and a bentonite plug was placed above the gravel to prevent any surface water contamination within the well.

3 RESULTS AND COMMENTS

3.1 Generalised ground profile

A summarized ground profile of the site is presented below in Table 2 based on the soils encountered during the installation of the groundwater monitoring wells.

Table 2. Generalised soil profile

Depth (m)	Profile Summary
0.0 – 0.1 m	**TOPSOIL; Silty SAND**, dark grey/ black, trace roots, loose
0.1 – 0.7 to 2.5 m	**SAND/ Silty SAND**, pale grey, loose
0.7 to 2.5 – Termination Depth	**Sandy CLAY**, Medium to High Plasticity, grey with mottled blue, wet; firm

3.2 Groundwater levels

Ten groundwater monitoring wells were installed on the 31st of May and the 1st of June 2023 by WML to investigate the groundwater level throughout the proposed lot. At the time of the investigation fieldwork, no existing groundwater monitoring wells were observed throughout the site. Groundewater levels were then measured through August, September and October, and are summarized below.

Table 3: Summary of groundwater depths observed

Test ID	Depth of Groundwater (m)			
	Observed 1/06/2023	Observed 10/8/2023	Observed 15/9/2023	Observed 31/10/2023
BH1	1.4	0.76	0.71	1.3
BH2	GNE	0.18	0.04	1.05
BH3	3.8	-0.10	-0.20	GNE
BH4	1.2	0.63	0.63	1.22
BH5	1.8	0.80	0.89	1.29
BH6	GNE	0.00[1)]	0.00[1)]	GNE
BH7	GNE	GNE	GNE	GNE
BH8	1.0	0.00	0.00	GNE
BH9	GNE	0.00	0.00	1.19
BH10	2.3	0.60	0.35	0.99

Notes: All depths are relative to the existing ground surface
GNE = Groundwater not encountered
[1)]Groundwater not encountered in borehole, but ponding present in the area around the monitoring well.

3.3 Initial comments

A considerable fluctuation was observed in the groundwater levels during the first visit. This may be due to perched groundwater and areas containing lower permeable soils closer to the surface. The groundwater measurements typically increased on the second visit, with several monitoring wells having water ponding at the surface in the area surrounding the well.

4 CLOSURE

We trust that the information provided within this report satisfies your present requirements and meets with your approval. Should you have any queries, please do not hesitate to contact the author of this report.

We draw your attention to the attached "*Report Limitations*" included with this report. This information sheet is intended to provide additional information about this report and the information included within it. This information is provided not to reduce the level of responsibility accepted by WML but to ensure that all parties that rely on this report, and the information contained herein, are aware of the responsibilities that each assumes in so doing.

5 REFERENCES

1. Standards Australia. 2017. *Geotechnical Site Investigations*. AS 1726:2017. SAI Global.

LIMITATIONS

REPORT LIMITATIONS

WML have undertaken investigations, performed consulting services, and prepared this report based on the Client's specific requirements, documents and information supplied, and previous experience. If changes occur in the nature or design of the project, we should be allowed to review this report and provide additional recommendations, if any. It is the responsibility of the Client to transmit the information and recommendations of this report to the appropriate organisations or people involved in design of the project, including but not limited to developers, owners, buyers, architects, engineers, and designers.

We performed our professional services in accordance with generally accepted geotechnical engineering principles and practices currently employed in the area; no warranty, expressed or implied, is made as to the professional advice included in this report.

Any data provided by third parties including, but not limited to: sub-consultants, published data, and the Client, may not be verified and WML assumes no responsibility for the adequacy, incompleteness, inaccuracies, or reliability of this information. WML does not assume any responsibility for assessments made partly or entirely based on information provided by third parties.

This report has been prepared based on investigation locations which are explicitly representative of the specific sample or test points. Interpretation of conditions between such points cannot be assumed to represent actual subsurface information and there are unknowns or variations in ground conditions between test locations that cannot be inferred or predicted.

This report is based upon field and other conditions encountered at the time of report preparation. If unexpected subsurface conditions are encountered, WML shall be notified immediately to review those conditions and provide additional and/or modified recommendations, as necessary.

Our services did not include any contamination or environmental assessment of the site or adjacent sites. The nature of geotechnical investigation differs from the environmental investigation practice. If you require any environmental considerations to be applied to your project, WML can advise on further steps to be undertaken.

Geotechnical assessments are typically based on judgment of the investigation data and visual observations of the site and materials.

This document must not be subject to unauthorised use that is, reusing without written authorisation of WML. Such authorisation is essential because it requires WML to evaluate the document's applicability given new circumstances, not the least of which is passage of time.

SITE PHOTOGRAPHS

PHOTOGRAPHIC RECORD

Client:	□A □ M□ □ righ□□ Son
Job Number:	□□□□□
Job Description:	□ro□ndwa□er Moni□oring
Date:	31/05 and 1/06 2023

Photo 1: General view of site

PHOTOGRAPHIC RECORD

Client:	□A □ M□ □ righ□□ Son
Job Number:	□□□□□
Job Description:	□ro□ndwa□er Moni□oring
Date:	31/05 and 1/06 2023

Photo 2: Dam observed at centre of site

PHOTOGRAPHIC RECORD

Client:	□A □ M□ □ righ□□ Son
Job Number:	□□□□□
Job Description:	□ro□ndwa□er Moni□oring
Date:	31/05 and 1/06 2023

Photo 3: Typical groundwater monitoring well

SITE PLAN

11207

Garvey Road Groundwater Monitoring Program

Legend

Borehole Location

Garvey Rd

BH1

BH10

BH7

BH8

BH4

BH2

BH3

BH6

BH9

BH5

Google Earth

N

100 m

APPENDIX B

SOIL LOGS

REPORT OF BOREHOLE: BH11

Job No	: 11207	Latitude	: -33.438490		
Client	: Example Client	Longitude	: 115.738843	Logged	: SD
Project	: Garvey road	UTM	:	Logged Date	: 28/11/2023
Location	: Lot 564 Garvey road	Drill Rig	: Drillman GT10	Checked	: IG
Contractor	: WIN geotech	Inclination	: -90 deg	Checked Date	: 10/01/2024

METHOD	WATER	DEPTH (m)	GRAPHIC LOG	USCS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY/ DENSITY	IN-SITU TESTING	SAMPLE	DCP TEST
Solid flight auger		0.25		SM	TOPSOIL; Silty SAND (SM) : medium dense, brown, fine to medium grained, dry, with roots .	D	MD			
		0.75		SW	SAND (SW) : medium dense, medium plasticity clay, grey brown, fine to medium grained, with medium plasticity clay, dry.	D	MD		B:	
		1		CL	Sandy CLAY (CL) : soft to firm, low plasticity, yellow brown, fine to medium grained sand, dry.	D	S-F			
		1.25		CI	CLAY (CI) : firm, medium plasticity, yellow brown, with fine to medium grained sand, moist.	M	F		D:	
		2		CI	CLAY (CI) : hard, medium plasticity, yellow brown, trace fine to medium grained sand, moist, trace silt.	M	H			
		3			**BH11 Terminated at 2.65m (Permeability test 133.5ml to 107ml @0.50m in 60secs)**					

REPORT OF BOREHOLE: BH12

Job No	: 11207	Latitude	: -33.416521		
Client	: Example Client	Longitude	: 115.736929	Logged	: SD
Project	: Garvey road	UTM	:	Logged Date	: 28/11/2023
Location	: Lot 564 Garvey road	Drill Rig	: Drillman GT10	Checked	: IG
Contractor	: WIN geotech	Inclination	: -90 deg	Checked Date	: 10/01/2024

METHOD	WATER	DEPTH (m)	GRAPHIC LOG	USCS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY/ DENSITY	IN-SITU TESTING	SAMPLE	DCP TEST
		0.25		SW	TOPSOIL; SAND (SW) : dense, grey, fine to medium grained, with low plasticity clay, trace fine to coarse sized gravel, dry.	D	D		B:	
				CL	Sandy CLAY (CL) : stiff, low plasticity, grey, fine to medium grained sand, inorganic, dry.	D	St			
		1			**BH12 refusal at 1m**					
		2								
		3								

DCP TEST: 0 5 10 15 20 25; 9; 4

REPORT OF BOREHOLE: BH13

Job No	: 11207	Latitude	: -33.413820		
Client	: Example Client	Longitude	: 115.739218	Logged	: SD
Project	: Garvey road	UTM	:	Logged Date	: 28/11/2023
Location	: Lot 564 Garvey road	Drill Rig	: Drillman GT10	Checked	: IG
Contractor	: WIN geotech	Inclination	: -90 deg	Checked Date	: 10/01/2024

METHOD	WATER	DEPTH (m)	GRAPHIC LOG	USCS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY/ DENSITY	IN-SITU TESTING	SAMPLE	DCP TEST
		0		SW	SAND (SW) : dense, grey, fine to medium grained, trace silt, dry.	D	D			8, 8, 6, 5, 4, 4
		1		SW	SAND (SW) : dense, brown, fine to medium grained, with silt, dry.	D	D			6, 19, 15, 7, 15
		1.75		CL	CLAY (CL) : stiff, low plasticity, mottled red grey, with fine to medium grained sand, inorganic, dry.	D	St			9, 11, 9, 7
		2			**BH13 Terminated at 2.65m**					
		3								

REPORT OF BOREHOLE: BH14

Job No	: 11207	Latitude	: -33.415958		
Client	: Example Client	Longitude	: 115.739629	Logged	: SD
Project	: Garvey road	UTM	:	Logged Date	: 28/11/2023
Location	: Lot 564 Garvey road	Drill Rig	: Drillman GT10	Checked	: IG
Contractor	: WIN geotech	Inclination	: -90 deg	Checked Date	: 10/01/2024

METHOD	WATER	DEPTH (m)	GRAPHIC LOG	USCS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY/ DENSITY	IN-SITU TESTING	SAMPLE	DCP TEST
		0.25		SM	TOPOSIL; Silty SAND (SM) : dense, brown, fine to medium grained, trace roots, dry.	D	D			
		0.75		SM	Silty SAND (SM) : dense, brown, fine to medium grained, dry.	D	D		D:	
		1		SC	Clayey SAND (SC) : dense, low plasticity clay, brown, fine to medium grained, dry.	D	D		B:	
		1.25		CL	CLAY (CL) : stiff, low plasticity, orange brown, with fine to medium grained sand, inorganic, dry.	D	St			
		1.75		CL	CLAY (CL) : very stiff, low plasticity, red brown, with fine to medium grained sand, inorganic, dry.	D	VSt			
		2			**BH14 refusal at 2m**					
		3								

DCP TEST: 0 5 10 15 20 25

4 2 2 1 2 4 4 5 7 8 8 17 15 17

REPORT OF BOREHOLE: BH15

Job No	: 11207	Latitude	: -33.415261		
Client	: Example Client	Longitude	: 115.740746	Logged	: SD
Project	: Garvey road	UTM	:	Logged Date	: 28/11/2023
Location	: Lot 564 Garvey road	Drill Rig	: Drillman GT10	Checked	: IG
Contractor	: WIN geotech	Inclination	: -90 deg	Checked Date	: 10/01/2024

METHOD	WATER	DEPTH (m)	GRAPHIC LOG	USCS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY/ DENSITY	IN-SITU TESTING	SAMPLE	DCP TEST
		0.25		SW	TOPSOIL; SAND (SW) : medium dense, grey brown, fine to medium grained, trace silt, trace roots, dry.	D	MD			
		1		SW	SAND (SW) : medium dense, grey, fine to medium grained, trace silt, dry.	D	MD			
		1.25		SW	SAND (SW) : medium dense, brown, fine to medium grained, with silt, dry.	D	MD			
		1.75		CL	CLAY (CL) : stiff, low plasticity, brown, with fine to medium grained sand, inorganic, dry.	D	St			
		2		CL	Sandy CLAY (CL) : very stiff, low plasticity, orange brown, fine to medium grained sand, inorganic, dry.	D	VSt			
		3			**BH15 Terminated at 2.65m**					

APPENDIX C

LABORATORY TESTING

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

MOISTURE DENSITY RELATIONSHIP REPORT

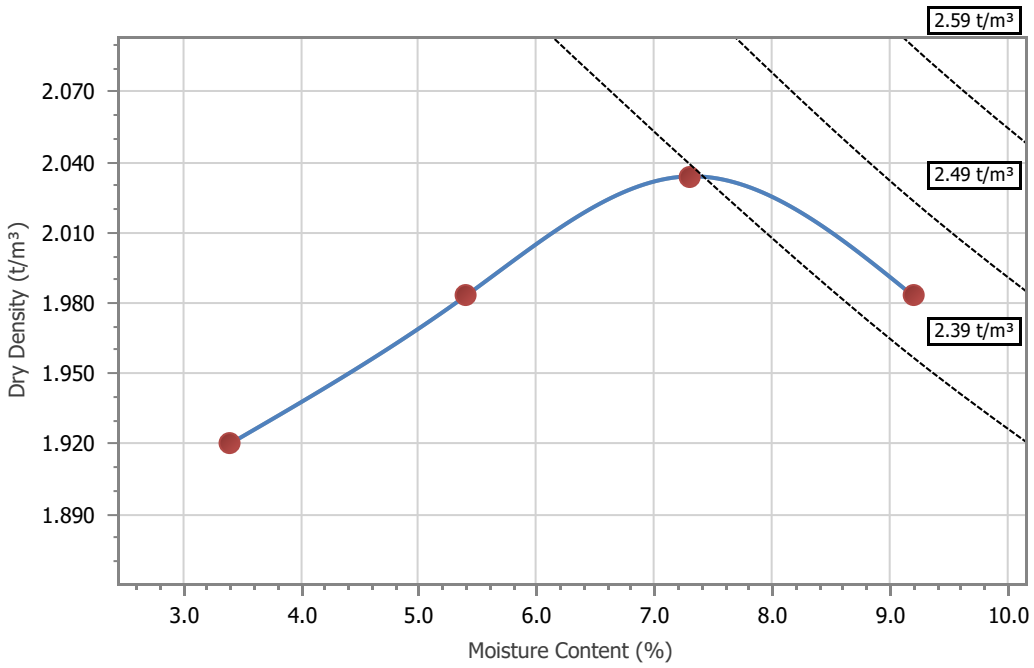
Client:	WML Consultants	Report Number:	5022/R/69034-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH12 Depth 0.3m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	25/01/2024 Page 1 of 1

Test Procedures	WA133.1, WA110.1, WA115.2, WA105.1	Bore hole No	BH12
Sample Number	5022/S/112477	Depth m	0.3
Sampling Method	Tested As Received		
Date Sampled	28/11/2023		
Sampled By	Client Sampled		
Date Tested	21/01/2024	Compactive Effort	Modified
Material Source	Borehole	Percent Retained 37.5mm (%)	0
Material Type		Percent Retained 19.0mm (%)	0
Liquid Limit Method	n/a	Total Curing Time (hrs)	71.8
Material Description	Brown SAND		

Moisture / Density Relationship Data

Moisture Content (%)	Dry Density (t/m³)
3.4	1.920
5.4	1.983
7.3	2.034
9.2	1.983

MOISTURE DENSITY RELATIONSHIP PLOT



Maximum Dry Density (t/m³):	**2.034**	**Optimum Moisture Content (%):**	**7.3**

Remarks

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W4Rep Rev 3

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: Bunbury
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

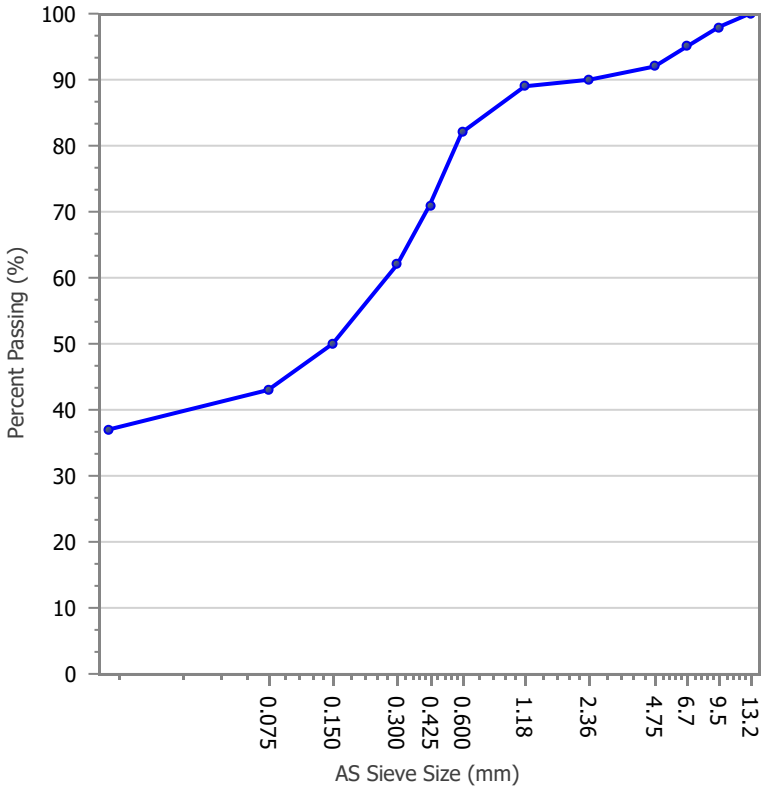
PARTICLE SIZE DISTRIBUTION REPORT

Client:	WML Consultants	Report Number:	5022/R/69103-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH11 Depth 1.25m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	30/01/2024 Page 1 of 1

Test Procedures:	WA115.1, WA105.1			
Sample Number	5022/S/112476	Bore hole No		BH11
Sampling Method	Tested As Received	Depth	m	1.25
Date Sampled	28/11/2023			
Sampled By	Client Sampled			
Date Tested	22/01/2024	Material Source		Borehole
Prep / Drying Method	Decanted / -	Material Type		-
		Specification		-

AS Sieve (mm)	Specification Minimum (%)	**Percent Passing (%)**	Specification Maximum (%)
13.2		**100**	
9.5		**98**	
6.7		**95**	
4.75		**92**	
2.36		**90**	
1.18		**89**	
0.600		**82**	
0.425		**71**	
0.300		**62**	
0.150		**50**	
0.075		**43**	
0.0135		**37**	

PARTICLE SIZE DISTRIBUTION GRAPH



Remarks

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Accreditation Number: 1986
Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W9Rep Rev 3

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: Bunbury
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

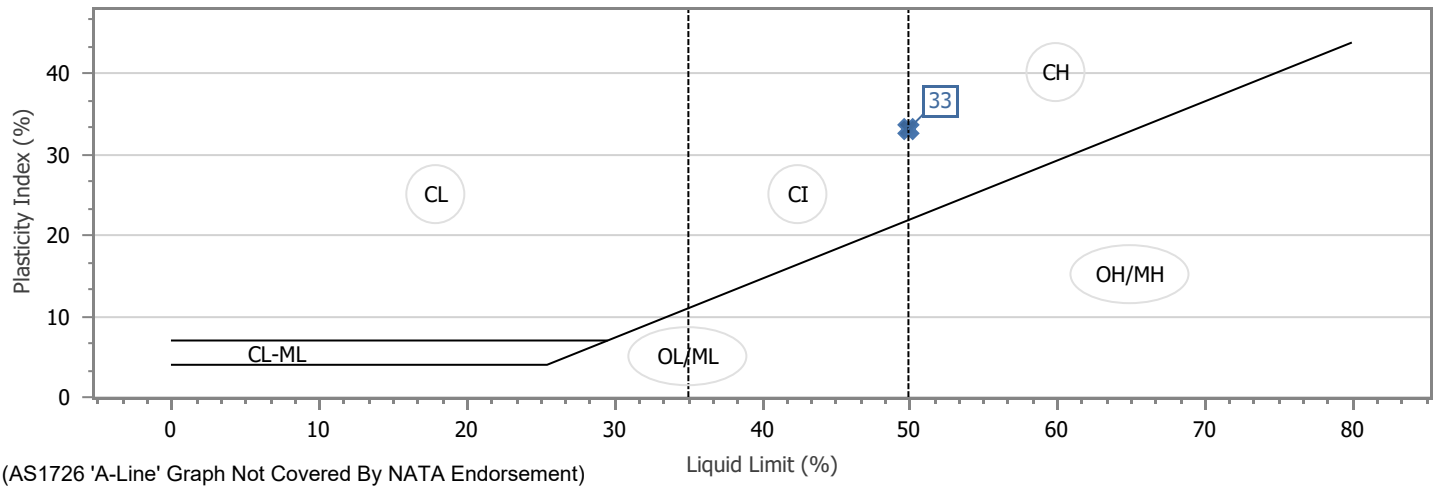
ATTERBERG LIMITS REPORT

Client:	WML Consultants	Report Number:	5022/R/69104-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH11 Depth 1.25m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	30/01/2024 Page 1 of 1

Test Procedures:	WA120.2, WA 122.1, WA121.1, WA123.1, WA105.1, WA110.1		
Sample Number	5022/S/112476	Sample Location	
Sampling Method	Tested As Received	Bore hole No	BH11
Date Sampled	28/11/2023	Depth m	1.25
Sampled By	Client Sampled		
Date Tested	25/01/2024		
Drying / Prep Method	Oven Dried / Dry Sieved	Material Source	Borehole
LL Water Type	Other	Material Type	-
LL Device Type	Penetrometer	Specification	-
Client Reference	-		
Material Description	Brown CLAY		

Atterberg Limit	Specification Minimum	Test Result	Specification Maximum
Liquid Limit (%)		**50**	
Plastic Limit (%)		**17**	
Plasticity Index (%)		**33**	
Linear Shrinkage (%)		**12.0**	
Linear Shrinkage Observations:	-		

Atterberg Limits 'A-Line' Graph



(AS1726 'A-Line' Graph Not Covered By NATA Endorsement)

Remarks

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W11Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

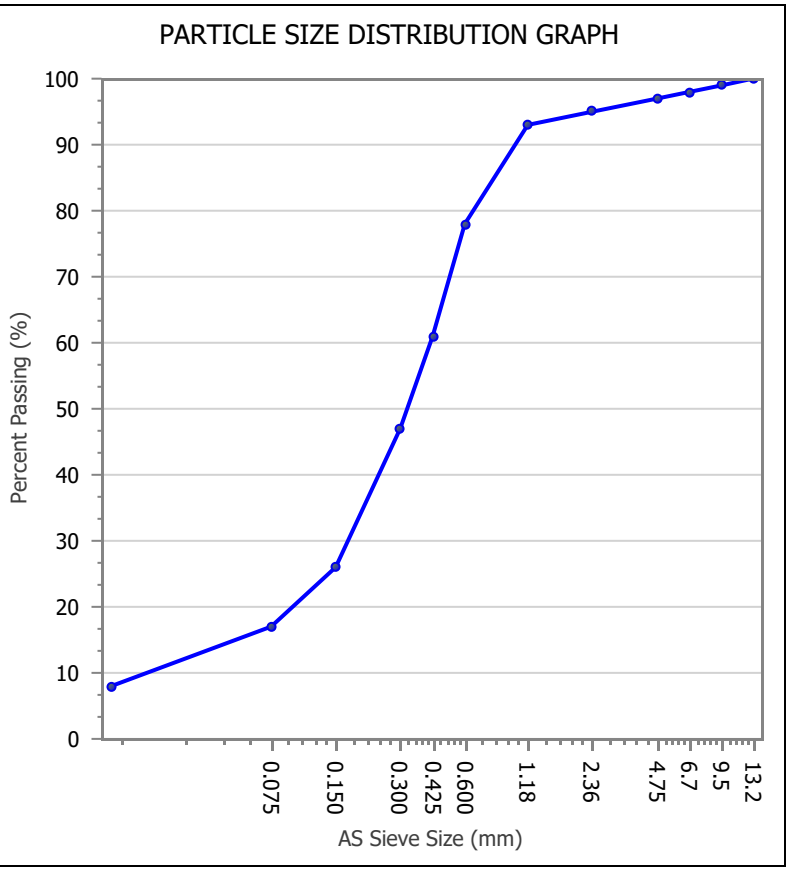
Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

PARTICLE SIZE DISTRIBUTION REPORT

Client:	WML Consultants	Report Number:	5022/R/69105-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH12 Depth 0.3m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	30/01/2024 Page 1 of 1

Test Procedures:	WA115.1, WA105.1			
Sample Number	5022/S/112477	Bore hole No		BH12
Sampling Method	Tested As Received	Depth	m	0.3
Date Sampled	28/11/2023			
Sampled By	Client Sampled			
Date Tested	23/01/2024	Material Source		Borehole
Prep / Drying Method	Decanted / -	Material Type		-
		Specification		-

AS Sieve (mm)	Specification Minimum (%)	**Percent Passing (%)**	Specification Maximum (%)
13.2		**100**	
9.5		**99**	
6.7		**98**	
4.75		**97**	
2.36		**95**	
1.18		**93**	
0.600		**78**	
0.425		**61**	
0.300		**47**	
0.150		**26**	
0.075		**17**	
0.0135		**8**	



Remarks

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NATA

Accreditation Number: 1986
Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W9Rep Rev 3

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

ATTERBERG LIMITS REPORT

Client:	WML Consultants	Report Number:	5022/R/69106-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH12 Depth 0.3m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	30/01/2024 Page 1 of 1

Test Procedures:	WA120.2, WA 122.1, WA121.1, WA123.1, WA105.1		
Sample Number	5022/S/112477	Sample Location	
Sampling Method	Tested As Received	Bore hole No	BH12
Date Sampled	28/11/2023	Depth m	0.3
Sampled By	Client Sampled		
Date Tested	24/01/2024		
Drying / Prep Method	- / -	Material Source	Borehole
LL Water Type	Other	Material Type	-
LL Device Type	Penetrometer	Specification	-
Client Reference	-		
Material Description	Brown SAND		

Atterberg Limit	Specification Minimum	Test Result	Specification Maximum
Liquid Limit (%)		**Not obtainable**	
Plastic Limit (%)		**Non-Plastic**	
Plasticity Index (%)		**Non Plastic**	
Linear Shrinkage (%)		**0.0**	
Linear Shrinkage Observations:	Est. LL: 17.1%		

Remarks

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W11Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

EMERSON CLASS NUMBER REPORT

Client:	WML Consultants	Report Number:	5022/R/69107-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH13 Depth 0.5m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	30/01/2024 Page 1 of 1

Test Procedures:	AS1289.3.8.1

Sample Number	5022/S/112478			
ID / Client ID	-			
Lot Number	BH13 Depth 0.5m			
Date / Time Sampled	28/11/2023			
Date Tested	30/01/2024			
Material Source	Borehole			
Material Type	-			
Sampling Method	Tested As Received			
Prep Material > 53mm (%)	-			
Water Type	Distilled			
Water Temperature (°C)	19			
Bore hole No	BH13			
Depth	0.5			
Soil Description	Dark Brown SAND			
Emerson Class Description	Slakes Dispersion after remoulding.			
Emerson Class Number	**3**			

Remarks

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W22Rep Rev 4

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

EMERSON CLASS NUMBER REPORT

Client:	WML Consultants	Report Number:	5022/R/69108-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH11 Depth 1.25m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	30/01/2024 Page 1 of 1

Test Procedures:	AS1289.3.8.1

Sample Number	5022/S/112476			
ID / Client ID	-			
Lot Number	BH11 Depth 1.25m			
Date / Time Sampled	28/11/2023			
Date Tested	30/01/2024			
Material Source	Borehole			
Material Type	-			
Sampling Method	Tested As Received			
Prep Material > 53mm (%)	-			
Water Type	Distilled			
Water Temperature (°C)	19			
Bore hole No	BH11			
Depth	1.25			
Soil Description	Brown CLAY			
Emerson Class Description	Slakes. Dispersion in soil/water suspension.			
Emerson Class Number	**5**			

Remarks

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

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Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

EMERSON CLASS NUMBER REPORT

Client:	WML Consultants	Report Number:	5022/R/69109-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH14 Depth 0.75m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	30/01/2024 Page 1 of 1

Test Procedures:	AS1289.3.8.1

Sample Number	5022/S/112480			
ID / Client ID	-			
Lot Number	BH14 Depth 0.75m			
Date / Time Sampled	28/11/2023			
Date Tested	30/01/2024			
Material Source	Borehole			
Material Type	-			
Sampling Method	Tested As Received			
Prep Material > 53mm (%)	-			
Water Type	Distilled			
Water Temperature (°C)	19			
Bore hole No	BH14			
Depth	0.75			
Soil Description	Pale Grey Silty SAND			
Emerson Class Description	Slakes. Flocculation in soil/water suspension.			
Emerson Class Number	**6**			

Remarks

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Form ID: W22Rep Rev 4

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ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

EMERSON CLASS NUMBER REPORT

Client:	WML Consultants	Report Number:	5022/R/69110-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH15 Depth 1.5m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	30/01/2024 Page 1 of 1

Test Procedures:	AS1289.3.8.1

Sample Number	5022/S/112481			
ID / Client ID	-			
Lot Number	BH15 Depth 1.5m			
Date / Time Sampled	28/11/2023			
Date Tested	30/01/2024			
Material Source	Borehole			
Material Type	-			
Sampling Method	Tested As Received			
Prep Material > 53mm (%)	-			
Water Type	Distilled			
Water Temperature (°C)	19			
Bore hole No	BH15			
Depth	1.5			
Soil Description	Pale Grey SAND			
Emerson Class Description	Slakes Dispersion after remoulding.			
Emerson Class Number	**3**			

Remarks

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

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Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W22Rep Rev 4

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

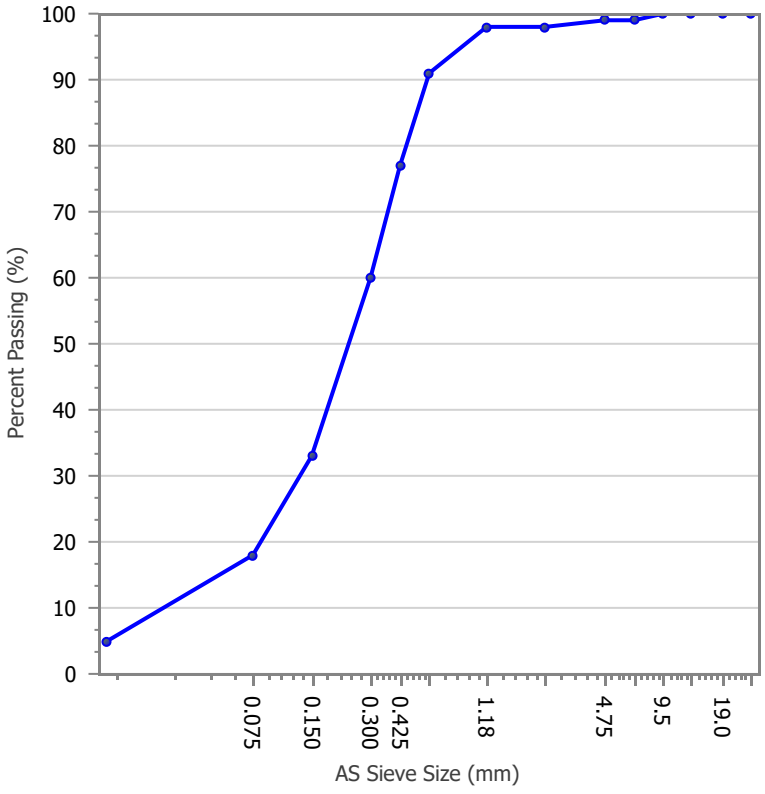
PARTICLE SIZE DISTRIBUTION REPORT

Client:	WML Consultants	Report Number:	5022/R/69259-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH11 Depth 0.5m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	6/02/2024 Page 1 of 1

Test Procedures:	WA115.1, WA105.1			
Sample Number	5022/S/112475	Bore hole No		BH11
Sampling Method	Tested As Received	Depth	m	0.5
Date Sampled	28/11/2023			
Sampled By	Client Sampled			
Date Tested	1/02/2024	Material Source		Borehole
Prep / Drying Method	Decanted / -	Material Type		White SAND
		Specification		-

AS Sieve (mm)	Specification Minimum (%)	**Percent Passing (%)**	Specification Maximum (%)
26.5		**100**	
19.0		**100**	
13.2		**100**	
9.5		**100**	
6.7		**99**	
4.75		**99**	
2.36		**98**	
1.18		**98**	
0.600		**91**	
0.425		**77**	
0.300		**60**	
0.150		**33**	
0.075		**18**	
0.0135		**5**	

PARTICLE SIZE DISTRIBUTION GRAPH



Remarks

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W9Rep Rev 3

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: Bunbury
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

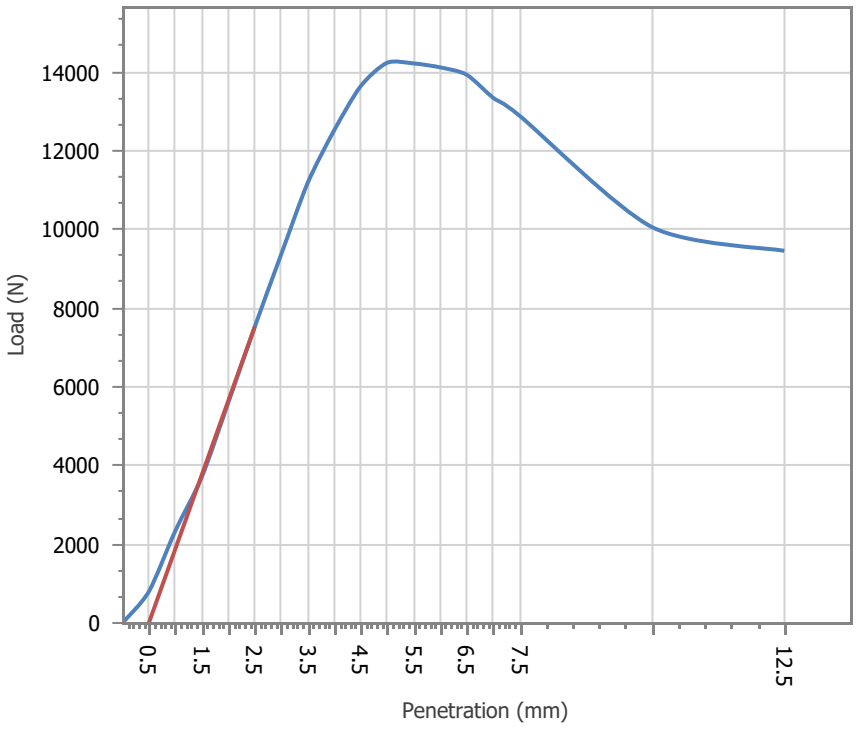
CALIFORNIA BEARING RATIO REPORT

Client:	WML Consultants	Report Number:	5022/R/69260-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH12 Depth 0.3m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	6/02/2024 Page 1 of 1

Test Procedures	WA141.1, WA105.1, WA133.1, WA110.1			
Sample Number	5022/S/112477	Bore hole No		BH12
Sampling Method	Tested As Received	Depth	m	0.3
Date Sampled	28/11/2023			
Sampled By	Client Sampled			
Date Tested	2/02/2024			
Material Source	Borehole	Material Limit Start		-
Material Type	Pale Brown SAND	Material Limit End		-
Client Reference	-	Compactive Effort		Modified
Material Description	Brown SAND			
Compaction Method	9 Blows per Layer			

Maximum Dry Density (t/m³):	2.034
Optimum Moisture Content (%):	7.3
Field Moisture Content (%):	2.5
Sample Percent Oversize (%)	0.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	95
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	1.937
Placement Dry Density Ratio (%):	95.2
Placement Moisture Content (%):	7.1
Placement Moisture Ratio (%):	97.3
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	9.0
Dry Density Ratio After Soak (%)	95.4
Moisture / Ratio After Soak (% / t/m³)	10.5 / 144.0
Moisture (top 30mm) After Pen (%):	10.8
Mst Ratio (top 30mm) After Pen (%)	148.0
Moisture (remainder) After Pen (%):	9.9
Mst Ratio (remainder) After Pen (%)	135.5
CBR Swell (%):	0.0
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**70**

CBR PENETRATION PLOT



Remarks

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Approved Signatory: Hermanus Coetzee
Form ID: W2ASRep Rev 3

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: Bunbury
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

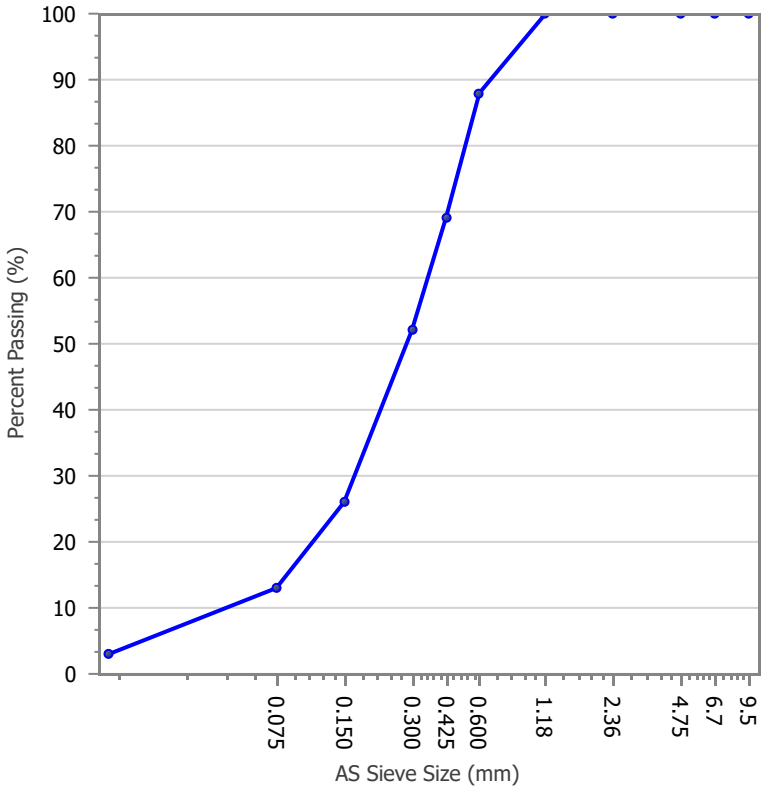
PARTICLE SIZE DISTRIBUTION REPORT

Client:	WML Consultants	Report Number:	5022/R/69261-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH14 Depth 0.3m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	6/02/2024 Page 1 of 1

Test Procedures:	WA115.1, WA105.1			
Sample Number	5022/S/112479	Bore hole No		BH14
Sampling Method	Tested As Received	Depth	m	0.3
Date Sampled	28/11/2023			
Sampled By	Client Sampled			
Date Tested	1/02/2024	Material Source		Borehole
Prep / Drying Method	Decanted / -	Material Type		Brown SAND
		Specification		-

AS Sieve (mm)	Specification Minimum (%)	**Percent Passing (%)**	Specification Maximum (%)
9.5		**100**	
6.7		**100**	
4.75		**100**	
2.36		**100**	
1.18		**100**	
0.600		**88**	
0.425		**69**	
0.300		**52**	
0.150		**26**	
0.075		**13**	
0.0135		**3**	

PARTICLE SIZE DISTRIBUTION GRAPH



Remarks

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Approved Signatory: Hermanus Coetzee
Form ID: W9Rep Rev 3

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

ATTERBERG LIMITS REPORT

Client:	WML Consultants	Report Number:	5022/R/69465-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH11 Depth 0.5m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	13/02/2024 Page 1 of 1

Test Procedures:	WA120.2, WA 122.1, WA121.1, WA123.1, WA105.1		
Sample Number	5022/S/112475	Sample Location	
Sampling Method	Tested As Received	Bore hole No	BH11
Date Sampled	28/11/2023	Depth m	0.5
Sampled By	Client Sampled		
Date Tested	7/02/2024		
Drying / Prep Method	Oven Dried / Dry Sieved	Material Source	Borehole
LL Water Type	Other	Material Type	White SAND
LL Device Type	Penetrometer	Specification	-
Client Reference	-		
Material Description	Grey Brown Silty SAND		

Atterberg Limit	Specification Minimum	Test Result	Specification Maximum
Liquid Limit (%)		**Not obtainable**	
Plastic Limit (%)		**Non-Plastic**	
Plasticity Index (%)		**Non Plastic**	
Linear Shrinkage (%)		**0.5**	
Linear Shrinkage Observations:	Est. LL: 19.4%		

Remarks

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NATA

Accreditation Number: 1986
Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W11Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
72 McCombe Road,
Davenport WA 6230

Laboratory: **Bunbury**
Phone: 08 9726 2187
Fax: 08 9721 2348
Email: Bunbury@constructionsciences.net

ATTERBERG LIMITS REPORT

Client:	WML Consultants	Report Number:	5022/R/69466-1
Client Address:	1st Floor 62 Wittenoom Street, Bunbury	Project Number:	5022/P/1661
Project:	Lot 564 Gravey Road	Lot Number:	BH14 Depth 0.3m
Location:	South West WA	Internal Test Request:	5022/T/20965
Supplied To:	n/a	Client Reference/s:	Job No. 11207:03
Area Description:		Report Date / Page:	13/02/2024 Page 1 of 1

Test Procedures:	WA120.2, WA 122.1, WA121.1, WA123.1, WA105.1		
Sample Number	5022/S/112479	Sample Location	
Sampling Method	Tested As Received	Bore hole No	BH14
Date Sampled	28/11/2023	Depth m	0.3
Sampled By	Client Sampled		
Date Tested	9/02/2024		
Drying / Prep Method	Oven Dried / Dry Sieved	Material Source	Borehole
LL Water Type	Other	Material Type	Brown SAND
LL Device Type	Penetrometer	Specification	-
Client Reference	-		
Material Description	Grey SAND		

Atterberg Limit	Specification Minimum	Test Result	Specification Maximum
Liquid Limit (%)		**Not obtainable**	
Plastic Limit (%)		**Non-Plastic**	
Plasticity Index (%)		**Non Plastic**	
Linear Shrinkage (%)		**1.0**	
Linear Shrinkage Observations:	Est. LL: 23.9%		

Remarks

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NATA

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Corporate Site Number: 5022

Approved Signatory: Hermanus Coetzee
Form ID: W11Rep Rev 2

Environmental and Agricultural Testing Services
Unit 5, 4 Mummery Cres
Bunbury WA 6230
Phone: 08 9721 7170
Email: eatsresults@eatswa.com.au
ABN 64 606 311 399

Certificate of Analysis

Client Name:	WML Consultants		
Address:	PO Box 2023, Bunbury, WA, 6231		
Phone No:	9722 3544	Email:	zchristian@wml.com.au
Lab No:	15204	Job No:	11207
Date samples received:	12/01/2024	Report date:	16/01/2024

Sample details: Twenty one soil samples received from WML Consultants on 12 January 2024, labelled 'Job 11207:03 lot 564 Garvey Road"

- BH11: 0.5; 1.0; 1.5; 2.0; 2.5.
- BH12: 0.5; 1.0.
- BH13: 0.5; 1.0; 1.5; 2.0; 2.5.
- BH14: 0.5; 1.0; 1.5; 2.0.
- BH15: 0.5; 1.0; 1.5; 2.0; 2.5.

The samples were in sealed plastic bags with the air excluded and frozen.
A portion of each sample tested for field pH_f and pH_{fox} on 15/01/2024.
The remainder has been frozen for storage for three months.

Scope of Work: Acid Sulfate Soils Field Tests pH_F, pH_{FOX}, Reaction rating, Fizz test.

Test Methods: Identification & Investigation of Acid Sulfate Soils and acidic landscapes, prepared by Department of Environmental Regulation, WA June 2015. pH tested using TPS Aqua-pH-ORP-Temp meter version 2.4 with Ionode Intermediate Junction pH combination electrode IJ44A calibrated according to manufacturer's instructions.

Test Results: See following page.

Comments:

- Confirmation of the field test results using Chromium Reducible Sulfur or SPOCAS laboratory analysis should be considered on 25% of the samples as per DWER guidelines.

Rachel Lancaster
BSc (Hort); PgDip (Agribusiness).

Lab No: 15204
Date tested: 15/01/2024
Label: Job 11207

Sample Number	Sample Name	Soil Description	pHf	pHfox	pH change pHf - pHfox	Reaction to peroxide (H_2O_2)	Fizz Test
					pH_{H2O2} = 4.56		
11	BH13 2.0	Not required	5.93	3.07	2.86	Low	None
12	BH13 2.5	Not required	6.24	3.22	3.02	None	None
13	BH14 0.5	Not required	5.35	4.34	1.01	None	None
14	BH14 1.0	Not required	5.64	4.57	1.07	None	None
15	BH14 1.5	Not required	5.52	4.24	1.28	None	None
16	BH14 2.0	Not required	5.12	3.77	1.35	None	None
17	BH15 0.5	Not required	5.86	4.52	1.34	None	None
18	BH15 1.0	Not required	5.34	4.28	1.06	None	None
19	BH15 1.5	Not required	6.13	3.76	2.37	None	None
20	BH15 2.0	Not required	5.80	4.02	1.78	Low	None
21	BH15 2.5	Not required	5.96	4.49	1.47	Low	None

End of report.

Environmental and Agricultural Testing Services
Unit 5, 4 Mummery Cres
Bunbury WA 6230
Phone: 08 9721 7170
Email: eatsresults@eatswa.com.au
ABN 64 606 311 399

Certificate of Analysis

Client Name:	WML Consultants		
Address:	PO Box 2023, Bunbury, WA, 6231		
Phone No:	9722 3544	Email:	zchristian@wml.com.au
Lab No:	15204	Order No:	11207:03
Date samples received:	12/01/2024	Report date:	18/01/2024

Sample details: Four soil samples for phosphorus retention index, collected by WML Consultants, labelled 11207:03 Lot 564 Garvey Road:

- BH11 1.25m
- BH13 0.5m
- BH14 0.75-1.25m
- BH15 1.5m.

Analysis Method: Samples are tested on an as received basis using EATS method 033. Results are expressed on a dry weight basis.

Analysis Results:

Sample	Moisture (%)	Phosphorus Retention Index (PRI)
BH11: 1.25m	12	108
BH13: 0.5m	13	611
BH14: 0.75-1.25m	15	1,225
BH15: 1.5m	16	33

Rachel Lancaster
BSc (Hort), PgDip (Agribusiness)

End of report

Lab No: 15204
Date tested: 15/01/2024
Label: Job 11207

Sample Number	Sample Name	Soil Description	pHf	pHfox	pH change pHf - pHfox	Reaction to peroxide (H_2O_2)	Fizz Test
					pH_{H2O2} = 4.56		
1	BH11 0.5	Not required	6.21	3.91	2.30	None	None
2	BH11 1.0	Not required	6.62	4.96	1.66	None	None
3	BH11 1.5	Not required	6.79	5.11	1.68	None	None
4	BH11 2.0	Not required	7.29	5.35	1.94	None	None
5	BH11 2.5	Not required	7.18	5.36	1.82	None	None
6	BH12 0.5	Not required	6.98	5.24	1.74	None	None
7	BH12 1.0	Not required	6.77	4.33	2.44	Low	None
8	BH13 0.5	Not required	4.91	3.59	1.32	None	None
9	BH13 1.0	Not required	5.26	3.41	1.85	None	None
10	BH13 1.5	Not required	5.65	3.15	2.50	Low	None

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Email: eatsresults@eatswa.com.au
ABN 64 606 311 399

Certificate of Analysis

Client Name:	WML Consultants		
Address:	PO Box 2023, Bunbury, WA, 6231		
Phone No:	9722 3544	Email:	zchristian@wml.com.au
Lab No:	15204	Order No:	11207:03
Date samples received:	12/01/2024	Report date:	18/01/2024

Sample details: Four soil samples for phosphorus retention index, collected by WML Consultants, labelled 11207:03 Lot 564 Garvey Road:

- BH11 1.25m
- BH13 0.5m
- BH14 0.75-1.25m
- BH15 1.5m.

Analysis Method: Samples are tested on an as received basis using EATS method 033. Results are expressed on a dry weight basis.

Analysis Results:

Sample	Moisture (%)	Phosphorus Retention Index (PRI)
BH11: 1.25m	12	108
BH13: 0.5m	13	611
BH14: 0.75-1.25m	15	1,225
BH15: 1.5m	16	33

Rachel Lancaster
BSc (Hort), PgDip (Agribusiness)

End of report

Environmental and Agricultural Testing Services
Unit 5, 4 Mummery Cres
Bunbury WA 6230
Phone: 08 9721 7170
Email: eatsresults@eatswa.com.au
ABN 64 606 311 399

Certificate of Analysis

Client Name:	WML Consultants		
Address:	PO Box 2023, Bunbury, WA, 6231		
Phone No:	9722 3544	Email:	zchristian@wml.com.au
Lab No:	15204	Job No:	11207
Date samples received:	12/01/2024	Report date:	16/01/2024

Sample details: Twenty one soil samples received from WML Consultants on 12 January 2024, labelled 'Job 11207:03 lot 564 Garvey Road"

- BH11: 0.5; 1.0; 1.5; 2.0; 2.5.
- BH12: 0.5; 1.0.
- BH13: 0.5; 1.0; 1.5; 2.0; 2.5.
- BH14: 0.5; 1.0; 1.5; 2.0.
- BH15: 0.5; 1.0; 1.5; 2.0; 2.5.

The samples were in sealed plastic bags with the air excluded and frozen.
A portion of each sample tested for field pH_f and pH_{fox} on 15/01/2024.
The remainder has been frozen for storage for three months.

Scope of Work: Acid Sulfate Soils Field Tests pH_F, pH_{FOX}, Reaction rating, Fizz test.

Test Methods: Identification & Investigation of Acid Sulfate Soils and acidic landscapes, prepared by Department of Environmental Regulation, WA June 2015. pH tested using TPS Aqua-pH-ORP-Temp meter version 2.4 with Ionode Intermediate Junction pH combination electrode IJ44A calibrated according to manufacturer's instructions.

Test Results: See following page.

Comments:

- Confirmation of the field test results using Chromium Reducible Sulfur or SPOCAS laboratory analysis should be considered on 25% of the samples as per DWER guidelines.

Rachel Lancaster
BSc (Hort); PgDip (Agribusiness).

Lab No: 15204
Date tested: 15/01/2024
Label: Job 11207

Sample Number	Sample Name	Soil Description	pHf	pHfox	pH change pHf - pHfox	Reaction to peroxide (H_2O_2)	Fizz Test
					pH_{H2O2} = 4.56		
1	BH11 0.5	Not required	6.21	3.91	2.30	None	None
2	BH11 1.0	Not required	6.62	4.96	1.66	None	None
3	BH11 1.5	Not required	6.79	5.11	1.68	None	None
4	BH11 2.0	Not required	7.29	5.35	1.94	None	None
5	BH11 2.5	Not required	7.18	5.36	1.82	None	None
6	BH12 0.5	Not required	6.98	5.24	1.74	None	None
7	BH12 1.0	Not required	6.77	4.33	2.44	Low	None
8	BH13 0.5	Not required	4.91	3.59	1.32	None	None
9	BH13 1.0	Not required	5.26	3.41	1.85	None	None
10	BH13 1.5	Not required	5.65	3.15	2.50	Low	None

Lab No: 15204
Date tested: 15/01/2024
Label: Job 11207

Sample Number	Sample Name	Soil Description	pHf	pHfox	pH change pHf - pHfox	Reaction to peroxide (H_2O_2)	Fizz Test
					pH_{H2O2} = 4.56		
11	BH13 2.0	Not required	5.93	3.07	2.86	Low	None
12	BH13 2.5	Not required	6.24	3.22	3.02	None	None
13	BH14 0.5	Not required	5.35	4.34	1.01	None	None
14	BH14 1.0	Not required	5.64	4.57	1.07	None	None
15	BH14 1.5	Not required	5.52	4.24	1.28	None	None
16	BH14 2.0	Not required	5.12	3.77	1.35	None	None
17	BH15 0.5	Not required	5.86	4.52	1.34	None	None
18	BH15 1.0	Not required	5.34	4.28	1.06	None	None
19	BH15 1.5	Not required	6.13	3.76	2.37	None	None
20	BH15 2.0	Not required	5.80	4.02	1.78	Low	None
21	BH15 2.5	Not required	5.96	4.49	1.47	Low	None

End of report.