JOB NO DE21/264 **MAY, 2022**

GOLDING CONTRACTORS PTY LTD

GEOTECHNICAL INVESTIGATION

PRECINCTS 5 AND 6

YARRABILBA

MORRISON GEOTECHNIC

PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL

Approval no: DEV2022/1341

Date: 5 June 2023

Queensland Government

MORRISON GEOTECHNIC

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4th May 2022

Golding Contractors Pty Ltd
Level 2, 40 McDougall Street
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ATTENTION: MR CAMERON MCCLURE
Email: cameron.mcclure@golding.com.au

Dear Cameron,

RE: REPORT ON GEOTECHNICAL INVESTIGATION FOR YARRABILBA – PRECINCTS 5 AND 6

1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the proposed residential development at Yarrabilba – Precincts 5 and 6 (herein referred to as the 'Site'). The work was requested by Mr. Cameron McClure, representing Golding Contractors Pty Ltd.

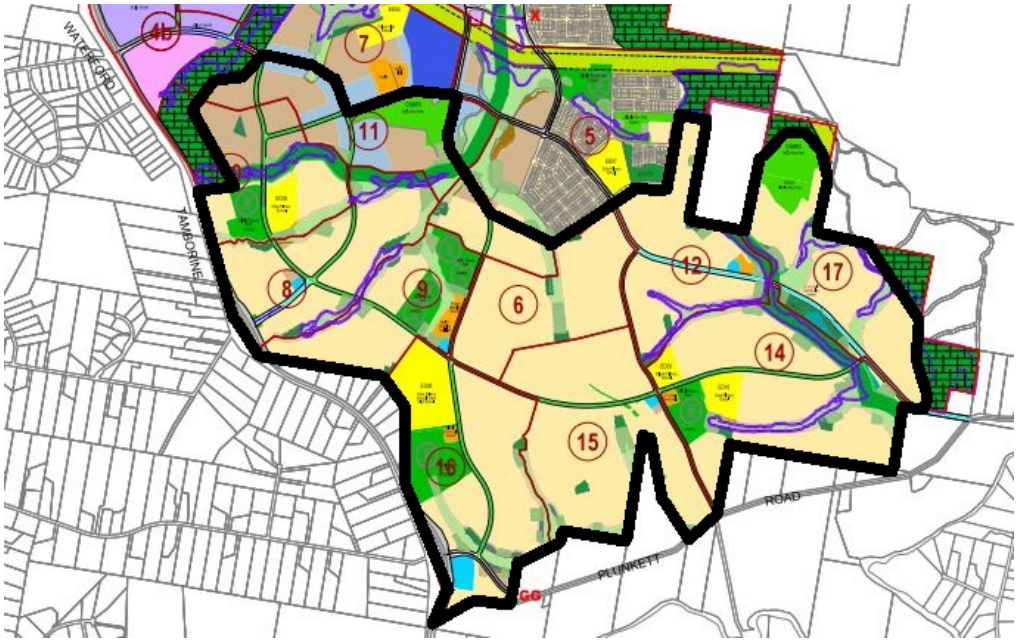
From the information provided, it is understood that cuts of up to approximately 10m will be carried out as part of the proposed development.

This report contains the results of the fieldwork and laboratory testing, together with the following information:

- Description of subsurface materials encountered in accordance with AS1726.
- Groundwater conditions and assessment.
- Site reactivity and characteristic ground surface movement, y_s.
- Earthworks, including temporary batter slopes.
- Excavatability assessment of the weathered rock
- Erodibility of the disturbed areas and reuse of subsurface materials.
- Preliminary recommendations for foundations.
- Retaining wall design parameters.
- Preliminary pavement design parameters.

Image 1 highlights the extent of the area of investigation located at Yarrabilba, as sourced from the Lend Lease plans provided by the client dated September 2019 (Dgn No. YAR_LUCA 190926). It should be noted that Precinct 17 was not able to be accessed during this investigation.

Image 1 – Aerial Image of Site (Provided by Lendlease)



2.0 METHODOLOGY

The geotechnical investigation of the area within Precinct 5 and Precinct 6 comprised the drilling of four (4) boreholes and ten (10) test pits. The test locations are summarised in Table 1 below.

Table 1 – Test Location summary

Test Locations	Location Description	Easting	Northing	Termination Depth (m)
TP5-1	Precinct 5	512089	6921771	2.80
TP5-2		512526	6921578	3.20
TP6-1	Precinct 6	512769	6921568	5.00
TP6-2		513038	6921574	2.00
TP6-3		512850	6921239	4.10
TP6-4		512909	6920982	3.10
TP6-5		512725	6920916	4.80
TP6-6		512612	6921106	1.90
TP6-7		512335	6921318	1.60
TP6-8		512138	6921035	5.00
BH6-1		513182	6921666	8.00
BH6-2		513277	6921481	8.00
BH6-3		513131	6921106	5.24
BH6-4		512426	6920857	5.86

The boreholes were drilled using a Hydrapower Scout drilling rig, initially using standard auger drilling methods incorporating 100mm diameter solid flight augers followed by wash boring techniques. Deeper in the profile, NMLC rock coring methods were adopted in all boreholes.

Standard Penetration Tests (SPT's) were carried out at regular depth intervals within the soil and the more weathered rock in each borehole to collect soil samples and help assess the in-situ soil strength. Additionally, pocket penetrometer tests were carried out on disturbed samples recovered during drilling to provide an indication of the shear strength of cohesive soils. The rock core collected was placed into core trays and photographed. Representative soil samples were collected for laboratory testing. The test pits were excavated to 5m below ground level which was the maximum extent of a 25 tonne excavator of with a 1.5m bucket with teeth or earlier refusal.

The subsurface conditions encountered in the depth range of the boreholes were logged and visually classified in accordance with *AS1726:2017* by a Geotechnical Engineer from Morrison Geotechnic. The borehole locations were recorded using a handheld GPS device with a reported accuracy of +/-5m.

Selected soil samples were submitted to the Morrison Geotechnic laboratory for Shrink Swell, Emerson Class Number and California Bearing Ratio (CBR) testing. Point Load Strength Index testing was carried out on samples of the rock core to assess the rock strength.

This report includes the following Appendices:

- Appendix A – Drawings provided by the Client.
- Appendix B – Borehole test location plan.
- Appendix C – Borehole logs.
- Appendix D – Laboratory test certificates.

3.0 SITE DESCRIPTION

The area of Yarrabilba is bound by Tamborine Waterford Road to the west, existing residential development to the north, environmental reserve to the east, and Plunkett Road to the south. Precinct 5 is located within Lot 2 on SP296375, and Precinct 6 is located within Lots 3004 and 3006 on SP327417, Lot 4 on SP296375 and Lot 2 on SP296375. Precincts 5 and 6 adjoins Precincts 8 and 9 to the west, Precincts 15 and 16 to the south and Precinct 12 to the east.

Precincts 5 and 6 was previously used as a pine plantation that has since been harvested. Occasional fallen trees, scattered timber stockpiles and rocks on the ground surface was evident in this area and is being used for agricultural purposes. At the time of the investigation, construction of the next stage of Yarrabilba was underway to the north and to the east of this precinct.

The gently undulating terrain typically ranged in the order of 2° to 3° slopes with 5° slopes in some areas. The vegetation in the proposed development area consisted of various ground cover including various grasses with common weeds and sparse mature trees. Rill and gully erosion of the upper soil layers was observed on some slopes by water turbulence or concentrated rapid water flow toward the vegetated gullies and the farm dams scattered throughout the area.

The concept plans for the bulk earthworks are given in Image 2.

Image 2 – Precincts 5 and 6 bulk earthworks plan (Provided by Peak Urban)

Site photographs 1 and 2 show the typical conditions of the Site at the time of the field work.

Site Photo 1 – Photo looking north towards borehole BH6-3

Site Photo 2 – Photo looking east towards test pit TP6-1

4.0 SUBSURFACE CONDITIONS

4.1 Regional Geology

Reference to the National Map website, https://nationalmap.gov.au (State of Queensland (Department of Resources, 2022 ©)) indicates that the surface and near-surface geology near the area of investigation comprises Quaternary aged alluvium over Late Triassic – Early Jurassic aged basement rocks. Table 2 summarises the Geological units described near the area of investigation.

Table 2 – Regional Geology summary

Rock Unit Name	Map Symbol	Lithological Summary	Dominant Rock	Age
Woogaroo Subgroup	RJbw	Sublabile to quartzose sandstone, siltstone, quartz-rich granule to cobble conglomerate and coal	SEDIMENTARY ROCK	LATE JURASSIC – EARLY JURASSIC
Qa - QLD	Qa	Clay, silt, sand and gravel; flood-plain alluvium	ALLUVIUM	QUATERNARY

4.2 Local Site Geology (Precincts 5 and 6)

The subsurface profile encountered within the boreholes typically comprised:

- **Topsoil Silty SAND** with grass rootlets, encountered from the ground surface to a depth of up to 0.3m in all test locations.
- **Natural Silty SAND,** very loose to medium dense, generally grey brown but occasionally orange brown, encountered in all test locations except BH6-1, BH6-3, BH6-4, to depths ranging between 0.3m and 1.3m.
- **Residual Clayey SAND,** medium dense, grey mottled orange brown, encountered in test location TP6-1 only to a depth of 1.6m.
- **Residual Silty CLAY,** stiff to hard, grey brown, orange brown, grey mottled orange brown and red brown, of high plasticity, encountered in all test locations except TP6-1 to depths ranging between 0.7m and 1.9m.
- **Residual Sandy CLAY ('Extremely Weathered Sandstone'),** found beneath the residual silty clay soils at a depth of 0.9m (BH6-4), 1.0m (BH6-1, BH6-3, TP6-2, and TP6-7), 1.3m (TP5-1, TP5-2, TP6-6), 1.5m (TP6-3), 1.6m (TP6-1, TP6-4), and 1.9m (BH6-2, TP6-5, and TP6-8), comprising pale grey, orange brown mottled orange brown, yellow brown, pale grey and red brown clay based soils of medium plasticity, hard consistency and described as 'Extremely Weathered Sandstone' and extending to depths ranging between 1.2m and 4.7m, grading to
- **SANDSTONE**, encountered in all test locations extending to the termination depth of 8.0m, comprising highly weathered to moderately weathered, very low strength to high strength sandstone.

Table 3 provides a summary of the subsurface profiles encountered within the depth range of the test locations within Precincts 5 and 6.

Table 3 – Summary of Encountered Subsurface Profiles (Precincts 5 and 6)

Test Location	Topsoil (m)	Natural Sand (SM) (m)		Residual Sand (SC) (m)	Residual Clay (CI-CH) (m)			Weathered Rock			Termination Depth (m)[3]
		Very Loose to Loose	Medium Dense	Medium Dense	Stiff	Very Stiff	Hard	Very Low to low strength	Low to Medium Strength	Medium to High Strength	
BH6-1	0.0 – 0.1	NE	NE	NE	NE	0.1 – 0.5	0.5 – 1.0 1.0 – 1.3[4]	1.3 – 2.0	2.0 – 3.02 4.19 – TD	3.02 – 4.19	8.0
BH6-2	0.0 – 0.1	0.1 – 0.8	NE	NE	0.8 – 1.0	1.0 – 1.9	1.9 – 2.5[4]	2.5 – 3.05 3.26 – 3.4	3.05 – 3.26 3.4 – 3.84 5.3 – TD	NE	8.0
BH6-3	0.0 – 0.3	NE	NE	NE	NE	0.3 – 1.0	1.0 – 1.8[4]	1.8 – 2.0 2.57 – 2.75 3.0 – TD	NE	NE	5.24

Test Location	Topsoil (m)	Natural Sand (SM) (m)		Residual Sand (SC) (m)	Residual Clay (CI-CH) (m)			Weathered Rock			Termination Depth (m)[3]
		Very Loose to Loose	Medium Dense	Medium Dense	Stiff	Very Stiff	Hard	Very Low to low strength	Low to Medium Strength	Medium to High Strength	
BH6-4	0.0 – 0.1	NE	NE	NE	NE	0.1 – 0.9	0.9 – 2.0[4]	2.0 – TD	NE	NE	5.86
TP5-1	0.0 – 0.2	0.2 – 0.5	NE	NE	NE	0.5 – 1.3	1.3 – 1.7[4]	1.7 – 2.7	2.7 – TD	NE	2.80[5]
TP5-2	0.0 – 0.1	NE	0.1 – 0.3	NE	NE	0.3 – 0.7	0.7 – 1.3[4]	1.3 – 3.1	3.1 – TD	NE	3.20[5]
TP6-1	0.0 – 0.1	0.5 – 1.3	0.1 – 0.5	1.3 – 1.6	NE	NE	1.6 – 4.7[4]	4.7 – TD	NE	NE	5.00
TP6-2	0.0 – 0.1	0.1 – 0.3	NE	NE	NE	0.3 – 1.0	1.0 – 1.2[4]	1.2 – 1.9	1.9 – TD	NE	2.00[5]
TP6-3	0.0 – 0.1	NE	0.1 – 0.3	NE	NE	0.3 – 0.9	0.9 – 1.5 1.5 – 1.7[4]	1.7 – 4.0	4.0 – TD	NE	4.10[5]
TP6-4	0.0 – 0.1	0.1 – 0.3	NE	NE	NE	0.3 – 1.6	1.6 – 1.9[4]	1.9 – 3.0	3.0 – TD	NE	3.10[5]
TP6-5	0.0 – 0.1	0.1 – 1.1	NE	NE	NE	1.1 – 1.9	1.9 – 2.7[4]	2.7 – 4.7	4.7 – TD	NE	4.80[5]
TP6-6	0.0 – 0.1	0.4 – 0.7	0.1 – 0.4	NE	NE	0.7 – 1.3	1.3 – 1.6[4]	1.6 – 1.8	1.8 – TD	NE	1.90[5]
TP6-7	0.0 – 0.1	NE	0.1 – 0.3	NE	NE	0.3 – 1.0	1.0 – 1.2[4]	1.2 – 1.5	1.5 – TD	NE	1.60[5]
TP6-8	0.0 – 0.1	0.1 – 0.4	0.4 – 1.0	NE	NE	1.0 – 1.5	1.5 – 1.9 1.9 – 2.5[4]	2.5 – TD	NE	NE	5.00

Notes:
(1) TD – Termination Depth.
(2) NE – Not Encountered.
(3) Depth below the existing ground surface level as at the time of field work on the 25/01/2022, 01/02/2022, 07/02/2022, 08/02/2022, 15/02/2022, 16/02/2022, and 18/02/2022.
(4) Residual Sandy Clay material described as 'Extremely Weathered Sandstone'.
(5) Excavator bucket refusal reached prior to test pit target depth.

4.3 Local Groundwater Conditions

At the time of the investigation, groundwater seepage was observed at test locations BH6-2 (0.7m), TP6-1 (0.7m), TP6-5 (0.8m), and TP6-8 (0.9m). Seepages were mostly observed within the natural sand-based soils during a season of above average rainfall. It must be noted that the drilling methods used below a depth of 1.5m in boreholes BH6-1 and BH6-3 and below a depth of 3m in BH6-4 meant that the presence of any groundwater or seepages could not be observed below these depths.

The presence, depth and flow rates of the groundwater will vary with seasonal changes, rainfall, subsurface material and permeability, integrity of in-ground services, proximity to existing waterways and water bodies, and the proximity to, type and density of vegetation.

5.0 LABORATORY TEST RESULTS

The laboratory test results are contained in Appendix C to this report and are summarised in the following tables.

Undisturbed samples of the natural clay soils taken in thin wall 50mm diameter steel tubes from selected boreholes were tested to assess volume change capability in the Shrink/Swell Index test (AS1289 7.1.1).

The results of the tests for all Precincts are summarised as follows in Table 4.

Table 4 – Shrink/Swell Index Test Results

Precinct	Test Location	Depth (m)	Shrink (%)	Swell (%)	Shrink Swell Index (I_{ss} %)
6	BH6-1	0.50 – 0.72	2.4	0.3	1.4
8	BH8-2	0.30 – 0.58	2.6	0.5	1.6
9	TP9-6	0.60 – 0.80	5.4	0.8	3.2
10	TP10-4	1.00 – 1.19	3.7	0.0	2.1
11	TP11-2	0.80 – 1.06	3.4	0.2	1.9
12	BH12-3	0.20 – 0.46	0.3	0.4	0.9

Precinct	Test Location	Depth (m)	Shrink (%)	Swell (%)	Shrink Swell Index (I_{ss} %)
14	BH14-3	0.50 – 0.72	3.9	0.4	2.3
15	BH15-1	0.50 – 0.78	4.4	1.5	2.9
16	TP16-1	0.60 – 0.84	1.6	0.1	0.9

The results of the Emerson Class tests for all Precincts were carried out by Morrison Geotechnic are summarised in Table 5.

Table 5 – Summary of Emerson Class Laboratory Test Results

Precinct	Test Location	Depth (m)	Material	Emerson Class Number
6	TP6-3	0.3 – 0.7	Residual – Silty CLAY (CH)[1]	6[(2)]
8	BH8-1	0.50 – 0.95	Residual – Silty CLAY (CH)[1]	6[(2)]
9	BH9-2	1.00 – 1.45	Residual – Sandy CLAY (CH)[1]	6[(2)]
10	TP10-6	0.9 – 1.3	Residual – Silty CLAY (CH)[(1)]	6[(2)]
11	TP11-6	1.50 – 1.80	Residual – Sandy CLAY (CI)[(1)]	6[(2)]
12	TP12-4	1.00 – 1.60	Residual – Silty CLAY (CH)[1]	6[(2)]
14	TP14-6	1.20 – 1.60	Residual – Silty CLAY (CH)[1]	6[(2)]
15	BH15-3	0.50 – 0.95	Residual – Silty CLAY (CH)[1]	6[(2)]
16	TP16-4	1.00 – 1.50	Residual – Silty CLAY (CH)[1]	6[(2)]

Notes:
(1) Subsurface materials described based on visual and tactile assessments of the test material.
(2) Soils assessed as having negligible to no dispersive tendencies.

Disturbed samples were taken for Standard Compaction and Soaked California Bearing Ratio testing. The test results for all Precincts are summarised in Table 6.

Table 6 – Standard Compaction and Soaked CBR Results

Precinct	Test Location	Depth (m)	Material	Standard Maximum Dry Density (t/m^3)	Optimum Moisture Content (%)	Field Moisture Content (%)	Soaked CBR (%)
6	TP6-3	0.3 – 0.7	Residual – Silty CLAY (CH)	1.67	21.0	24.3	2.5
8	TP8-9	0.2 – 0.8	Natural – Silty SAND (SM)	1.77	11.5	5.2	25
9	TP9-3	0.3 – 0.9	Residual – Clayey SAND (SC)	1.88	13.0	13.3	13
10	TP10-6	0.9 – 1.3	Residual – Silty CLAY (CH)	1.68	21.5	22.1	9
11	TP11-6	1.5 – 1.8	Residual – Sandy CLAY (CI)	1.82	15.0	15.9	5
12	TP12-4	1.0 – 1.6	Residual – Silty CLAY (CH)	1.63	21.5	24.2	1.5
14	TP14-6	1.2 – 1.6	Residual – Silty CLAY (CH)	1.68	20.0	23.1	2.0
15	TP15-1	0.6 – 1.2	Residual – Clayey SAND (SC)	1.94	11.5	15.9	25
16	TP16-4	1.0 – 1.5	Residual – Sandy CLAY (CI)	1.80	15.0	14.7	13

The results of the Point Load Strength Index test results for Precincts 5 and 6 are presented in Table 7.

Table 7 – Point Load Strength Index Test Results

Precinct	Borehole Location	Depth (m)	Loading Direction	I_s (MPa)	$I_{s(50)}$ (MPa)	Descriptive Term[(1)]
6	BH6-1	3.00 – 3.10	Diametral	2.69	2.70	H
			Axial	1.65	1.60	H
		6.60 – 6.70	Diametral	0.33	0.33	M
			Axial	0.37	0.34	M
	BH6-3	2.60 – 2.70	Diametral	0.18	0.18	L
			Axial	0.13	0.12	L

Notes:
(1) L (Low Strength), M (Medium Strength), and H (High Strength).

6.0 SOIL REACTIVITY AND CHARACTERISTIC GROUND SURFACE MOVEMENTS

This section presents the results of the investigation in terms of the reactivity of the subsurface materials encountered within all Precincts and provides estimates of characteristic ground surface movements for the encountered subsurface profiles and existing soil moisture conditions.

Classification of sites where ground movements are predominantly due to soil reactivity under normal soil moisture conditions, as defined in Section 1.3.2 of AS2870:2011, can be based on Table 2.1 and Table 2.3 of AS2870:2011.

The site classifications for the individual lots will depend on the predominant subsurface profile at each location, and the conditions existing after the bulk earthworks have been completed. Further sampling and laboratory testing must be carried out on each individual lot prior to the final design of any proposed structures at the site.

The designer should ensure that this methodology and the derived parameters are applicable for this site and the proposed structures.

Laboratory testing returned Shrink/Swell Index values ranging between 0.4% and 3.2% for the residual clay based soil.

Due to the presence of trees and abnormal moisture conditions, a 'P' classification applies to this site in accordance with AS2870:2011.

If "normal" soil conditions prevail, the following characteristic ground surface movements y_s are expected:

- Up to 35mm (Class M) can be expected based on the laboratory test results for the typical **natural profile** consisting of silty clay and depth of seasonal moisture variation (Hs) to 2.3m depth with a 50% cracked zone.
- If **cut earthworks** are carried out, reducing the cracked zone to zero (for the depth of cut), ground surface movements due to soil reactivity are expected to be in the order of up to 60mm (Class H1).
- If **filling** is carried out using onsite material up to 0.5m depth, ground surface movements due to soil reactivity are expected to be in the order of up to 65mm (Class H2).
- Additional ground surface movements are to be expected in areas of deep fill (>3m) that are associated with self-weight settlement of the fill. Self-weight settlements in the order of 0.5% to 1% of the fill depth can be expected, based on well compacted fill.

In areas where trees are present, the design of new building footings must take account of the calculated characteristic ground surface movement, y_s, and the potential surface movement resulting from tree induced suction changes, y_t, calculated as described in Appendix H of AS2870:2011. We note the presence of established trees within the area of investigation and the gully areas. Any footings within the mature height of these trees should be designed for the potential additional ground surface movements associated with the presence of these trees that can cause abnormal moisture conditions as defined in AS2870:2011.

Potential ground surface movements because of trees (y_t) can be assessed using Appendix H of AS2870:2011 and the parameters in Table 8.

Table 8 – Ground Surface Movements Due to Effects of Trees

Design Suction Change Depth H_s (m)	Single Tree		Tree Group	
	Maximum Extra Suction Change (pF)	Maximum Design Drying Depth H_t (m)	Maximum Extra Suction Change (pF)	Maximum Design Drying Depth H_t (m)
2.3	0.35	3.0	0.43	3.6

The characteristic ground surface movements may change where:

- Earthworks are carried out.
- Abnormal soil moisture conditions exist on site or are allowed to develop, and
- Tree planting is carried out on site or trees are removed on or adjacent to the site.

All footings and slab systems for structures founding at grade should be designed to accommodate the expected ground surface movements for the conditions existing after completion of the earthworks, including the additional suction effects of trees.

7.0 EARTHWORKS RECOMMENDATIONS

All earthworks procedures should be carried out in a responsible manner in accordance with AS3798:2007 “Guidelines on Earthworks for Commercial and Residential Developments”. The earthworks contractor should make themselves familiar with the site conditions prior to mobilisation.

From the supplied earthworks plans, cuts of up to 10m would be carried out in the area. In addition to this, it is assumed that cutting and filling that is typical of large residential estates will be carried out in the areas of Precincts 5 and 6.

Dewatering and filling of the existing farm dams will require special consideration. The depth of these dams and profile of the dam walls is currently unknown.

It is recommended that a staged dewatering procedure be developed for the farm dams. The dam dewatering should be monitored and managed by a suitably qualified engineer. A staged dewatering process will reduce the likelihood of instability within the dam walls due to elevated pore water pressure. Groundwater monitoring wells within the dam walls could be installed to monitor the groundwater level during the dewatering.

If the dam backfill depths are in the order of 5m or more, then deep fill considerations will need to be made by the earthworks designer including potentially excessive settlements. Differential settlements may also be apparent between the fill and natural ground along the edges of the dam. Settlement monitoring can be carried out to monitor the settlement over time.

7.1 Trafficability

At the time of the field investigation, trafficability was fair due to the dry conditions, and vegetation on site. The area was not able to be accessed during periods of high rainfall.

Trafficability problems could arise for earthworks and construction machinery from:

- Softening of the upper level soils during and after periods of rainfall. This is expected to occur in the topsoil materials and upper layers of the sand/clay based soils on site and may require the installation of seepage cut-off drains should construction commence during or following an extended period of wet weather.
- Disturbance of the upper level soil fabric with removal of vegetation. Depressions could be formed resulting in potential water traps, which could cause further softening of exposed soils.

To maintain site trafficability, it is recommended that following stripping, clearing, and grubbing, the exposed surface be inspected and assessed. Areas which demonstrate excessive movement and/or do not improve sufficiently under proof rolling should be removed and replaced as required. To help achieve adequate trafficability during wet weather, placement of a granular layer (say nominal layer thickness 150mm) should be considered to improve trafficability.

Maintaining adequate drainage conditions is also essential. Runoff should be diverted away from the construction area to prevent the ponding of water.

Potential trafficability problems with this site should not be underestimated. The site will very quickly become non trafficable if appropriate drainage control measures, together with construction practices appropriate for site conditions, are not maintained.

The contractors should fully inform themselves of the ground conditions on site prior to commencement of earthworks. This requirement should be explicit in any earthworks specifications or contract.

7.2 Reuse of Onsite Material as Structural Fill

The insitu soils obtained from site cuttings or stockpiled material on site, where free of organic and deleterious material, may be used for structural fill in accordance with AS3798, provided the moisture content of the soils on placement approximates the Optimum Moisture Content (OMC) required for compaction. This may require conditioning to bring the soils to OMC. However, it should be noted that the residual silty clay soils of high plasticity may present difficulties in handling, placement, and compaction if the appropriate moisture content cannot be achieved, particularly if the clay soils are overly moist.

It is likely that sediments and soft soils will be present at the base of the farm dams. These materials may not be suitable for reuse due to high organic content and sensitivity to moisture variation.

7.3 Filling Procedures

The following earthworks procedures are recommended where fill is to be placed:

- Clearing and stripping should be carried out across the building and pavement areas.
- Depressions formed by the removal of vegetation, underground elements, etc. should have all disturbed and weakened soil removed.
- After stripping and removal of the weak residual soils, the competent exposed natural surface should be proof rolled under the supervision of Morrison Geotechnic using a static vehicle with a tare of at least 10 tonnes and then compacted to 95% Standard Maximum Dry Density (SMDD). Where pavements are to be constructed, compaction to 100% SMDD is required. Areas demonstrating excessive movement should be treated (dried and recompacted) or removed and replaced with compacted fill. Treatment should be to a standard sufficient so that the subgrade passes proof rolling, and that compaction can be achieved in the first layer of fill. Proof rolling in excavation areas can be deferred until excavations reach subgrade level.
- If “weak” materials with high moisture content are encountered at depth, these materials may not be able to withstand a proof roll and so special subgrade improvement works may be required. If such materials are encountered at subgrade level, subgrade replacement or a bridging layer (e.g. geofabric and crushed rock) may be required.
- Provided the placement moisture content of any imported fill or select insitu material approximates the Optimum Moisture Content (OMC) for compaction, suitable compaction should be achievable using typical compaction machinery. The fill materials should be compacted in layers not exceeding 300mm loose thickness. However, layer thicknesses will be dependent on the compaction plant type and size, use of vibration, material type and condition. Final maximum placement layer thicknesses will need to be determined when compaction plant, as well as material type and conditions, are known.
- With use of the moderately reactive clay soils, close control of moisture content during placement and compaction is required to reduce the potential for swelling and shrinkage movement. Moisture content within the range of OMC (Standard Optimum Moisture Content) to OMC +2% is recommended. Foundation design must reflect the use of the potentially reactive clay soils if they are used as structural fill.
- Imported select fill material, if required, should be a good quality select fill material with a soaked CBR of at least 10%, a maximum aggregate size of 50mm and a maximum Shrink/Swell Index of 1.0%.
- All fill placed to raise the ground surface should be compacted in layers not exceeding 300mm loose thickness to a density not less than 95% SMDD in accordance with AS1289 5.1.1 (Standard Compaction). Where pavements are to be constructed, fill compaction and compaction of the natural soil subgrade to 100% SMDD is required.

- Pavement gravels should comply with DTMR quality specification for base, subbase, and blanket materials (MRS11.05 Base Type 2.1, Subbase Type 2.3, and Blanket Type 2.5).
- Field density testing should be carried out in each fill lift placed to check the standard of compaction achieved and the placement moisture content if applicable. The frequency and extent of testing should be as per guidelines in AS3798:2007, Section 8.0.
- The silty sand has acceptable engineering properties if it can be compacted and confined by overlying layers. However, where exposed at the surface it tends to be loose, highly erodible, can carry water after periods of wet weather, can be 'spongy' and cause trafficability problems when wet, and can be slow to drain and to dry out.
- High moisture content or groundwater seepages were observed within the residual sand based soils and at the residual sand/clay soil and soil/rock interfaces. This may cause difficulties both during construction and during high rainfall periods after the completion of the development.
- It is recommended that all earthworks operations be supervised under Level 1 engineering supervision by Morrison Geotechnic. Engineering certification should be provided by a Registered Professional Engineer of Queensland (RPEQ).

7.4 Bulking Factors

Bulking factors will vary across the Site and will depend on soil and rock type. Based on published typical values (Look, 2014), the estimated typical bulking factors for the material types encountered on the site are summarised in Table 9.

Table 9 – Bulking Factors

Material	Bulk Up on Excavation to Transport	Bulking Factor for Excavation to Placement and Compaction
Granular Soils	10% – 15%	0% – 10%
Cohesive Soil	20% – 40%	0% – 10%
Sedimentary Rock	40% – 70%	5% – 20%

Typical wastage of approximately 5% by volume may be adopted for the natural cohesive soils, increasing to approximately 10% to 15% for earthworks in the very low strength rock.

7.5 Excavation Conditions

This section broadly discusses the excavation characteristics of the material encountered during the geotechnical investigation. The information and advice presented in this section of the report is based on the conditions encountered in boreholes drilled within Precincts 5 and 6. Variations in these conditions will occur across this area and must be expected.

Excavations in the residual sand-based soils, residual clay-based soils and very low strength weathered sandstone rock should be within the capacity of conventional earthmoving equipment such as medium to large sized excavators (15t – 30t). More efficient excavations in the very low to low strength weathered sandstone rock may be achieved using large excavators fitted with toothed buckets and ripper attachments.

Where the harder rock was encountered and cored during the investigation (allowing Point Load Strength Index testing to be carried out), assessment of estimated rock excavation conditions has been carried out by the methods derived by Pettifer & Fookes (1994) (P&F). The P&F methodology involves measurement of rock strength to be made by Point Load Strength Index testing and discontinuity spacing from logging the intact core specimens recovered from the boreholes. These two rock properties are used to estimate excavation conditions using the P&F chart.

A summary of the point load strength and defect spacing of the weathered rock within Precincts 5 and 6 from boreholes BH6-1 and BH6-3 is given in Table 10 over the page.

Table 10 – Summary of Point Load Strength and Defect Spacing

Test Location	Depth Range (m)	Representative Range of Point Load Strength Index, $I_{s(50)}$ (MPa)	Approximate Average Defect Spacing Range (m)
BH6-1	3.02 – 4.19	1.60 – 2.70	0.06 – 0.20
BH6-1	6.55– 7.11	0.33 – 0.34	0.60 – 2.00
BH6-3	2.57 – 2.75	0.12 – 0.18	0.06 – 0.20

Figure 1 shows the rock characteristics in Table 10 plotted on the P&F chart.

Figure 1 – Assessment of Excavation Conditions for Borehole BH1 Rock Core

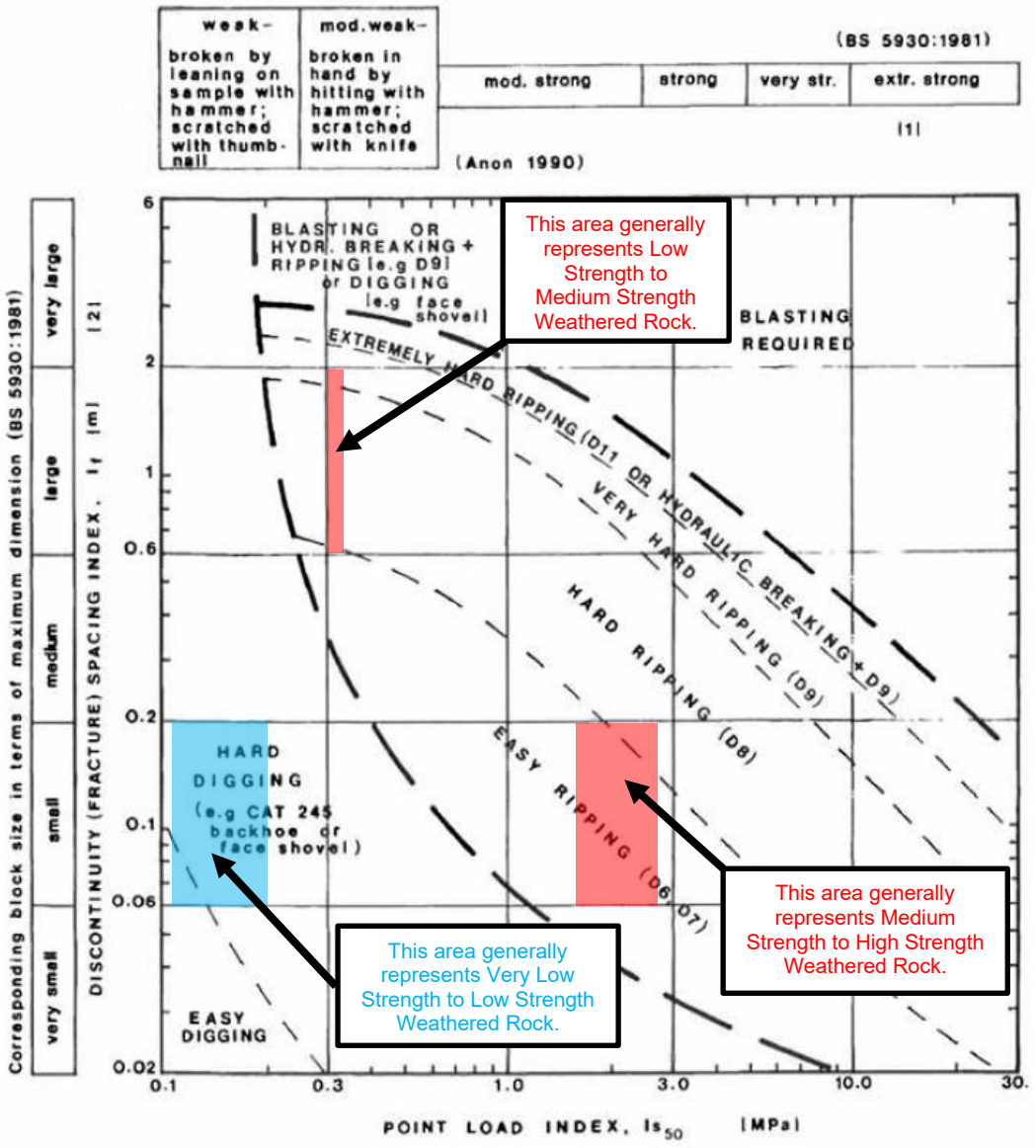


Figure 1 indicates that the excavation of the coarse grained, medium strength to high strength sandstone encountered in BH6-1 between the depth range of approximately 3.02m and 4.19m is 'easy ripping' (CAT D6-D7 dozer). The very low strength to low strength sandstone encountered in BH6-3 between the depth of 2.57m to 2.75m is 'hard digging' (CAT 245 excavator). The low strength to medium strength sandstone encountered in BH6-1 between the depth of 6.55 – 7.11 is hard to very hard ripping (CAT D9 dozer).

7.6 Cut and Fill Batters

Maximum cut batter angles for the different materials encountered on Site are shown in Table 11 for unsurcharged batters up to 1.5m high where no groundwater is present. Where surcharges are located within H (height of the batter) of the top of the batter, some reduction in the design angle will be required.

Care must be taken with unsupported batters to ensure no adjacent structures or services are undermined. Structures or services are to be set back behind the crests of unsupported batters to a minimum horizontal distance of at least 1.5 times the depth of excavation.

If unsupported batters higher than 1.5m are required, further assessment must be carried out. All structural fill batters should be overconstructed and trimmed back at no steeper than 2.5(H):1(V) or 22° and be top soiled, mulched and vegetated to reduce erosion.

Some lateral ground movement can be expected behind batters constructed in accordance with Table 11.

Table 11 – Recommended Batter Angles for Cut and Fill Batters

Material	Short Term (°)[1,2]	Long Term (°)
Uncontrolled Fill	26	NR
Controlled Fill	45	22
Natural Sand Based Soil (Loose to Medium Dense or Stronger)	45	22
Natural Clay Based Soil (Stiff or Stronger)	45	22
Very Low Strength Rock	60	45

Notes:
(1) Subject to inspection by an experienced geotechnical engineer/engineering geologist.
(2) Batters assumed to have no seepage.

It is essential that permanent cut and fill batters and embankments are suitably protected from erosion and scour by appropriate drainage and vegetation/surface treatment. Runoff should not be allowed to discharge directly across the batters.

It is expected that the preference for temporary excavations is to excavate battered or benched excavations without resorting to the use of temporary lateral support systems. However, should any of the above conditions prevail or if the angles presented in Table 11 cannot be achieved or if temporary vertical excavations must exceed 1.5m in height without a horizontal cut bench, the use of temporary lateral support may be required, and this should be designed prior to the commencement of excavation.

Temporary structural retention systems that may be considered include:

- A shoring box (with end plates).
- Sheet piles.
- Suitable propping.

The temporary retention systems should be designed by a suitably qualified and competent engineer.

7.7 Soil Erodibility

Emerson Class laboratory testing was carried out on selected clay-based soil samples to help assess the dispersion potential of the encountered soils. The Emerson Class results presented in Table 5 in Section 5.0 indicate that the encountered soils have a low dispersion potential. It must be noted that an Emerson Class Number of 6 indicates that the clay soil is non-dispersive.

Rill and gully erosion of the upper soil layers was observed on most slopes, this was caused by water turbulence or concentrated rapid water flow toward the vegetated gullies and the farm dams.

Permanent cut and fill batters must be suitably protected from erosion and scour and should include:

- Directing upslope surficial water flows away from all sloping batters to limit erosion and the ingress of water into the batters. Runoff should not be allowed to discharge directly across the batters.
- Vegetating exposed batters as soon as practically possible to reduce the effects of erosion during and following periods of rainfall. It should be noted that exposed batters are susceptible to surficial erosion and require ongoing maintenance until fully established.

8.0 FOUNDATION RECOMMENDATIONS

8.1 High Level Footings

The residual clay soils are assessed to be highly reactive in relation to moisture content variations. The foundation systems supporting structures at shallow depth within Precincts 5 and 6 should be designed and constructed to accommodate the potential ground movement resulting from the volume instability of the reactive clay soils, as discussed in Section 6.0.

The design of high level footings can be based on the allowable bearing pressures presented in Table 12.

Table 12 – Allowable Bearing Pressures for High Level Footings

Material		Allowable Vertical Bearing Pressure (kPa)
New Controlled Fill(1)	Dependant on Classification	100
Natural/Residual Granular Based Soil	Very Loose to Loose	NR
	Medium Dense	100
Residual Clay Based Soil	Stiff	100
	Very Stiff	200
	Hard	300
Weathered Rock	Very low strength	600

Notes:
(1) New controlled fill to be placed in accordance with AS3798-2007 under Level One Supervision.
(2) All footings must be assessed by a suitably qualified person to confirm allowable bearing pressures.
(3) NR – Not Recommended.

All strip and pad footings, and the ground beams of stiffened rafts and slabs should be founded into the natural/residual granular soils, residual stiff or stronger clay soils, weathered rock or 'Level 1' controlled structural fill. Ground slabs shall be appropriately detailed including articulation to accommodate potential differential settlement associated with varying strata across the building footprint.

High level footing settlements due to structural loading are not expected to exceed 1.0% of the footing width, where footings are designed for the allowable bearing pressures given in Table 12.

Footings founding in different strata (i.e. controlled fill/natural clay and weathered rock), may result in potential differential settlements across the footprints of the structure. This is mainly an issue where the depth to the harder material (residual soil or weathered rock) varies significantly. Differential settlements equal to 50% of the predicted settlements can be expected. If these settlements are considered excessive, all footings should be founded within consistent strata (i.e. the residual clay soils).

The footings shall be designed to accommodate any differential self-weight settlement of the fill material that could be between 0.5% and 1% of the fill height.

All footings are to be assessed by a competent and qualified engineer following excavation and prior to placement of reinforcement steel and pouring of concrete. Where required, such as in areas of weaker

natural soils, footings may be made up of mass concrete poured to the underside of the footing, or alternatively, footings may be constructed over mass concrete filled, backhoe excavated pedestals.

If footings cannot be poured on the same day as the excavations, a concrete blinding layer of at least 50mm thickness is recommended.

8.2 Deep Footings

If high level founding depths, pad or strip sizes are considered excessive, or the ground surface movements cannot be tolerated, a deep footing system may be considered. Given the materials encountered within Precincts 5 and 6, bored piles or screw piles are considered a suitable system for deep footings, although groundwater impacts will have to be addressed for bored piles if groundwater is encountered.

It is recommended that all piles be socketed at least two pile diameters into the residual very stiff or stronger clay based soils. The design of bored piles can be carried out using the ultimate geotechnical pressures presented in Table 13 as follows.

Table 13 – Ultimate Design Parameters for Bored Piles

Material		Ultimate Geotechnical Shaft Adhesion (kPa)	Ultimate Geotechnical End Bearing Pressure[4] (kPa)	
			L ≥ 2D	L ≥ 4D
Natural/Residual Granular Based Soil	Very Loose to Medium Dense	NC	NR	NR
Residual Clay Based Soil	Stiff	NC	NR	NR
	Very Stiff	50	600	900
	Hard	75	1200	1800
Weathered Rock	Very Low Strength	100	NC	2500
	Low Strength	200	NC	4500
	Medium Strength	300	NC	6500
	High Strength	400	NC	8500

Notes:
(1) NC – Not considered; NR – Not recommended.
(2) L – Pile socket length; D – Pile diameter.
(3) Ultimate geotechnical shaft adhesion resistance should only be considered below a depth of 2.3m (or 3.6m where tree groups are present) due to moisture variations of the clay strata.
(4) All founding material should be verified during construction by a suitably qualified geotechnical engineer.

For uplift loading the shaft friction values shown in Table 13 should be factored by 0.7. A suitable geotechnical strength reduction factor (Φ_g) should be adopted using the methodology presented in AS2159:2009. Refer to AS2159 Section 4.3 for further advice regarding Φ_g. Without further information on the building and footing design, Φ_g of 0.4 is recommended.

The ultimate design geotechnical pressures presented in Table 13, in conjunction with the strength reduction factor recommended above, are used to assess the “design geotechnical strength” (R_{dg}) of the pile, as defined in AS2159:2009 (Piling – Design and Installation) by considering the shaft and base areas. The design geotechnical strength must be greater than the “design action effect” (E_d).

The bases and sides of bored pile holes must be thoroughly cleaned of all loose soil and rock debris using a proper cleaning tool. The practice of adding water and spinning the auger is not acceptable. If there is any doubt as to the effectiveness of the base cleaning, the base resistance must be ignored.

Groundwater seepage was observed at test locations BH6-2 (0.7m), TP6-1 (0.7m), TP6-5 (0.8m), and TP6-8 (0.9m). If seepage or groundwater is encountered during bored pile drilling, special treatment will be required. This may vary between removal of the water and water affected material prior to concrete placement (where the inflow rate is low) or lining the holes with steel liners socketed into low permeability material to achieve an impermeable seal against any water charged soils above. If seepage into the pile hole still occurs, it may be controllable by pumping, otherwise the piles will have to be constructed under water using tremie methods. Shaft adhesion must be ignored for the portion of the pile that is permanently lined.

Drilling piles is not only dependent on the subsurface material characteristics but also the type (power and size) of the bored pile drilling rig, drilling teeth, size of pile, etc. It is recommended that a specialist drilling contractor be consulted about design and construction of piles.

During construction, all bored piles must be inspected by an experienced geotechnical engineer or engineering geologist to confirm the geotechnical strength parameters presented in Table 13 and to check the capacity of the piles.

The total long-term settlements of bored piles designed in accordance with the information given in this section should be limited to between 1% and 2% of the pile diameter or 15mm whichever is the greater. Differential settlements should not exceed 50% of the total settlements.

As an alternative to bored piles, screw piles could be considered. The capacity of screw piles is typically checked during installation by the monitoring of the installation torque. If screw piles are adopted, advice should be sought from specialist contractors regarding required pile sizes and installation torques.

9.0 RETAINING WALL DESIGN PARAMETERS

This section provides advice and recommendations for free headed and fixed headed retaining walls constructed as part of the proposed development.

The design of fixed or free headed permanent retaining wall systems supporting fill or natural soils can be based on the lateral earth pressure distribution given by:

$$p = K\gamma H + Kq \text{ (kPa)}$$

In the above equation, H (m) is the distance down from the top of the wall, γ (kN/m^3) is the bulk density and q (kPa) is any uniform surface surcharge loading behind the wall. K is the appropriate earth pressure coefficient. Where adjacent footings apply line or point loads behind the retaining walls, further advice must be sought.

Retaining walls are to be designed with respect to internal stability properties such as sliding, overturning, and bearing capacity failure. The retaining walls are also to be assessed and designed for global stability. Internal and global stability design should be carried out in accordance with AS4678:2002 (Earth-Retaining Structures).

Based on the results of the investigation, laboratory testing and previous experience with similar materials, the following unfactored design parameters summarised in Table 14 have been estimated for the different material types encountered.

Table 14 – Unfactored Retaining Wall Design Parameters

Material		Bulk Density γ (kN/m^3)	Rankine Earth Pressure Coefficient (1)			Long Term Effective Friction Angle (°)	Long Term Effective Cohesion, c' (kPa)
			Active, K_a	At Rest, K_o	Passive, K_p		
Controlled Fill		20	0.41	0.58	2.46	25	2
Natural Silty/Clayey Sands	Loose	18	0.36	0.53	2.77	28	0
	Medium Dense or stronger	19	0.31	0.47	3.25	32	0
Natural Clay Soils	Stiff	19	0.39	0.56	2.56	26	2
	Very Stiff	19	0.39	0.56	2.56	26	3
	Hard	20	0.38	0.55	2.66	27	5
Weathered Rock	Very Low Strength	20	0.27	0.43	3.69	35	5

Notes:
(1) These values of earth pressure coefficient ignore the effect of wall friction.
(2) These values do not account for a slope either in front of or behind the retaining walls.

Drainage is perhaps one of the most important considerations in the design and construction of earth retaining structures and it is necessary to separate the surface drainage from the sub soil drainage system.

Surface water must be diverted away from the back of retaining walls to prevent the ponding of surface water behind the top of the wall. This usually includes placing a 300mm to 500mm thick layer of compacted clay over the sub soil system to act as a seal.

Sub soil drainage comprising of free draining granular material connecting to slotted PVC pipes must be placed behind the permanent retaining walls to prevent the build-up of groundwater pressures behind the walls and this must discharge to a point of legal discharge.

The “active” earth pressure coefficient, K_a, should be used for free headed walls which can rotate while the “at rest” earth pressure coefficient, K_o, should be used for stiff or propped walls which cannot rotate or accept movement.

10.0 PRELIMINARY PAVEMENT DESIGN PARAMETERS

This section provides recommendations for both concrete and flexible pavements for all Precincts.

Laboratory testing was carried out on samples of the natural and residual soils to assess the typical soaked California Bearing Ratio (CBR). The CBR value represents the ‘strength’ of this material when compacted to 100% Standard Maximum Dry Density (SMDD), under saturated conditions.

The soaked CBR tests produced a range of results of 25% for the natural silty sand (SM), 13% to 25% for the residual clayey sand (SC), 1.5% to 9% for the residual silty clay (CH), and 5% to 13% for the residual sandy clay (CI).

Based on the borehole record sheets and following earthworks operations, it is envisaged that residual clays or weathered rock will form the majority of the pavement subgrades. The recommended preliminary design soaked CBR values are presented in Table 15 can be considered in the areas where the natural/residual clay soils form the subgrade.

Table 15 – Preliminary Soaked CBR Values

Material	Preliminary Soaked CBR Value (%)
Natural – Silty SAND (SM)	10
Residual – Clayey SAND (SC)	10
Residual – Silty CLAY (CH)	1.5
Residual – Sandy CLAY (CI)	5

Following the subgrade preparation, CBR testing must be carried out to confirm the preliminary assigned design values given in Table 15.

In addition to the recommendations contained in Section 7.3, the following general earthworks recommendations for pavement areas are made:

- Perimeter drains to be incorporated at the pavement edges to prevent possible deterioration under wet weather.
- Pavements should be well drained during and upon completion of construction. Water should not be allowed to pond on or near pavement surfaces.
- Pavement gravel should comply with the DTMR quality specifications for subbase and base course materials.
- Subgrades should be compacted to achieve a minimum density ratio of 100% SMDD.
- Pavement materials should be compacted to the following minimum density ratios:
  - Subbase 95% - AS 1289 5.2.1 (modified).
  - Base 98% - AS 1289 5.2.1 (modified).

- Inspections and testing should be carried out following general earthworks operations to confirm subgrade conditions.

11.0 LIMITATIONS OF GEOTECHNICAL INVESTIGATION

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(b) cannot predict the ground conditions encountered at any untested location because the ground conditions surrounding test sampling locations, (or between any two test sampling locations) may be different from the test samples we have obtained
(c) is not an environmental, contamination or hazardous materials assessment; may be invalid, incomplete or inaccurate (including errors in the scope of work, investigation methodology, observations, opinions and advice) where the information provided to Morrison Geotechnic was invalid, incomplete or inaccurate.
(d) is limited to observations of those parts of the site that were accessible at the time of the field investigation and is not based on observations about areas of the site which were inaccessible to the investigation equipment (including slopes, heavily vegetated areas or service corridors); and

(e) is not a comprehensive representation of the actual site conditions and may only show a reasonable interpretation of conditions encountered at discrete, widely spaced test locations, as selected by the Client, along with general site observations.

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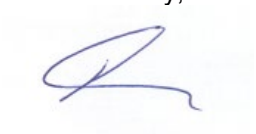
If further information becomes available, or additional assumptions need to be made, Morrison Geotechnic reserves its right to amend this Report.

Yours faithfully,



D MARSDEN
For and on Behalf of
MORRISON GEOTECHNIC PTY LIMITED

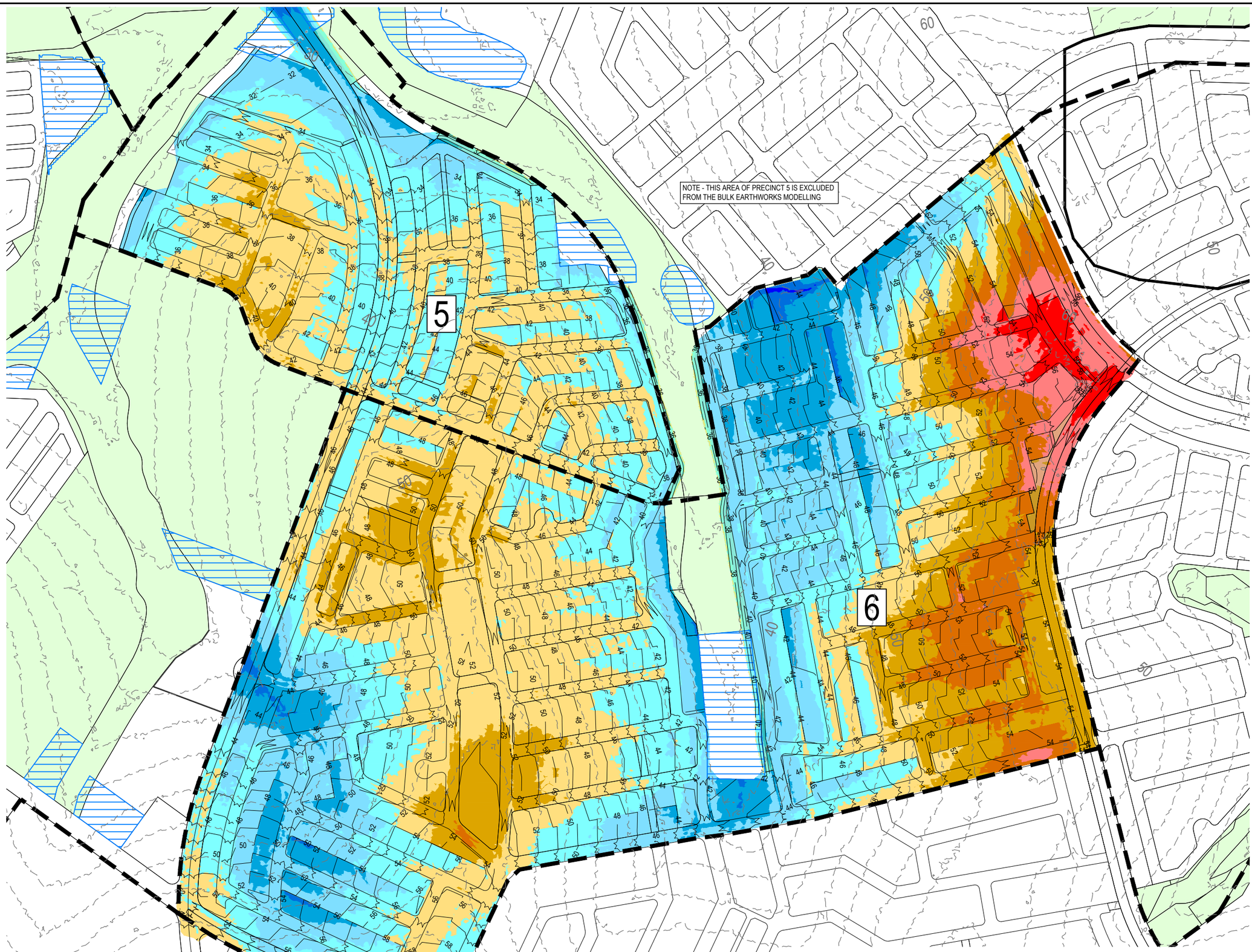
Reviewed By:

M BALLARD (RPEQ 10223)
For and on Behalf of
MORRISON GEOTECHNIC PTY LIMITED

Encl Appendix A – Drawings provided by the Client.
Appendix B – Borehole test location plan.
Appendix C – Borehole logs.
Appendix D – Laboratory test certificates.
Important Information about your Geotechnical Engineering Report

APPENDIX A

DRAWINGS PROVIDED BY CLIENT



REV	DATE
P1	DRAFT

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SCALE
1:2500 50 0 50 100 A1
1:5000 A3

CLIENT
LENDLEASE

PROJECT NAME
YARRABILBA

DRAWING TITLE
CONCEPT BULK EARTHWORKS DEPTH RANGE ANALYSIS PRECINCT 5 AND 6

PROJECT No.	DRAWING No.	REVISION
17-0135	SK100	P1

APPENDIX B

LOCATION PLAN

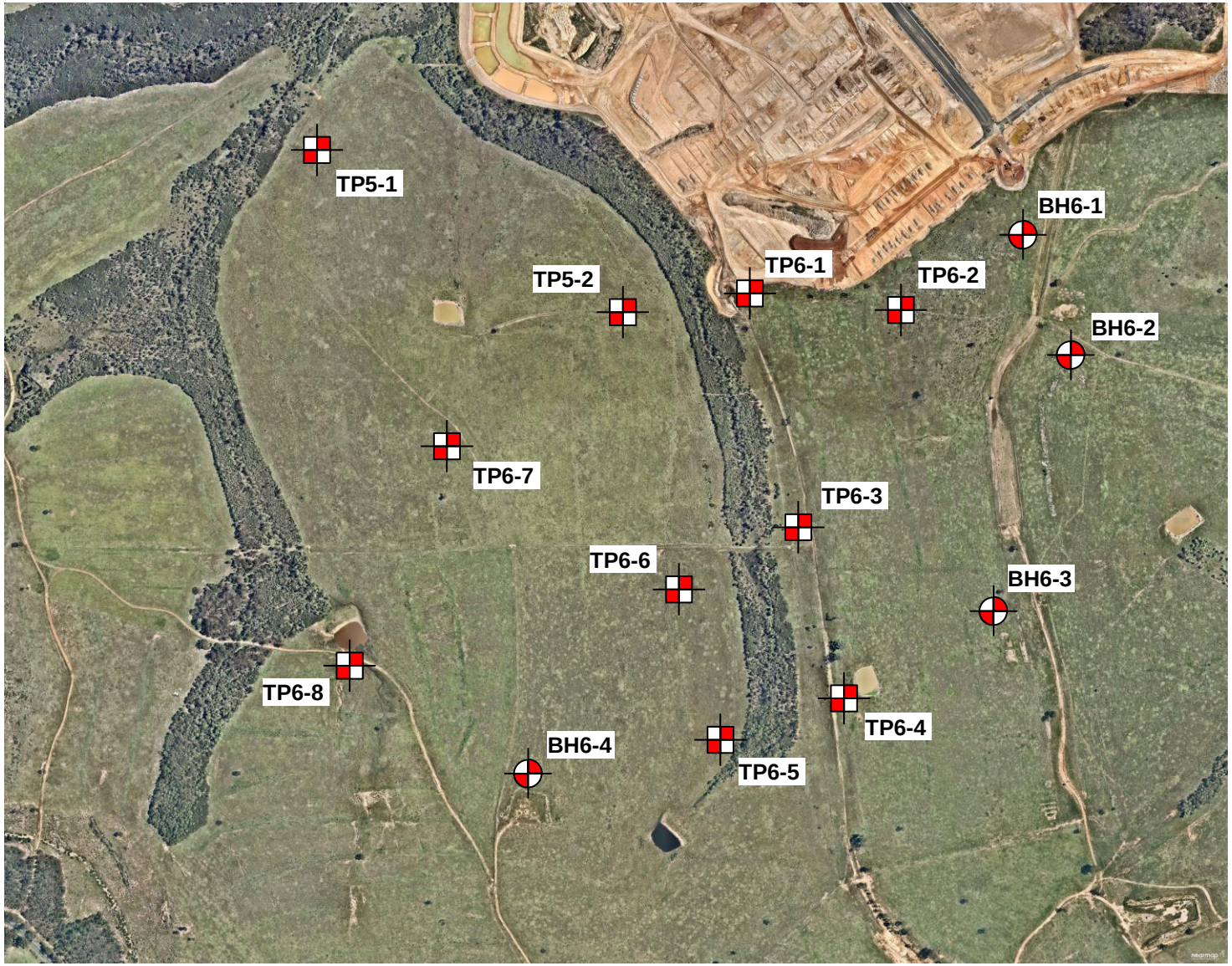

Image Source: Nearmap ©, November 2021

APPROXIMATE BOREHOLE LOCATIONS

APPROXIMATE TEST PIT LOCATIONS

MORRISON GEOTECHNIC

Brisbane | Gold Coast | Maroochydore
Unit 1, 35 Limestone Street
(PO Box 3063), Darra Q 4076
P (07) 3279 0900 **F** (07) 3279 0955
ABN 51 009 878 899
www.morrisongeo.com.au

TITLE: SITE PLAN AND BOREHOLE LOCATIONS			DRAWING NO.: DE21/264/SP01	
JOB LOCATION: YARRABILBA – PRECINCTS 5 AND 6			SCALE: NOT TO SCALE	
CLIENT: GOLDING CONTRACTORS PTY LTD	DATE: 21.04.22	DRAWN: DM	SIZE: A4	

APPENDIX C

BOREHOLE LOGS

MORRISON GEOTECHNIC

ENGINEERING LOG

BOREHOLE NO. : BH6-1
JOB NO. : DE21-264
SHEET: 1 OF 3

EASTING : 513182
NORTHING : 6921666
ELEVATION : m (AHD)
TOTAL DEPTH : 8m

DRILLING CONTRACTOR : Applied Geotechnical Drilling
DRILLING RIG : Hydrapower Scout
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 7/02/2022

DRILLING				MATERIAL							TEST SAMPLE		
Method	Casing	Water	RL (m) / Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
SA/TC	HW		0.0	Residual		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L				
						CH	Silty CLAY (CH): Very stiff, high plasticity, grey brown mottled red brown, trace of fine to coarse grained sand, moist.	w~PL	VSt				PP = 250kPa
			0.5			CH	Silty CLAY (CH): Hard, high plasticity, grey mottled orange brown and red brown, with fine to coarse grained sand, moist.	w<PL	H			U50	PP = 450kPa
			1.0			CI	Sandy CLAY (CI): Hard, medium plasticity, pale grey mottled orange brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H				
WB			1.5	Rock			SANDSTONE: Very low strength, highly weathered, fine to coarse grained, pale grey and orange brown.		VL	HW		SPT 30/90	
			2.0				SANDSTONE: Low strength to medium strength, moderately weathered, medium to coarse grained, pale grey and orange brown, with fine sized gravel.		L-M	MW			
			2.5										
			3.0									SPT 30/20	HB - No sample recovered
							Borehole BH6-1 continued on Cored Borehole Log						
			3.5										
			4.0										
			4.5										
			5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

ENGINEERING LOG

CORED BOREHOLE NO. : BH6-1

JOB NO. : DE21-264
SHEET: 2 OF 3

EASTING : 513182
NORTHING : 6921666
ELEVATION : m (AHD)
TOTAL DEPTH : 8m

LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 7/02/2022

DRILLING					MATERIAL								ROCK MASS DEFECTS			
Method	Casing	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Material Description	Weathering / Cementation	Estimated Strength Symbol	Estimated Strength VL L M H VH EH	IS(50) (MPa)	UCS (MPa)	RQD %	Total Core Recovery (%)	Defect Spacing (mm) 20 60 200 600 2000	Defect Description
				0.5												
				1.0												
				1.5												
				2.0												
				2.5												
				3.0												
NMLC				3.5	Rock		SANDSTONE: Medium strength to high strength, moderately weathered, medium to coarse grained, pale grey and orange brown, with fine sized gravel. 3.11m to 3.22m: Fractured along core length.	MW	M-H		D=2.7 A=1.6		48%	Run:1 / 100%		J, 10°, Ro, Cv, Cn, Op J, 10°, Ro, Pl, Su, Op J, 10°, Ro, Pl, Cn, Op J, 10°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op J, 10°, Ro, Pl, Cn, Op
				4.0			As above but orange brown.						69%	Run:2 / 100%		J, 10°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op Drill break Drill break J, 10°, Ro, Pl, Su, Op J, 10°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op Drill break P, 5°, Ro, Ir, Su, Op
				4.5			SANDSTONE: Low strength to medium strength, moderately weathered, fine to medium grained, orange brown. 4.28m to 4.56m: Extremely weathered band, pale grey. As above but red brown. 4.64m to 4.88m: Extremely weathered band, pale grey.	MW	L-M				73%	Run:3 / 100%		P, 5°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op
				5.0			As above but orange brown and red brown.									P, 5°, Ro, Pl, Su, Op

See Explanatory Notes for details of abbreviations and basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

CORED BOREHOLE NO. : BH6-1

JOB NO. : DE21-264
SHEET: 3 OF 3

EASTING : 513182
NORTHING : 6921666
ELEVATION : m (AHD)
TOTAL DEPTH : 8m

LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 7/02/2022

DRILLING					MATERIAL								ROCK MASS DEFECTS			
Method	Casing	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Material Description	Weathering / Cementation	Estimated Strength Symbol	Estimated Strength VL L M H VH EH	IS(50) (MPa)	UCS (MPa)	RQD %	Total Core Recovery (%)	Defect Spacing (mm) 20 60 200 600 2000	Defect Description
NMLC				5.5	Rock		SANDSTONE: Low strength to medium strength, moderately weathered, fine to medium grained, orange brown.	MW	L-M							P, 5°, Ro, Pl, Su, Op
							As above but pale grey and orange brown.									P, 5°, Ro, Pl, Cn, Op
																P, 5°, Ro, Pl, Vn, Op (Carbonaceous)
				6.0												J, 10°, Ro, Pl, Co, Op (Clay)
							As above but orange brown and grey.						73%	Run:3 / 100%		P, 5°, Ro, Pl, Su, Op
							6.17m to 6.21m: Extremely weathered band.									P, 5°, Ro, Pl, Su, Op
																P, 5°, Ro, Pl, Su, Op
				6.5			6.54 to 6.58m: Band of fine sized quartz gravel.				D=0.33					J, 10°, Ro, Pl, Su, Op
							As above but fine to coarse grained.				A=0.34					
				7.0												
							As above but slightly weathered, occasional carbonaceous laminae, grey.	SW					100%	Run:4 / 100%		P, 5°, Ro, Un, Vn, Op (Carbonaceous)
				7.5												Drill break
							As above but grey brown.									Drill break
				8.0			End of BH6-1 at 8m									
				8.5												
				9.0												
				9.5												
				10.0												

See Explanatory Notes for details of abbreviations and basis of descriptions

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TITLE: BOREHOLE CORE PHOTOGRAPH – 3.0m to 8.0m				DRAWING NO.: DE21/264/SP01
JOB LOCATION: YARRABILBA - PRECINCT 6				SCALE: NOT TO SCALE
CLIENT: GOLDING CONTRACTORS PTY LTD		DATE: 03.02.22	DRAWN: DM	SIZE: A4

MORRISON GEOTECHNIC

ENGINEERING LOG

BOREHOLE NO. : BH6-2
JOB NO. : DE21-264
SHEET: 1 OF 3

EASTING : 513277
NORTHING : 6921481
ELEVATION : m (AHD)
TOTAL DEPTH : 8m

DRILLING CONTRACTOR : Applied Geotechnical Drilling
DRILLING RIG : Hydrapower Scout
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 8/02/2022

DRILLING				MATERIAL								TEST SAMPLE		
Method	Casing	Water	RL (m) / Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
SA/TC	HW		0.0	Natural		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark brown, trace of low plasticity fines, with fine to medium sized gravel, with rootlets, moist.	M	L				
						SM	Silty SAND (SM): Loose, fine to coarse grained, orange brown, with fine to medium sized gravel, trace of high plasticity fines, moist.	M	L				
		▶	0.5				As above but wet.	W				SPT 2,1,2 N=3	
				Residual		CH	Silty CLAY (CH): Stiff, high plasticity, grey mottled orange brown and red brown, with fine to coarse grained sand, moist.	w>PL	St				
			1.0				As above but very stiff, red brown mottled pale grey and orange brown.	w~PL	VSt				PP = 350kPa
WB			1.5									SPT 9,12,12 N=24	
			2.0				Sandy CLAY (CI): Stiff, high plasticity, pale grey mottled orange brown and red brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H				
			2.5	Rock			SANDSTONE: Very low strength to low strength, highly weathered, fine to coarse grained, orange brown, with fine sized gravel.		VL-L	HW			
			3.0									SPT 30/50	HB - No sample recovered
							Borehole BH6-2 continued on Cored Borehole Log						
			3.5										
			4.0										
			4.5										
			5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

CORED BOREHOLE NO. : BH6-2

JOB NO. : DE21-264
SHEET: 2 OF 3

EASTING : 513277
NORTHING : 6921481
ELEVATION : m (AHD)
TOTAL DEPTH : 8m

LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 8/02/2022

DRILLING					MATERIAL								ROCK MASS DEFECTS			
Method	Casing	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Material Description	Weathering / Cementation	Estimated Strength Symbol	Estimated Strength VL L M H VH EH	IS(50) (MPa)	UCS (MPa)	RQD %	Total Core Recovery (%)	Defect Spacing (mm) 20 60 200 600 2000	Defect Description
				0.5												
				1.0												
				1.5												
				2.0												
				2.5												
				3.0												
NMLC				3.5	Rock		SANDSTONE: Low strength to medium strength, moderately weathered, fine to coarse grained, orange brown, with fine sized gravel.	MW	L-M							P, 5°, Ro, Pl, Su, Op J, 10°, Ro, Cv, Su, Op P, 5°, Ro, Pl, Su, Op J, 10°, Ro, Pl, Su, Op
							As above but very low strength, highly weathered, pale grey and orange brown.	HW	VL							P, 5°, Ro, Pl, Su, Op J, 10°, Ro, Pl, Su, Op
							3.32 to 3.4m: Extremely weathered band. As above but low strength to medium strength, moderately weathered, orange brown and grey.	MW	L-M							J, 10°, Ro, Pl, Cn, In (5mm Clay) Drill break J, 10°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op
				4.0			CORE LOSS						14%	Run:1 / 35%		
				4.5		CL		CL								
				5.0												

See Explanatory Notes for details of abbreviations and basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

CORED BOREHOLE NO. : BH6-2

JOB NO. : DE21-264
SHEET: 3 OF 3

EASTING : 513277
NORTHING : 6921481
ELEVATION : m (AHD)
TOTAL DEPTH : 8m

LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 8/02/2022

DRILLING					MATERIAL								ROCK MASS DEFECTS			
Method	Casing	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Material Description	Weathering / Cementation	Estimated Strength Symbol	Estimated Strength VL L M H VH EH	IS(50) (MPa)	UCS (MPa)	RQD %	Total Core Recovery (%)	Defect Spacing (mm) 20 60 200 600 2000	Defect Description
NMLC							CORE LOSS	CL					14%			
				5.5	Rock		SANDSTONE: Low strength to medium strength, moderately weathered, fine to coarse grained, orange brown, with fine sized gravel. 5.46m to 5.51m: Extremely weathered band, grey and orange brown. As above but orange brown and grey brown.	MW	L-M				96%	Run:2 / 100%		P, 5°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op P, 5°, Ro, Pl, Su, Op Drill break Drill break P, 5°, Ro, Su, Op P, 5°, Ro, Pl, Su, Op
				6.0												
				6.5												
				7.0												
				7.5												
				8.0			End of BH6-2 at 8m									
				8.5												
				9.0												
				9.5												
				10.0												

See Explanatory Notes for details of abbreviations and basis of descriptions

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TITLE: BOREHOLE CORE PHOTOGRAPH – 3.0m to 8.0m				DRAWING NO.: DE21/264/SP02
JOB LOCATION: YARRABILBA - PRECINCT 6				SCALE: NOT TO SCALE
CLIENT: GOLDING CONTRACTORS PTY LTD	DATE: 03.02.22	DRAWN: DM	SIZE: A4	

MORRISON GEOTECHNIC

ENGINEERING LOG

BOREHOLE NO. : BH6-3
JOB NO. : DE21-264
SHEET: 1 OF 3

EASTING : 513131
NORTHING : 6921106
ELEVATION : m (AHD)
TOTAL DEPTH : 5.24m

DRILLING CONTRACTOR : Applied Geotechnical Drilling
DRILLING RIG : Hydrapower Scout
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 1/02/2022

DRILLING				MATERIAL							TEST SAMPLE		
Method	Casing	Water	RL (m) / Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
SA/TC	HW		0.0	Residual		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L				
			0.5			CH	Silty CLAY (CH): Very stiff, high plasticity, orange brown and red brown, with fine to coarse grained sand, moist.	w~PL	VSt				PP = 300kPa
			1.0									SPT 2,4,8 N=12	
WB			1.5			CI	Sandy CLAY (CI): Hard, medium plasticity, grey mottled orange brown and red brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H				PP = 450kPa
			2.0	Rock			SANDSTONE: Very low strength, highly weathered, fine to coarse grained, pale grey and orange brown, occasional extremely weathered bands.		VL	HW			
							Borehole BH6-3 continued on Cored Borehole Log						
			2.5										
			3.0										
			3.5										
			4.0										
			4.5										
			5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

CORED BOREHOLE NO. : BH6-3

JOB NO. : DE21-264
SHEET: 2 OF 3

EASTING : 513131
NORTHING : 6921106
ELEVATION : m (AHD)
TOTAL DEPTH : 5.24m

LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 1/02/2022

DRILLING					MATERIAL								ROCK MASS DEFECTS			
Method	Casing	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Material Description	Weathering / Cementation	Estimated Strength Symbol	Estimated Strength VL L M H VH EH	IS(50) (MPa)	UCS (MPa)	RQD %	Total Core Recovery (%)	Defect Spacing (mm) 20 60 200 600 2000	Defect Description
				0.5												
				1.0												
				1.5												
				2.0												
NMLC				2.5		CL	CORE LOSS	CL					24%	Run:1 / 24%		
					Rock		SANDSTONE: Very low strength to low strength, highly weathered, fine to medium grained, orange brown, trace of fine sized gravel.	HW	VL-L		D=0.18 A=0.12					Drill break
				3.0		CL	CORE LOSS	CL								
					Rock		SANDSTONE: Very low strength to low strength, highly weathered, fine to medium grained, orange brown and pale grey, trace of fine sized gravel.	HW	VL-L				89%	Run:2 / 89%		Drill break Drill break Drill break Drill break Drill break J, 10°, Ro, Pl, Su, Op Drill break
				3.5			As above but pale grey and orange brown.									Drill break Drill break Drill break J, 20°, Ro, Cu, Su, Op Drill break J, 20°, Ro, Cu, Su, Op Drill break
				4.0												Drill break Drill break Drill break Drill break J, 70°, Ro, Un, Su, Op Drill break
				4.5			As above but with occasional carbonaceous laminae. as above but orange brown.									Drill break P, 5°, Ro, Pl, Su, Op
				5.0												Drill break

See Explanatory Notes for details of abbreviations and basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

CORED BOREHOLE NO. : BH6-3

JOB NO. : DE21-264
SHEET: 3 OF 3

EASTING : 513131
NORTHING : 6921106
ELEVATION : m (AHD)
TOTAL DEPTH : 5.24m

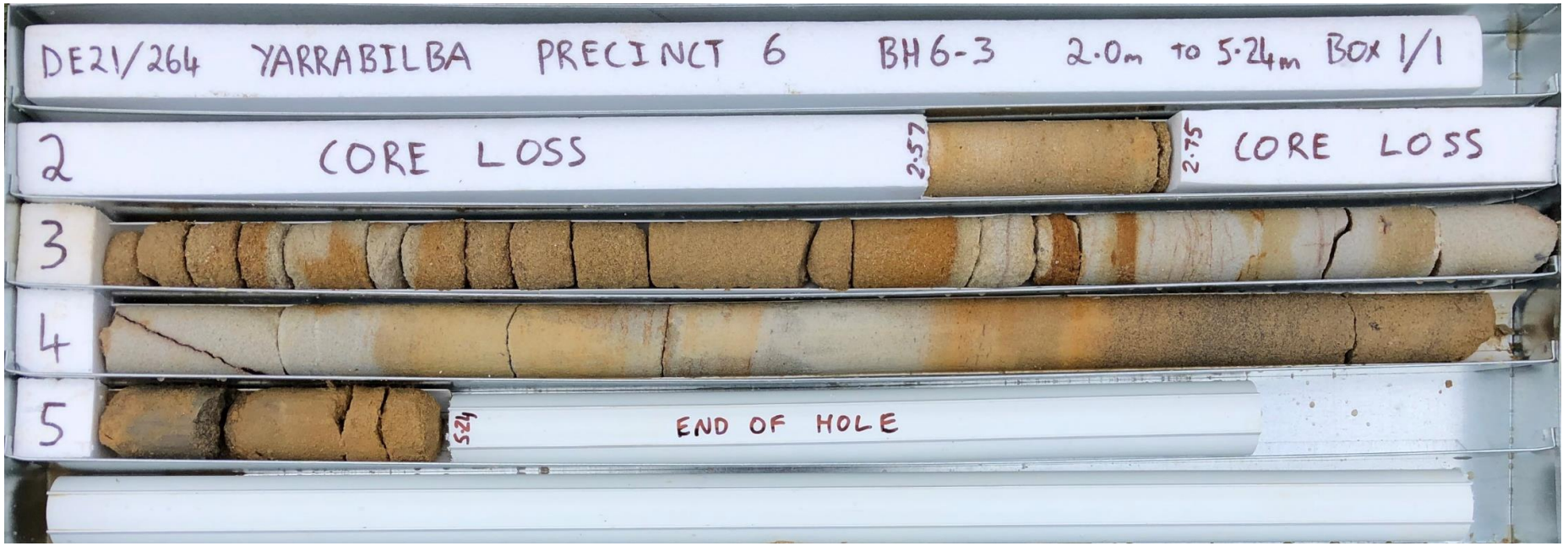
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 1/02/2022

DRILLING					MATERIAL							ROCK MASS DEFECTS			
Method	Casing	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Material Description	Weathering / Cementation	Estimated Strength Symbol	Estimated Strength VL L M H VH EH	IS(50) (MPa)	UCS (MPa)	RQD %	Total Core Recovery (%)	Defect Spacing (mm) 20 60 200 600 2000	Defect Description
NMLC					Rock		SANDSTONE: Very low strength to low strength, highly weathered, fine to medium grained, orange brown and pale grey, trace of fine sized gravel.	HW	VL-L				89%			Drill break Drill break Drill break
							End of BH6-3 at 5.24m									

5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0

See Explanatory Notes for details of abbreviations and basis of descriptions



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TITLE: BOREHOLE CORE PHOTOGRAPH – 2.0m to 5.24m				DRAWING NO.: DE21/264/SP03
JOB LOCATION: YARRABILBA - PRECINCT 6				SCALE: NOT TO SCALE
CLIENT: GOLDING CONTRACTORS PTY LTD	DATE: 03.02.22	DRAWN: DM	SIZE: A4	

MORRISON GEOTECHNIC

ENGINEERING LOG

BOREHOLE NO. : BH6-4
JOB NO. : DE21-264
SHEET: 1 OF 3

EASTING : 512426
NORTHING : 6920857
ELEVATION : m (AHD)
TOTAL DEPTH : 5.86m

DRILLING CONTRACTOR : Applied Geotechnical Drilling
DRILLING RIG : Hydrapower Scout
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 25/01/2022

DRILLING				MATERIAL								TEST SAMPLE		
Method	Casing	Water	RL (m) / Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
SA/TC	HQ		0.5	Residual		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark brown, with fine to medium sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L				
						CH	Silty CLAY (CH): Very stiff, high plasticity, orange brown, with fine to coarse grained sand, trace of fine sized gravel, moist.	w~PL	VSt				PP = 350kPa
			1.0			CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled orange brown and red brown, with fine to coarse grained sand, moist.	w~PL	VSt			SPT 3,3,8 N=11	
			1.5			CI	Sandy CLAY (CI): Hard, medium plasticity, orange brown mottled pale grey and red brown, fine to coarse grained sand, trace of fine sized gravel, moist (XW Sandstone).	w<PL	H			SPT 9,15,15 N=30	
			2.0	Rock			SANDSTONE: Very low strength, highly weathered, fine to coarse grained, orange brown and pale grey.		VL	HW			
WB			2.5									SPT 15,21, 30/130	
			3.0										
			3.5										
			4.0				As above but pale grey and orange brown, occasional low strength bands.					SPT 24,30/100	
			4.5				Borehole BH6-4 continued on Cored Borehole Log						
			5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

CORED BOREHOLE NO. : BH6-4

JOB NO. : DE21-264
SHEET: 2 OF 3

EASTING : 512426
NORTHING : 6920857
ELEVATION : m (AHD)
TOTAL DEPTH : 5.86m

LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 25/01/2022

DRILLING					MATERIAL								ROCK MASS DEFECTS			
Method	Casing	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Material Description	Weathering / Cementation	Estimated Strength Symbol	Estimated Strength VL L M H VH EH	IS(50) (MPa)	UCS (MPa)	RQD %	Total Core Recovery (%)	Defect Spacing (mm) 20 60 200 600 2000	Defect Description
				0.5												
				1.0												
				1.5												
				2.0												
				2.5												
				3.0												
				3.5												
				4.0												
NMLC				4.5	Rock		SANDSTONE: Very low strength to low strength, highly weathered, fine to coarse grained, pale grey.	HW	VL-L				92%	Run:1 / 100%		− J, 10°, Ro, Ir, Cn, Op − J, 10°, Ro, Cv, Vn, Op − P, 5°, Ro, Pl, Cn, Op
							As above but orange brown and pale grey.									
				5.0												

See Explanatory Notes for details of abbreviations and basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

CORED BOREHOLE NO. : BH6-4

JOB NO. : DE21-264
SHEET: 3 OF 3

EASTING : 512426
NORTHING : 6920857
ELEVATION : m (AHD)
TOTAL DEPTH : 5.86m

LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 25/01/2022

DRILLING					MATERIAL								ROCK MASS DEFECTS			
Method	Casing	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Material Description	Weathering / Cementation	Estimated Strength Symbol	Estimated Strength VL L M H VH EH	IS(50) (MPa)	UCS (MPa)	RQD %	Total Core Recovery (%)	Defect Spacing (mm) 20 60 200 600 2000	Defect Description
NMLC				5.5	Rock		SANDSTONE: Very low strength to low strength, highly weathered, fine to coarse grained, pale grey.	HW	VL-L				92%	Run:1 / 100%		− P, 5°, Ro, Pl, Su, Op − P, 5°, Ro, Pl, Cn, Op − J, 20°, Ro, Pl, Su, Op − J, 20°, Ro, Pl, Su, Op
							As above but with occasional carbonaceous laminae.									
				6.0			End of BH6-4 at 5.86m									
				6.5												
				7.0												
				7.5												
				8.0												
				8.5												
				9.0												
				9.5												
				10.0												

See Explanatory Notes for details of abbreviations and basis of descriptions

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TITLE: BOREHOLE CORE PHOTOGRAPH – 4.25m to 5.86m				DRAWING NO.: DE21/264/SP04
JOB LOCATION: YARRABILBA - PRECINCT 6				SCALE: NOT TO SCALE
CLIENT: GOLDING CONTRACTORS PTY LTD		DATE: 03.02.22	DRAWN: DM	SIZE: A4

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP5-1
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512089
NORTHING : 6921771
ELEVATION : m (AHD)
TOTAL DEPTH : 2.8m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 18/02/2022

EXCAVATION			MATERIAL							TEST SAMPLE		
Method	Water	RL (m) / Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth		0.5	Natural		SM	TOPSOIL Silty SAND (SM): Very loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	VL		1		
					SM	Silty SAND (SM): Very loose, fine to coarse grained, orange brown, trace of high plasticity fines, trace of tree roots, moist.	M	VL		1 2 0		
		1.0	Residual		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled orange brown, with fine to coarse grained sand, fissured, moist.	w~PL	VSt		1 2 2 3 5		PP = 300kPa
		1.5			CI	Sandy CLAY (CI): Hard, medium plasticity, pale grey mottled orange brown and red brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H		3 3 4 7 20/90		PP = 380kPa
		2.0	Rock			SANDSTONE: Very low strength, highly weathered, fine to coarse grained, pale grey and orange brown.		VL	HW			
		2.5				As above but very low strength to low strength.		VL-L				
						As above but low strength to medium strength.		L-M				
		3.0				End of TP5-1 at 2.8m						Excavator bucket refusal
		3.5										
		4.0										
		4.5										
		5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP5-2
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512526
NORTHING : 6921578
ELEVATION : m (AHD)
TOTAL DEPTH : 3.2m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 18/02/2022

EXCAVATION				MATERIAL								TEST SAMPLE		
Method	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth			0.0	Natural		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L		1		
						SM	Silty SAND (SM): Medium dense, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist.	M	MD		3		
				Residual		CH	Silty CLAY (CH): Very stiff, high plasticity, grey brown mottled orange brown and red brown, with fine to coarse grained sand, trace of fine sized gravel, moist.	w~PL	VSt		3		
			0.5								2		
											2		PP = 250kPa
											3		
						Cl	Sandy CLAY (Cl): Hard, medium plasticity, pale grey mottled orange brown and red brown, fine to coarse grained sand, trace of fine sized gravel, occasional very low strength sandstone bands, moist (XW Sandstone).	w~PL	H		8		
			1.0								13		
											15		
											13		
											17		
											20		
				Rock			SANDSTONE: Very low strength, highly weathered, fine to coarse grained, pale grey and orange brown.		VL	HW			
			1.5										
							As above but very low strength to low strength.		VL-L				
			2.0										
							As above but pale grey, orange brown and red brown.						
			2.5										
			3.0										
							As above but low strength to medium strength, pale grey and orange brown.		L-M				
							End of TP5-2 at 3.2m						Excavator bucket refusal
			3.5										
			4.0										
			4.5										
			5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP6-1
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512769
NORTHING : 6921568
ELEVATION : m (AHD)
TOTAL DEPTH : 5m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 15/02/2022

EXCAVATION				MATERIAL								TEST SAMPLE		
Method	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth	▶		0.0	Natural		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L		1		
						SM	Silty SAND (SM): Medium dense, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist to wet (possible alluvium).	M-W	MD		2		
			0.5				As above but very loose.		VL		3		
	▶						As above but wet.	W			2		Trench walls collapsing
											2		
			1.0			SM	Silty SAND (SM): Very loose, fine to coarse grained, orange brown, with high plasticity fines, trace of fine sized gravel, moist to wet.	M-W	VL		1		
											1		
											0		
											0		
				Residual		SC	Clayey SAND (SC): Loose, fine to coarse grained, grey mottled orange brown, high plasticity fines, with fine to medium sized gravel, moist to wet.	M	MD		1		
			1.5								1		
											2		
											9		
											5		
						Cl	Sandy CLAY (Cl): Hard, medium plasticity, pale grey mottled orange brown, fine to coarse grained sand, trace of fine sized gravel, moist (XW Sandstone).	w<PL	H		12		
											14		
											17		
			2.0								20		
													PP = 500kPa
			2.5				As above but pale grey mottled orange brown and red brown, occasional very low strength bands.						
			3.0										PP = 550kPa
			3.5				As above but pale grey mottled orange brown, yellow brown and red brown.						
			4.0										PP = 550kPa
			4.5										
				Rock			SANDSTONE: Very low strength to low strength, highly weathered, fine to coarse grained, grey, orange brown and red brown.		VL-L	HW			
			5.0										Excavator extent reached

End of TP6-1 at 5m

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP6-2
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 513038
NORTHING : 6921574
ELEVATION : m (AHD)
TOTAL DEPTH : 2m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 15/02/2022

EXCAVATION				MATERIAL								TEST SAMPLE		
Method	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth			0.0	Natural		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L		1		
						SM	Silty SAND (SM): Loose, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist.	M	L		1		
				Residual		CH	Silty CLAY (CH): Very stiff, high plasticity, orange brown mottled red brown, with fine to coarse grained sand, moist.	w~PL	VSt		2		
			0.5								2		
											3		
											3		
											2		PP = 300kPa
											2		
											3		
			1.0								2		
						Cl	Sandy CLAY (Cl): Hard, medium plasticity, pale grey mottled orange brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H		13		
											16		
				Rock			SANDSTONE: Very low strength to low strength, highly weathered, fine to coarse grained, orange brown and pale grey, with fine sized gravel.		VL-L	HW	20/80		
			1.5										
			2.0				As above but low strength to medium strength.		L-M				
							End of TP6-2 at 2m						Excavator bucket refusal
			2.5										
			3.0										
			3.5										
			4.0										
			4.5										
			5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP6-3
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512850
NORTHING : 6921239
ELEVATION : m (AHD)
TOTAL DEPTH : 4.1m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 16/02/2022

EXCAVATION				MATERIAL								TEST SAMPLE		
Method	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth			0.0	Natural		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L		1		
						SM	Silty SAND (SM): Medium dense, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist.	M	MD		2		
											4		
				Residual		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled orange brown and red brown, trace of fine to coarse grained sand, moist.	w~PL	VSt		5		
			0.5								2	B	PP = 300kPa
											2		
											2		
											2		
											3		
			1.0			CH	Sandy CLAY (CH): Hard, high plasticity, grey mottled orange brown, fine to coarse grained sand, moist.	w<PL	H		3		
											3		
											5		
											4		PP = 500kPa
											4		
			1.5								5		
						CI	Sandy CLAY (CI): Hard, medium plasticity, pale grey mottled orange brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H		12		
											20/90		
				Rock			SANDSTONE: Very low strength, highly weathered, fine to medium grained, orange brown and grey.		VL	HW			
			2.0										
			2.5				As above but grey and orange brown, occasional extremely weathered bands.						
			3.0				As above but with interbedded very low strength siltstone and sandstone bands.						
			3.5				As above but very low strength to low strength.		VL-L				
			4.0				As above but low strength to medium strength.		L-M				
							End of TP6-3 at 4.1m						Excavator bucket refusal
			4.5										
			5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP6-4
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512909
NORTHING : 6920982
ELEVATION : m (AHD)
TOTAL DEPTH : 3.1m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 16/02/2022

EXCAVATION			MATERIAL							TEST SAMPLE		
Method	Water	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth		0.0	Natural		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L		2		
					SM	Silty SAND (SM): Loose, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist.	M	L		1		
			Residual		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled orange brown and red brown, with fine to coarse grained sand, moist.	w~PL	VSt		1		
		0.5								2		
										3		PP = 250kPa
										5		
										9		
		1.0								9		
										6		
										10		
										7		
		1.5								7		
										6		
										4		
										4		
					Cl	Sandy CLAY (Cl): Hard, medium plasticity, pale grey mottled orange brown and red brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H		6		
		2.0	Rock			SANDSTONE: Very low strength, highly weathered, fine to coarse grained, pale grey, orange brown and red brown.		VL	HW	20		
		2.5				As above but very low strength to low strength.		VL-L				
		3.0				As above but low strength to medium strength.		L-M				
						End of TP6-4 at 3.1m						Excavator bucket refusal
		3.5										
		4.0										
		4.5										
		5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP6-5
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512725
NORTHING : 6920916
ELEVATION : m (AHD)
TOTAL DEPTH : 4.8m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 18/02/2022

EXCAVATION			MATERIAL							TEST SAMPLE		
Method	Water	Depth (m) / RL (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth	▶	0.0	Natural		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L		1		
					SM	Silty SAND (SM): Loose, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist (possible alluvium).	M	L		1		
		0.5								1		
										2		
										2		
										1		
					SM	Silty SAND (SM): Loose, fine to coarse grained, orange brown, with high plasticity fines, moist to wet.	M-W	L		1		
										1		
		1.0				As above but very loose, wet.	W	VL		0		
										0		
										0		
			Residual		CH	Sandy CLAY (CH): Very stiff, high plasticity, grey mottled orange brown, fine to coarse grained sand, moist.	w~PL	VSt		1		
						As above but very stiff.				3		
										3		
		1.5								2		PP = 350kPa
										3		
										3		
										7		
										5		
		2.0			CI	Sandy CLAY (CI): Hard, medium plasticity, pale grey mottled orange brown and red brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H		11		
						As above but pale grey mottled orange brown.				14		
										15		
										14		PP > 600kPa
										13		
		2.5								16		
										18		
										20		
			Rock			SANDSTONE: Very low strength, highly weathered, fine to coarse grained, pale grey and orange brown, occasional extremely weathered bands.		VL	HW			
		3.0										
		3.5										
		4.0										
		4.5				As above but very low strength to low strength.		VL-L				
						As above but low strength to medium strength.		L-M				
		5.0				End of TP6-5 at 4.8m						Excavator bucket refusal

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP6-6
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512612
NORTHING : 6921106
ELEVATION : m (AHD)
TOTAL DEPTH : 1.9m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 18/02/2022

EXCAVATION			MATERIAL							TEST SAMPLE		
Method	Water	RL (m) / Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth		0.0	Natural		SM	TOPSOIL Silty SAND (SM): Very loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	VL		0		
					SM	Silty SAND (SM): Medium dense, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist.	M	MD		2 4 3		
		0.5			SM	Silty SAND (SM): Loose, fine to coarse grained, orange brown, trace of high plasticity fines, moist to wet.	M-W	L		2 1 1		
			Residual		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled orange brown and red brown, with fine to coarse grained sand, moist.	w~PL	VSt		2 2 2		PP = 300kPa
		1.0			CH	Silty CLAY (CH): Very stiff, high plasticity, pale grey mottled orange brown and red brown, with fine to coarse grained sand, moist.	w~PL	VSt		3 3		PP = 350kPa
					CI	Sandy CLAY (CI): Hard, medium plasticity, pale grey mottled orange brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H		5 20		
		1.5	Rock			SANDSTONE: Very low strength to low strength, highly weathered, fine to coarse grained, pale grey and orange brown.		VL-L	HW			
						As above but low strength to medium strength.		L-M				
		2.0				End of TP6-6 at 1.9m						Excavator bucket refusal
		2.5										
		3.0										
		3.5										
		4.0										
		4.5										
		5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP6-7
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512335
NORTHING : 6921318
ELEVATION : m (AHD)
TOTAL DEPTH : 1.6m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 18/02/2022

EXCAVATION			MATERIAL							TEST SAMPLE		
Method	Water	Depth (m) / RL (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth		0.0	Natural		SM	TOPSOIL Silty SAND (SM): Loose, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	L		2		
					SM	Silty SAND (SM): Medium dense, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist.	M	MD		2		
			Residual		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled orange brown and red brown, trace of fine sized gravel, trace of fine to coarse grained sand, moist.	w~PL	VSt		3		
		0.5								2		
										2		
										2		
										2		PP = 300kPa
		1.0								2		
					CI	Sandy CLAY (CI): Hard, medium plasticity, pale grey mottled orange brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H		16		
										20		
			Rock			SANDSTONE: Very low to low strength, highly weathered, fine to coarse grained, pale grey and orange brown.		VL-L	HW			
		1.5				As above but low strength to medium strength.		L-M				
						End of TP6-7 at 1.6m						Excavator bucket refusal
		2.0										
		2.5										
		3.0										
		3.5										
		4.0										
		4.5										
		5.0										

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

ENGINEERING LOG

EXCAVATION NO. : TP6-8
JOB NO. : DE21-264
SHEET: 1 OF 1

EASTING : 512138
NORTHING : 6921035
ELEVATION : m (AHD)
TOTAL DEPTH : 5m

EQUIPMENT OPERATOR : ACE Rental
EQUIPMENT MODEL : Hitachi Zaxis 225US LC
LOGGED BY : DM
CHECKED BY : MB

CLIENT : Golding Contractors Pty Ltd
PROJECT : Yarrabilba - Geotechnical Investigation
LOCATION : Precincts 5 and 6
DATE : 18/02/2022

EXCAVATION				MATERIAL								TEST SAMPLE		
Method	Water	RL (m)	Depth (m)	Geological Unit	Graphic Log	Classification Symbol	Material Description	Moisture Condition	Consistency / Strength	Cementation / Weathering	DCP	Sample / Test	Field Records / Comments
1.5m Bucket with Teeth			0.0	Natural		SM	TOPSOIL Silty SAND (SM): Medium dense, fine to coarse grained, dark grey brown, trace of fine sized gravel, trace of low plasticity fines, with rootlets, moist.	M	MD		3		
						SM	Silty SAND (SM): Loose, fine to coarse grained, grey brown, trace of fine sized gravel, trace of low plasticity fines, trace of tree roots, moist.	M	L		1		
											1		
											2		
			0.5			SM	Silty SAND (SM): Medium dense, fine to coarse grained, grey brown mottled orange brown, trace of high plasticity fines, moist to wet.	M-W	MD		4		
											4		
											3		
											3		Trench walls collapsing
	▶										3		
			1.0				As above but wet.	W			2		
				Residual		CH	Silty CLAY (CH): Very stiff, high plasticity, grey mottled orange brown, with fine to coarse grained sand, moist.	w~PL	VSt		2		
											3		
											3		PP = 350kPa
											4		
			1.5								6		
							As above but hard.	w<PL	H		6		
											6		PP = 550kPa
											6		
											7		
			2.0			CI	Sandy CLAY (CI): Hard, medium plasticity, pale grey mottled orange brown, fine to coarse grained sand, moist (XW Sandstone).	w<PL	H		11		
											20		
			2.5	Rock			SANDSTONE: Very low strength, highly weathered, fine to coarse grained, pale grey and orange brown, occasional extremely weathered bands.		VL	HW			
			3.0										
			3.5										
			4.0										
			4.5				As above but very low strength to low strength.		VL-L				
			5.0										Excavator extent reached

End of TP6-8 at 5m

See Explanatory Notes for details of abbreviations & basis of descriptions

MORRISON GEOTECHNIC

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SOIL DESCRIPTION AND CLASSIFICATION

The description and classification of soils is carried out in accordance with AS1726 -2017 "Geotechnical Site Investigations" and is based on the Unified Soil Classification System. A Behavioural approach has been adopted in this standard when identifying, naming and classifying soil.

CLASSIFICATION GROUP

Major Divisions			Size (mm)
Coarse Grained (<35% clay/silt)	Boulders		>200
	Cobbles		63 – 200
	Gravel	coarse	19 – 63
		medium	6.7 – 19
		fine	2.36 – 6.7
	Sand	coarse	0.6 – 2.36
		medium	0.21 – 0.6
		fine	0.075 – 0.21
Fine Grained (>35% Clay/silt)	Silt		0.002 – 0.075
	Clay		<0.002
	Peat		N/A – Peat and other highly organic soils

MINOR/SECONDARY COMPONENT

Most natural soils are a mixture of basic soil types. The primary soil is described and modified by secondary constituents as follows:

Coarse Grained Soils

% Fines	Modifier	% Accessory Coarse Fraction	Modifier
≤ 5	Add '**trace** clay/silt'	≤ 15	Add '**trace** sand/gravel'
>5, ≤12	Add '**with** clay/silt'	>15, ≤30	Add '**with** sand/gravel
>12	Prefix soil name with silty /clayey	>30	Prefix soil name with Sandy/gravelly

Fine Grained Soils

% Sand/gravel	Modifier
≤ 15	Use 'trace'
>15, ≤30	Add '**with** sand/gravel
>30	Prefix soil name with Sandy/gravelly

COHESIVE SOIL DESCRIPTION

Plasticity

Descriptive term	Range of Liquid Limit for SILT	Range of Liquid Limit for CLAY
Low Plasticity	≤50%	≤35%
Medium Plasticity	Not applicable	>35 and <50%
High Plasticity	>50%	<50%

Consistency

Term	Indicative undrained Shear Strength (c_u) kPa
Very Soft (VS)	≤12
Soft (S)	>12 and ≤25
Firm (F)	>25 and ≤50
Stiff (St)	>50 and ≤100
Very Stiff (VSt)	>100 and ≤200
Hard (H)	>200

NON-COHESIVE SOIL DESCRIPTION

Relative Density

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

Particle size distribution

Well graded – a good representation of all particle sizes.

Poorly graded – an excess or deficiency of one or more intermediate particle sizes.

Gap graded – an absence of one or more intermediate particle sizes.

Uniform – essentially of one particle size.

Particle Shape

Equidimensional particles may be described as ***rounded, sub-rounded, sub-angular, or angular.***

Two dimensional particles with third dimension small by comparison may be described as ***flaky or platy.***

One dimensional particles with the other two dimensions small by comparison may be described as ***elongated.***

Cementation

Soils or defects within soils may be cemented together by various substances. The following terms are used to describe cemented soils.

- *Weakly cemented – the soil may be easily disaggregated by hand in air or water*
- *Moderately cemented – effort is required to disaggregate the soil by hand in air and water*

SOIL ORIGIN

Residual Soil	Soil developed on extremely weathered rock
Aeolian	Deposited by wind.
Alluvium	Deposited by streams and rivers.
Colluvium	Deposited on slopes (transported downslope by gravity).
Lacustrine	Deposited by lakes.
Marine	Deposited in ocean basins, beaches and estuarine (tidal river)
Topsoil	Mantle of surface and/or near surface soil often but not always defined by high levels of organic material, both dead and living.
Fill	Any material that has been placed by anthropogenic (human derived) processes

TYPICAL REPRESENTATION AND TERMS

GRAVEL	Clean Gravels (Little or no Fines)	GW	Well graded gravels and gravel/sand mixtures
		GP	Poorly graded gravels and gravel/sand mixtures
	Gravel with Fines	GM	Silty Gravels, gravel/sand/silt mixtures
		GC	Clayey Gravels, gravel/sand/clay mixtures
SANDS	Clean Sands (Little or no Fines)	SW	Well graded sands, gravelly sands
		SP	Poorly graded sands, gravelly/sand mixtures
	Sands with Fines	SM	Silty sands
		SC	Clayey Sands
SILTS and CLAYS	Liquid Limit >50%	MH	High plasticity inorganic silts, silt mixtures
		CH	High plasticity inorganic clays, clay mixtures
		OH	High plasticity organic clays and silts
	Liquid Limit >35% <50%	CI	Intermediate/medium plasticity inorganic clay
		OI	Intermediate plasticity organic silt/clay
	Liquid Limit ≤35%	CL	Low plasticity inorganic clays, clay mixtures
		OL	Low plasticity organic clay/silts
HIGHLY ORGANIC		Pt	Peat, Humus, Swamp Soils with high organics

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ROCK DESCRIPTION AND CLASSIFICATION

CLASSIFICATION METHODS

The rock classifications are broadly consistent with Australian Standard AS 1726, Geotechnical Site Investigation Code. Generally, rock is described by the following:

Composition of rock material	Rock name Grain size Texture and fabric Colour
Condition of Rock Material	Strength Weathering
Rock Mass Properties	Structure of rock Defects

STRENGTH

Term	Symbol	Point Load Index Is50 (MPa)	Field Guide
Very Low	VL	>0.03 ≤0.1	Material crumbles under a firm blow with sharp edge of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 3cm thick can be broken by figure pressure
Low	L	>0.1 ≤0.3	Easily scored with a knife; indentations 1mm-3mm show in the specimen with firm blow of the pick point; has dull sound under hammer. A piced of core 150mm long 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling
Medium	M	>0.3 ≤1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty rings under hammer.
High	H	1 ≤ 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	>3 ≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer
Extremely High	EH	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer

WEATHERING

Designation		Symbol		Definition
Extremely Weathered		XW		Material is weathered to such an extent that is has soil properties.
Distinctly Weathered	Highly Weathered	DW	HW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually ironstaining. Porosity may be increased by leaching or be decreased due to deposition of weathering products in pores
	Moderately Weathered		MW	
Slightly weathered		SW		Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh Rock		FR		Rock shows no sign of decomposition or staining

TEXTURE AND FABRIC

The texture and fabric of a rock specifically refers to the arrangement of the constituent grains or crystals in a rock.

Bedding Term	Thickness (mm)
Extremely thickly bedded	>6000
Very thickly bedded	2000-6000
Thickly bedded	600-2000
Medium bedded	200-600
Thinly bedded	60-200
Very thinly bedded	20-60
Laminated	6-20
Very Thinly Laminated	<6

DEFECTS

Defects are fractures in the rock mass and include joints, faults, sheared planes, cleavages and bedding partings.

Types

J – Joint
F – Fault
V – Vein
Fo – Foliation
B – Bedding
Cz – Crushed zone
Sz – Sheared zone
Bz – Broken zone

Defect descriptors

Roughness	
Slk	Slickenside, visible evidence of striation
S	Smooth, surface appears and feel smooth
SR	Slightly rough, asperities on the defect surface and distinguishable and can be felt
R	Rough, some ridges and angle steps are evident, asperities are clearly visible and surface feels abrasive
VR	Very Rough, near right angle steps and ridges occur on the defect surface

Planarity	
Pl	Planar, no variation in orientation
Un	Undulating, wavy surface
St	Stepped, well defined steps present
Ir	Irregular, many changes in orientation
Aperture	
o	Open
c	Closed

Type of Infilling	
Cl	Clay
Ca	Calcite
Fe	Iron Oxide
Qz	Quartz
CA	Calcrete
Li	Limonite
Si	Silt
Uk	Unknown

Amount of Infilling	
Cn	Clean, no visible coating or infilling
Su	Surface stain, no visible coating or infilling but surfaces are discoloured
Vn	Veneer, a visible coating or infilling up to 1mm thick
Co	Coating, visible coating or infilling up to 1mm thick
In	Filled, coating or infilling greater than 1mm thick with amount in millimetres

Thick soil infilling to be described as seams

TYPICAL ROCK TYPES

Refer to AS1726 Table 15,16 and 17 for guide to naming of rocks.

Sedimentary	Conglomerate Breccia Sandstone Greywacke Mudstone Siltstone Claystone Limestone Shale Dolomite Shale Tuff Chert Coal
Metamorphic	Gniess Marble Schist Quartzite Serpentinite Phyllite Slate Hornfels
Igneous	Granite Diorite Gabbro Dolerite Rhyolite Andesite Basalt

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SYMBOLS AND ABBREVIATIONS

Drilling methods

SA	Solid Flight Auger
HS	Hollow Stem Auger
WB	Wash Boring
NMLC	Triple tube rotary core drilling
HA	Hand Auger
PHA	Hydraulic powered hand auger
CPT	Cone Penetrometer Testing

Drilling Bits and Attachments

TC	Tungsten Carbide bit
V	V bit
RR	Rock Roller (tricone)
BB	Blade Bit

Excavation Attachments

GP	General Purpose toothed bucket
Ba	Batter Bucket
TT	Tiger Teeth
RB	Hydraulic rock breaker
ST	Single Tine

Sampling and Testing

SPT	Standard Penetrometer Testing
N	SPT Blow Count
HB	SPT hammer bouncing
DCP	Dynamic Cone Penetrometer Testing
SV	Shear Vane Test
U50	Undisturbed 50mm tube sample
D	Disturbed Sample
W	Water Sample
PP	Pocket Penetrometer
Rec	Length of sample recovered
R	Refusal
RQD	Rock Quality Designation
PL	Point Load Test
A	Point Load Test (axial)
D	Point Load Test (diametral)
L	Point Load Test (irregular Lump)
BH	Borehole
TP	Test Pit

Water/Moisture

D	Dry
M	Moist
W	Wet
▶	First noted depth of water ground water inflow
▼	Steady Water Level

Soil Properties

C_u	Undrained Shear Strength
C'	Effective Shear Stress
Φ_u	Angle of friction – Undrained
Φ'	Angle of friction – Drained
γ	Unit Weight
G_s	Specific Gravity
MC	Moisture Content
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
WPI	Weighted Plasticity Index
LS	Linear Shrinkage
PSD	Particle Size Distribution
D_n	n% of particles smaller than specified diameter

k	Hydraulic Conductivity
M_v	Coefficient of Volume Compressibility
C_α	Coefficient of Secondary Compression
C_c	Compression Index
C_v	Coefficient of consolidation
OCR	Over Consolidation Ratio
e	Void Ratio
n	Porosity
E	Elastic Modulus
CBR	California Bearing Ratio
UCS	Unconfined Compressive Strength
Is(50)	Point Load Strength Index
MDR	Moisture Density Relationship
DD	Dry Density
WD	Wet Density
MDD	Maximum Dry Density
OMC	Optimum Moisture Content
SDDR	Standard (compactive effort) dry density ratio
DOS	Degree of Saturation
APD	Apparent Particle Density
Y_s	Characteristic Surface Movement
Iss	Shrink/Swell Index
H_s	Depth of design soil suction change
H_t	Maximum drying depth close to a tree
σ	Total stress
σ'	Effective stress
u	Pore Water Pressure

Foundation Design

q_u	Ultimate soil bearing capacity (shallow foundations)
q_a	Allowable soil bearing capacity (shallow foundations)
f_s	Ultimate shaft friction (piled foundations)
f_b	Ultimate base bearing pressure (piled foundations)
R_{dg}	Ultimate geotechnical strength (Compression)
R_{ug}	Ultimate geotechnical strength (Uplift)
ϕ_g	Geotechnical Strength Reduction Factor
f'_c	Design characteristic strength of concrete

Standards and Specifications

AS	Australian Standards
MRD	Department of Transport and Main Roads
MRS	Main Roads Specification
MRTS	Main Roads Technical Specification
ISO	International Organization for Standardization

Miscellaneous

CTB	Cement treated base
RSS	Reinforced soil structure
CFA	Continuous flight auger
CH	Chainage

APPENDIX D

LABORATORY TEST CERTIFICATES

Material Test Report

Report Number: DE21/264-2
Issue Number: 1
Date Issued: 02/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15378
Dates Tested: 10/02/2022 - 24/02/2022
Location: Yarrabilba

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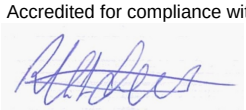

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Shrink Swell Index AS 1289 7.1.1 & 2.1.1					
Sample Number	D22-15378A	D22-15378B			
Date Sampled	09/02/2022	09/02/2022			
Date Tested	24/02/2022	24/02/2022			
Material Source	In-Situ	In Situ			
Sample Location	BH6-1 (0.50m - 0.72m)	BH8-2 (0.30m - 0.58m)			
Inert Material Estimate (%)	1	1			
Pocket Penetrometer before (kPa)	450	450			
Pocket Penetrometer after (kPa)	210	400			
Shrinkage Moisture Content (%)	25.4	20.2			
Shrinkage (%)	**2.4**	**2.6**			
Swell Moisture Content Before (%)	28.0	21.0			
Swell Moisture Content After (%)	29.8	22.7			
Swell (%)	**0.3**	**0.5**			
Shrink Swell Index Iss (%)	**1.4**	**1.6**			
Visual Description	silty Clay	silty Clay			
Cracking	MC	SC			
Crumbling	No	No			
Remarks	**	**			

Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.
Cracking Terminology: UC Uncracked, SC Slightly Cracked, MC Moderately Cracked, HC Highly Cracked, FR Fragmented.
NATA Accreditation does not cover the performance of pocket penetrometer readings.

Material Test Report

Report Number: DE21/264-6
Issue Number: 1
Date Issued: 06/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15698
Dates Tested: 23/03/2022 - 29/03/2022
Location: Yarrabilba

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Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Shrink Swell Index AS 1289 7.1.1 & 2.1.1					
Sample Number	D22-15698A	D22-15698B	D22-15698C	D22-15698D	D22-15698E
Date Sampled	22/03/2022	22/03/2022	22/03/2022	22/03/2022	22/03/2022
Date Tested	29/03/2022	29/03/2022	29/03/2022	29/03/2022	29/03/2022
Material Source	In-Situ	In-Situ	In-Situ	In-Situ	In-Situ
Sample Location	TP9-6 (0.60m - 0.80m)	TP10-4 (1.00m - 1.19m)	TP11-2 (0.80m - 1.06m)	BH12-3 (0.20m - 0.46m)	TP16-1 (0.60m - 0.84m)
Inert Material Estimate (%)	1	1	1	1	1
Pocket Penetrometer before (kPa)	450	350	600	600	600
Pocket Penetrometer after (kPa)	220	240	350	280	490
Shrinkage Moisture Content (%)	28.4	23.4	21.9	15.9	18.9
Shrinkage (%)	**5.4**	**3.7**	**3.4**	**0.3**	**1.6**
Swell Moisture Content Before (%)	32.8	20.1	18.6	20.5	14.9
Swell Moisture Content After (%)	37.1	23.9	24.3	25.2	17.4
Swell (%)	**0.8**	**0.0**	**0.2**	**0.8**	**0.1**
Shrink Swell Index Iss (%)	**3.2**	**2.1**	**1.9**	**0.4**	**0.9**
Visual Description	**	**	**	**	**
Cracking	SC	SC	UC	MC	SC
Crumbling	No	No	No	No	No
Remarks	**	**	**	**	**

Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.
Cracking Terminology: UC Uncracked, SC Slightly Cracked, MC Moderately Cracked, HC Highly Cracked, FR Fragmented.
NATA Accreditation does not cover the performance of pocket penetrometer readings.

Material Test Report

Report Number: **DE21/264-3**
Issue Number: 1
Date Issued: 03/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15379
Dates Tested: 10/02/2022 - 25/02/2022
Location: Yarrabilba

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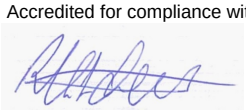

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Shrink Swell Index AS 1289 7.1.1 & 2.1.1					
Sample Number	D22-15379A	D22-15379B			
Date Sampled	09/02/2022	09/02/2022			
Date Tested	25/02/2022	25/02/2022			
Material Source	In-Situ	In-Situ			
Sample Location	BH14-3 (0.50m - 0.72m)	BH15-1 (0.50m - 0.78m)			
Inert Material Estimate (%)	1	1			
Pocket Penetrometer before (kPa)	450	300			
Pocket Penetrometer after (kPa)	270	160			
Shrinkage Moisture Content (%)	24.5	23.5			
Shrinkage (%)	**3.9**	**4.4**			
Swell Moisture Content Before (%)	21.5	20.0			
Swell Moisture Content After (%)	28.5	28.9			
Swell (%)	**0.4**	**1.5**			
Shrink Swell Index Iss (%)	**2.3**	**2.9**			
Visual Description	silty Clay	silty Clay			
Cracking	SC	SC			
Crumbling	No	No			
Remarks	**	**			

Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.
Cracking Terminology: UC Uncracked, SC Slightly Cracked, MC Moderately Cracked, HC Highly Cracked, FR Fragmented.
NATA Accreditation does not cover the performance of pocket penetrometer readings.

Material Test Report

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Report Number: DE21/264-4A
Issue Number: 1
Date Issued: 09/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15509
Sample Number: D22-15509A
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 04/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP6-3 (0.30m - 0.70m)**
Material Source: Silty CLAY

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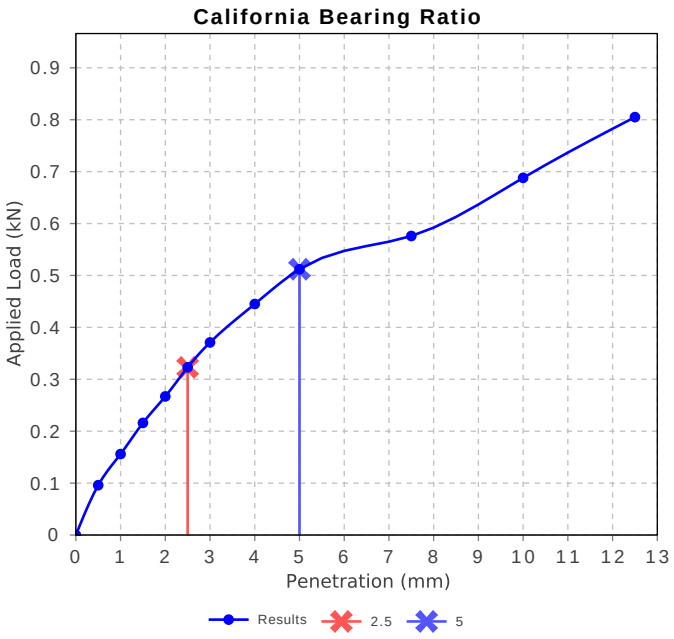
Senior Technician
NATA Accredited Laboratory Number: 1169

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**2.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.67		
Optimum Moisture Content (%)	21.0		
Laboratory Density Ratio (%)	100.5		
Laboratory Moisture Ratio (%)	98.0		
Dry Density after Soaking (t/m^3)	1.63		
Field Moisture Content (%)	24.3		
Moisture Content at Placement (%)	20.8		
Moisture Content Top 30mm (%)	27.6		
Moisture Content Rest of Sample (%)	22.2		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	49.0		
Swell (%)	3.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

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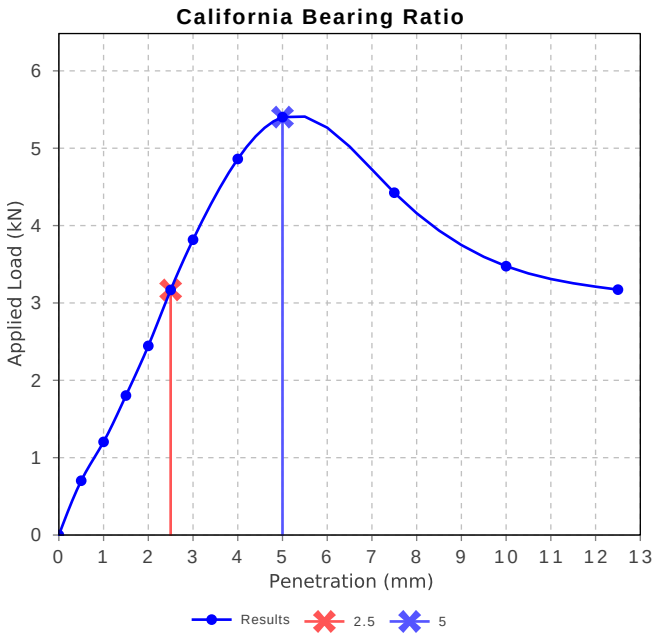
Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-7A**
Issue Number: 1
Date Issued: 08/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15697
Sample Number: D22-15697A
Date Sampled: 21/03/2022
Dates Tested: 23/03/2022 - 31/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP8-9 (0.20m - 0.80m)**
Material Source: Silty SAND

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**25**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.77		
Optimum Moisture Content (%)	11.5		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	99.0		
Dry Density after Soaking (t/m^3)	1.77		
Field Moisture Content (%)	5.2		
Moisture Content at Placement (%)	11.5		
Moisture Content Top 30mm (%)	11.7		
Moisture Content Rest of Sample (%)	14.5		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	2.0		
Swell (%)	-0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

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Report Number: DE21/264-4B
Issue Number: 1
Date Issued: 09/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15509
Sample Number: D22-15509B
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 03/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP9-3 (0.30m - 0.90m)**
Material Source: Clayey SAND

NATA WORLD RECOGNISED ACCREDITATION

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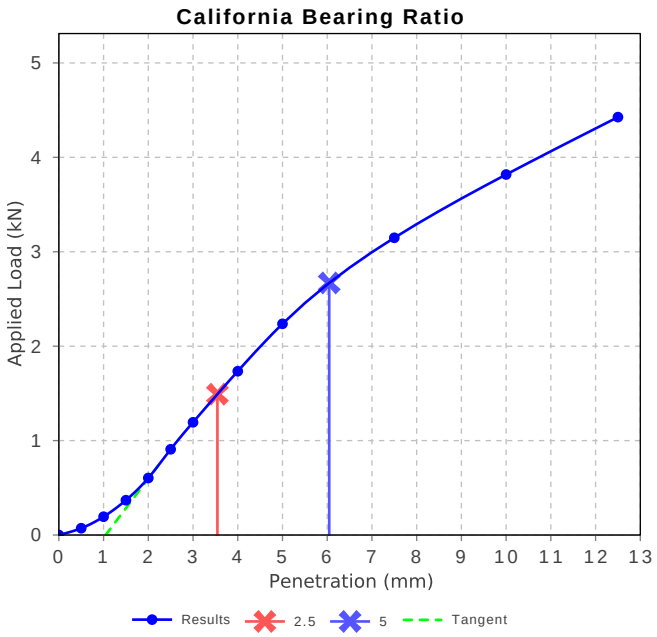
Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**13**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.88		
Optimum Moisture Content (%)	13.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.5		
Dry Density after Soaking (t/m^3)	1.89		
Field Moisture Content (%)	13.3		
Moisture Content at Placement (%)	13.2		
Moisture Content Top 30mm (%)	13.7		
Moisture Content Rest of Sample (%)	13.6		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	26.1		
Swell (%)	-0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

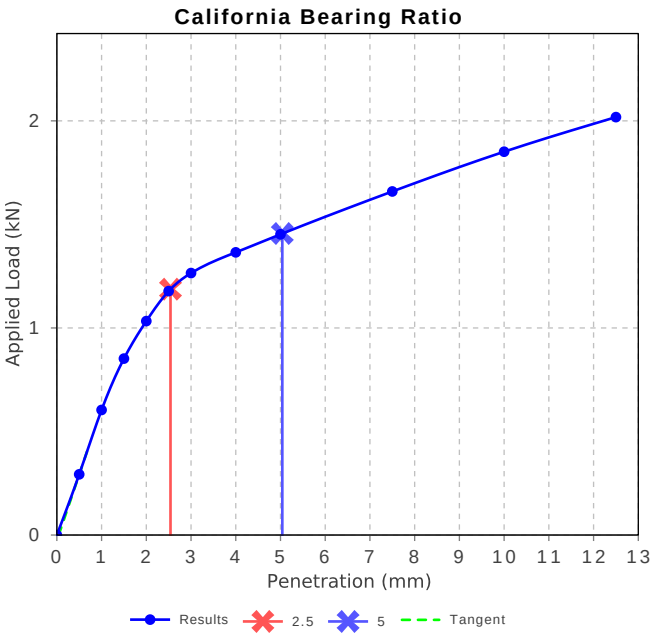
MORRISON GEOTECHNIC
Brisbane | Gold Coast | Maroochydore
Morrison Geotechnic Pty Ltd
ABN: 51 009 878 899
Brisbane Laboratory
Unit 1, 35 Limestone Darra QLD 4076
Phone: (07) 3279 0900
Email: rmitchell@mgeo.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-7C**
Issue Number: 1
Date Issued: 08/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15697
Sample Number: D22-15697C
Date Sampled: 21/03/2022
Dates Tested: 23/03/2022 - 01/04/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP10-6 (0.90m - 1.30,)**
Material Source: Silty CLAY

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**9**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.68		
Optimum Moisture Content (%)	21.5		
Laboratory Density Ratio (%)	100.5		
Laboratory Moisture Ratio (%)	98.0		
Dry Density after Soaking (t/m^3)	1.69		
Field Moisture Content (%)	22.1		
Moisture Content at Placement (%)	20.8		
Moisture Content Top 30mm (%)	23.1		
Moisture Content Rest of Sample (%)	21.2		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	51.9		
Swell (%)	-0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

MORRISON GEOTECHNIC
Brisbane | Gold Coast | Maroochydore
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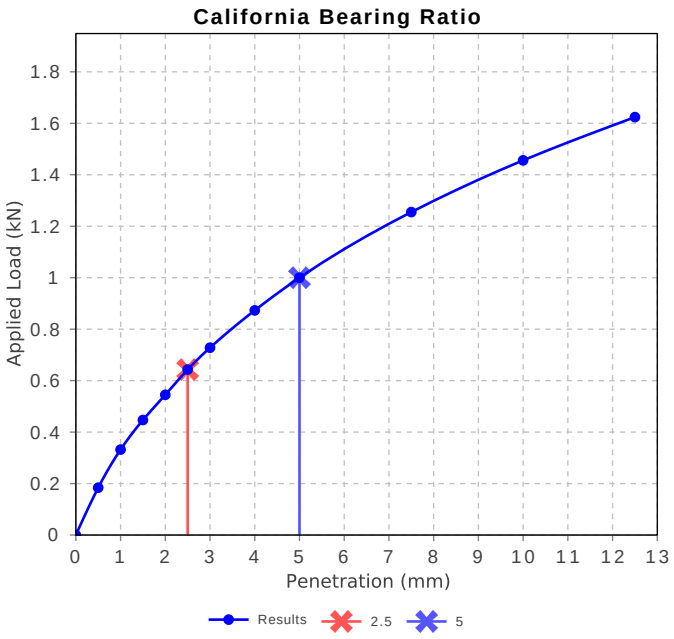
Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-7E**
Issue Number: 1
Date Issued: 08/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15697
Sample Number: D22-15697D
Date Sampled: 21/03/2022
Dates Tested: 23/03/2022 - 02/04/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP11-6 (1.50m - 1.80m)**
Material Source: Sandy CLAY

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.82		
Optimum Moisture Content (%)	15.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	104.0		
Dry Density after Soaking (t/m^3)	1.80		
Field Moisture Content (%)	15.9		
Moisture Content at Placement (%)	15.8		
Moisture Content Top 30mm (%)	17.1		
Moisture Content Rest of Sample (%)	16.5		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	48.0		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

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Report Number: DE21/264-4C
Issue Number: 1
Date Issued: 09/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15509
Sample Number: D22-15509D
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 04/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP12-4 (1.00m - 1.60m)**
Material Source: Silty CLAY

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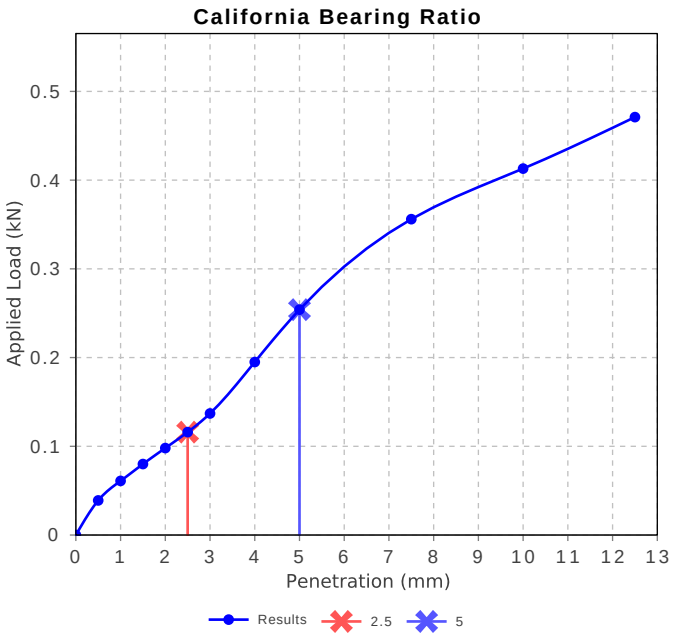
Senior Technician
NATA Accredited Laboratory Number: 1169

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**1.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.63		
Optimum Moisture Content (%)	21.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	101.0		
Dry Density after Soaking (t/m^3)	1.58		
Field Moisture Content (%)	24.2		
Moisture Content at Placement (%)	21.5		
Moisture Content Top 30mm (%)	30.6		
Moisture Content Rest of Sample (%)	24.1		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	50.4		
Swell (%)	3.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

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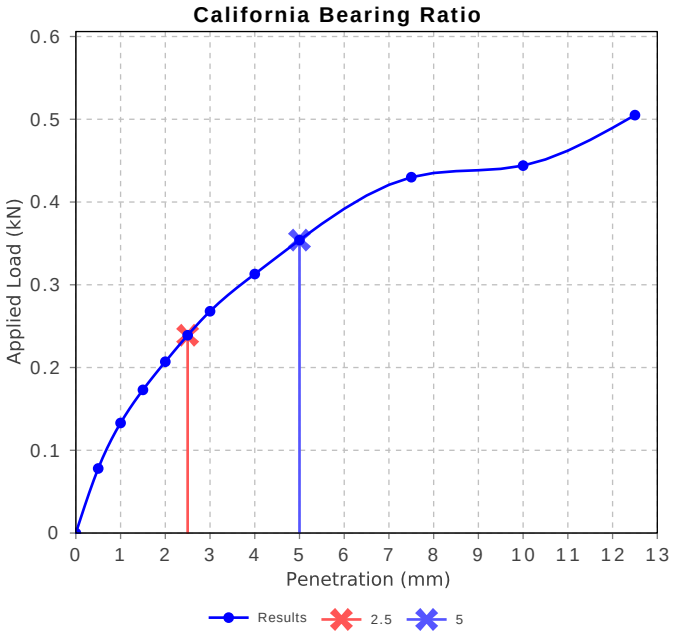
Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-5A**
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Material amended*
Date Issued: 12/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15510
Sample Number: D22-15510A
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 05/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP14-6 (1.20m - 1.60m)**
Material Source: Silty CLAY

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**2.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.68		
Optimum Moisture Content (%)	20.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	98.5		
Dry Density after Soaking (t/m^3)	1.61		
Field Moisture Content (%)	23.1		
Moisture Content at Placement (%)	19.9		
Moisture Content Top 30mm (%)	30.4		
Moisture Content Rest of Sample (%)	22.2		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	48.0		
Swell (%)	5.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

MORRISON GEOTECHNIC
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Report Number: DE21/264-5B
Issue Number: 1
Date Issued: 10/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15510
Sample Number: D22-15510B
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 03/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP15-1 (0.60m - 1.00m)**
Material Source: Clayey SAND

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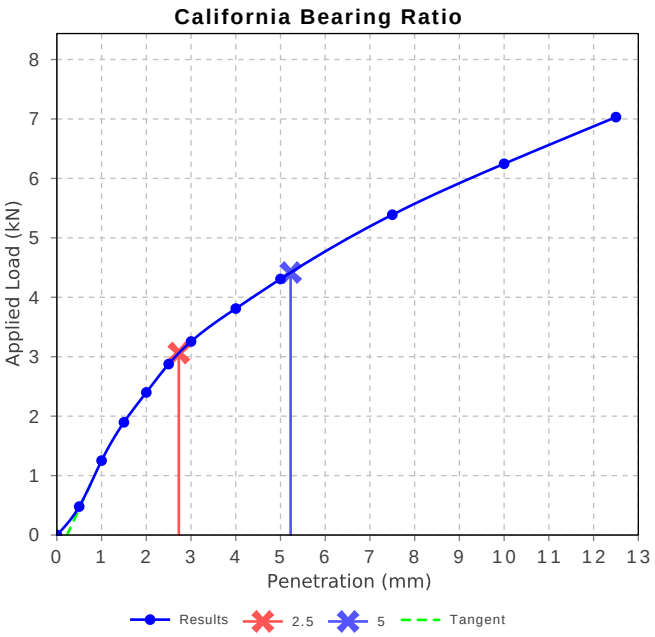
California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**25**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.94		
Optimum Moisture Content (%)	11.5		
Laboratory Density Ratio (%)	100.5		
Laboratory Moisture Ratio (%)	97.0		
Dry Density after Soaking (t/m^3)	1.96		
Field Moisture Content (%)	15.9		
Moisture Content at Placement (%)	11.0		
Moisture Content Top 30mm (%)	12.5		
Moisture Content Rest of Sample (%)	11.0		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	23.7		
Swell (%)	-0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

Report Number: **DE21/264-5C**
Issue Number: 1
Date Issued: 10/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15510
Sample Number: D22-15510D
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 03/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP16-4 (1.00m - 1.50m)**
Material Source: Sandy CLAY

MORRISON GEOTECHNIC
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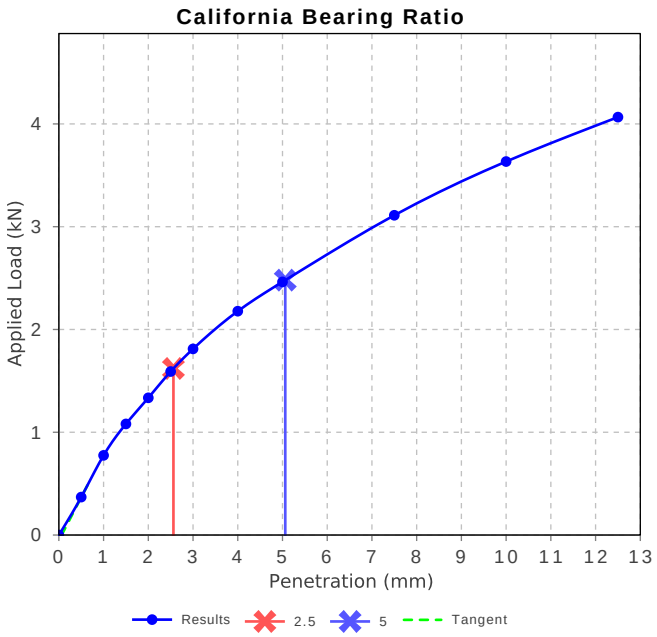
Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**13**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	VISUAL		
Maximum Dry Density (t/m^3)	1.80		
Optimum Moisture Content (%)	15.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	99.5		
Dry Density after Soaking (t/m^3)	1.81		
Field Moisture Content (%)	14.7		
Moisture Content at Placement (%)	14.8		
Moisture Content Top 30mm (%)	15.7		
Moisture Content Rest of Sample (%)	15.2		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	25.1		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

MORRISON GEOTECHNIC
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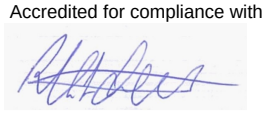

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-4D**
Issue Number: 1
Date Issued: 09/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15509
Sample Number: D22-15509A
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 09/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP6-3 (0.30m - 0.70m)**
Material Source: Silty CLAY

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	silty Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	26		

Material Test Report

MORRISON GEOTECHNIC
Brisbane | Gold Coast | Maroochydore
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Report Number: **DE21/264-7B**
Issue Number: 1
Date Issued: 08/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15697
Sample Number: D22-15697B
Date Sampled: 21/03/2022
Dates Tested: 23/03/2022 - 01/04/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **BH8-1 (0.50m - 0.95m)**
Material Source: Silty CLAY

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Senior Technician
NATA Accredited Laboratory Number: 1169

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	Silty CLAY		
Nature of Water	DISTILLED		
Temperature of Water (^{o}C)	25		

Material Test Report

MORRISON GEOTECHNIC
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Report Number: **DE21/264-4E**
Issue Number: 1
Date Issued: 09/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15509
Sample Number: D22-15509C
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 09/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **BH9-2 (1.00m - 1.45m)**
Material Source: Sandy CLAY

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Senior Technician
NATA Accredited Laboratory Number: 1169

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	sandy CLAY		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	26		

Material Test Report

Report Number: **DE21/264-7D**
Issue Number: 1
Date Issued: 08/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15697
Sample Number: D22-15697C
Date Sampled: 21/03/2022
Dates Tested: 23/03/2022 - 01/04/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP10-6 (0.90m - 1.30,)**
Material Source: Silty CLAY

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Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	Silty CLAY		
Nature of Water	DISTILLED		
Temperature of Water (^{o}C)	25		

Material Test Report

MORRISON GEOTECHNIC
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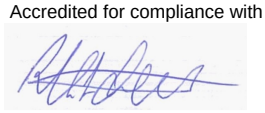

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-7F**
Issue Number: 1
Date Issued: 08/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15697
Sample Number: D22-15697D
Date Sampled: 21/03/2022
Dates Tested: 23/03/2022 - 01/04/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP11-6 (1.50m - 1.80m)**
Material Source: Sandy CLAY

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	Sandy CLAY		
Nature of Water	DISTILLED		
Temperature of Water (^{o}C)	25		

Material Test Report

MORRISON GEOTECHNIC
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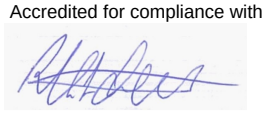

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-4F**
Issue Number: 1
Date Issued: 09/03/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15509
Sample Number: D22-15509D
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 09/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP12-4 (1.00m - 1.60m)**
Material Source: Silty CLAY

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	silty CLAY		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	26		

Material Test Report

MORRISON GEOTECHNIC
Brisbane | Gold Coast | Maroochydore
Morrison Geotechnic Pty Ltd
ABN: 51 009 878 899
Brisbane Laboratory
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Phone: (07) 3279 0900
Email: rmitchell@mgeo.com.au

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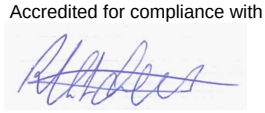

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-5D**
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Material Description amended*
Date Issued: 12/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15510
Sample Number: D22-15510A
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 10/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP14-6 (1.20m - 1.60m)**
Material Source: Silty CLAY

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	-		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	26		

Material Test Report

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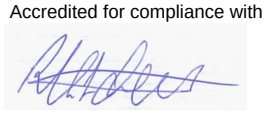

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-5E**
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Material Description amended*
Date Issued: 12/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15510
Sample Number: D22-15510C
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 10/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **BH15-3 (0.50m - 0.95m)**
Material Source: Silty CLAY

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	-		
Nature of Water	DISTILLED		
Temperature of Water (^{o}C)	26		

Material Test Report

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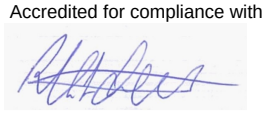

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Report Number: **DE21/264-5F**
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Material Description amended*
Date Issued: 12/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project Number: DE21/264
Project Name: GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15510
Sample Number: D22-15510D
Date Sampled: 22/02/2022
Dates Tested: 24/02/2022 - 10/03/2022
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **TP16-4 (1.00m - 1.50m)**
Material Source: Sandy CLAY

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	-		
Nature of Water	DISTILLED		
Temperature of Water (^{o}C)	26		

Material Test Report

Report Number: **DE21/264-1**
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Samples split over various pages*
Date Issued: 27/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project: DE21/264 - GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15383
Sample Number: D22-15383A
Date Sampled: 09/02/2022
Dates Tested: 11/02/2022 - 22/02/2022
Sample Location: **BH6-1 (3.00m - 3.10m)**
Material Source: SANDSTONE

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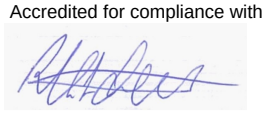

Approved Signatory: Rhys Mitchell
Senior Technician
NATA Accredited Laboratory Number: 1169

Determination of Point Load (AS 4133.4.1)								
Sample #	Specimen	Location	Test Type	I_s (Mpa)	$I_{s(50)}$ (Mpa)	Rock Type	Moisture Condition	Failure Mode
D22-15383A	1	BH6-1 (3.00m - 3.10m)	Diametral	2.69	2.7	**	**	**
D22-15383A	2	BH6-1 (3.00m - 3.10m)	Axial	1.65	1.6	**	**	**

Material Test Report

Report Number: **DE21/264-1**
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Client Reference: 4500371029
Work Request: 15383
Sample Number: D22-15383A
Date Sampled: 09/02/2022
Dates Tested: 11/02/2022 - 22/02/2022
Sample Location: **BH6-1 (3.00m - 3.10m)**
Material Source: SANDSTONE

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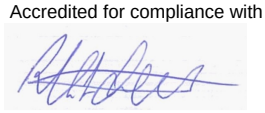

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Determination of Point Load (AS 4133.4.1)								
Sample #	Specimen	Location	Test Type	I_s (Mpa)	$I_{s(50)}$ (Mpa)	Rock Type	Moisture Condition	Failure Mode
D22-15383B	1	BH6-1 (6.60m - 6.70m)	Diametral	0.33	0.33	**	**	**
D22-15383B	2	BH6-1 (6.60m - 6.70m)	Axial	0.37	0.34	**	**	**

Material Test Report

Report Number: **DE21/264-1**
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Reissue Reason: *Samples split over various pages*
Date Issued: 27/04/2022
Client: GOLDING CONTRACTORS PTY LTD
P O BOX 1643, MILTON QLD 4064
Project: DE21/264 - GEOTECHNICAL INVESTIGATION
Project Location: YARRABILBA PRECINCTS 5, 6, 8, 9, 10, 11, 12, 14, 15, 16, 17
Client Reference: 4500371029
Work Request: 15383
Sample Number: D22-15383A
Date Sampled: 09/02/2022
Dates Tested: 11/02/2022 - 22/02/2022
Sample Location: **BH6-1 (3.00m - 3.10m)**
Material Source: SANDSTONE

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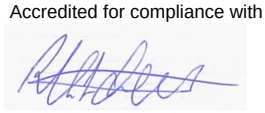

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Determination of Point Load (AS 4133.4.1)								
Sample #	Specimen	Location	Test Type	I_s (Mpa)	$I_{s(50)}$ (Mpa)	Rock Type	Moisture Condition	Failure Mode
D22-15383C	1	BH6-3 (2.60m - 2.70m)	Diametral	0.18	0.18	**	**	**
D22-15383C	2	BH6-3 (2.60m - 2.70m)	Axial	0.13	0.12	**	**	**

Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have 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. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE
THE BEST PEOPLE ON EARTH

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