Report on Geotechnical Investigation

7A-11 Racecourse Road, 1-3 Faunce Street and 38-50 Young Street

300304375-400.5

Prepared for
Waluya Pty Ltd

19 July 2024

Stantec

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1	22/09/2023	First Issue	NM	GA
2	8/02/2023	Revision to address Council comments	NM	GA

Our report is based on information made available by the client. The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Stantec is both complete and accurate. Whilst, to the best of our knowledge, the information contained in this report is accurate at the date of issue, changes may occur to the site conditions, the site context or the applicable planning framework. This report should not be used after any such changes without consulting the provider of the report or a suitably qualified person.

Version	Effective Date	Description of Revision	Prepared by	**Reviewed by**
3	14/03/2024	Revision to address Without Prejudice meeting comments	NM	GA
4	22/04/2024	Revision to address comments for conciliation conference	NM	GA
5	19/07/2024	Updated reference to latest plans	NM	GA

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1 Introduction

1.1 Overview

This report documents the results of the geotechnical investigation undertaken by Stantec Australia Pty Ltd (Stantec) for the proposed Bus Depot located at 7A-11 Racecourse Road, 1-3 Faunce Street and 38-50 Young Street West Gosford NSW ('the site').

The geotechnical investigation has been undertaken in accordance with Stantec's proposal (Ref No. *300304375 7A-11 Racecourse Road, 5-9 Faunce Street & 36 Young Street, West Gosford*, dated 21 December 2022) and was commissioned by Waluya Pty Ltd ('the client').

This geotechnical report has been prepared to assist in the detailed civil and structural design and construction of the proposed structure. This report was undertaken in conjunction with a contamination assessment "*Detailed Site Investigation - 7A -11 Racecourse Road, 1-3 Faunce Street & 38-50 Young Street, West Gosford*" dated 6 July 2023 [1].

Stantec were supplied the following documents by the client:

- Architectural Drawings for Development Application prepared by DEM (Aust) Pty Ltd (Project ref. 4548-00, Rev. A07, dated 15 July 2024).
- Structural Drawings prepared by Triaxial Consulting Pty Ltd (Project ref. TX17790.00, Drawing No. S1.01-S6.03, Issue B, dated 18 March 2024).

1.2 Proposed Development

Based on a review of the supplied plans, the proposed development is understood to comprise the following:

- Construction of an at grade bus parking lot comprising Ninety-six (96) spaces with finished design levels for the majority of the site approximately 9.0 m Australian Height Datum (mAHD);
- Construction of an at grade car park comprising one-hundred and thirteen (113) spaces;
- Office administration and workshop buildings;
- On site fuel storage and bus refuelling bowser; and
- Construction of multiple retaining walls on the perimeter of the site with a maximum height of approximately 6.22 m on the eastern perimeter.

1.3 Objectives

This geotechnical report outlines the investigation findings, provides comments on the implication of the geotechnical conditions as well as design and construction implications comprising:

- A description of soil conditions to a depth as necessary below natural surface level for the design of the building foundations and carpark pavements, including provision of relevant design parameters;
- Earthworks procedures and guidelines including site preparation, depth to rock and groundwater (if encountered), excavation conditions, temporary and permanent batter stability, slope stability considerations, the suitability of the site soils for use as fill, along with fill construction and compaction procedures;
- Identification of suitable footing types & founding levels including;
  - Recommendations on bearing pressures for foundations, including end bearing and skin friction for piles;
  - Advice on footing settlements;
- Retaining wall design parameters and recommendations; and
- Recommendations for internal pavement design.

2 Desktop Review

2.1 Previous Investigation

The geotechnical investigation was undertaken in conjunction with Detailed Site Investigation (DSI) to assess the site for actual or potential contamination. The DSI scope included collection and review of historical land titles; sampling of soils from 26 test pits, 18 hand auger locations and four groundwater wells; laboratory analysis of collected samples and preparation of a report.

The typical subsurface profile encountered during the DSI comprised uncontrolled filling to maximum depth of 2.2 m, overlying residual soils and sandstone bedrock. The filling was observed across the entirety of the site, comprised mostly of silty sand and gravelly sand. Anthropogenic inclusions within fill material were observed, including bricks, terracotta clay tiles, rubber, glass, ceramic tiles, timber, metal, PVC piping, aggregates and charcoal.

Asbestos in soil contamination was identified west of the stables structure within the site. Materials in this area are preliminarily classified as Special Waste (Asbestos) General Solid Waste (non-putrescible) for the purposes of offsite disposal.

Metals, TRH and PFOS contamination of soil and groundwater was identified in exceedance of adopted Tier 1 ecological criteria but are not considered to present an unacceptable risk to site users under the proposed land-use.

2.2 Published Data

2.2.1 Soil Landscape Maps

A review of the NSW Office of Environment and Heritage, eSPADE v2.2 mapping system [2] indicates that the site is situated within the Erina soil landscape (**9131er**) comprising of moderately deep to deep podzolic soils, located on undulating to rolling rises and low hills on the Terrigal Foundation of the Narrabeen Group. Soils of this landscape are generally strongly to very strongly acidic and highly plastic.

2.2.2 Regional Geology

Reference to the New South Wales (NSW) Seamless Geology dataset accessed on NSW Governments web mapping application “Minview” [3] indicates that the site is situated within the Burralow Formation (**Tngb**) which apart of the wider Gosford Subgroup. This is known to comprise fine grained, micaceous, quartz- to quartz-lithic sandstone; interbedded with siltstone, grey shale and red-brown claystone and residual soils derived from the weathering of the parent rock.

Figure 2-1 Summary of Site Geology

2.2.3 Acid Sulfate Soils

A review of the NSW Office of Environment and Heritage, eSPADE v2.2 mapping system [2] indicate that the site is located in an area of no known occurrences of Acid Sulfate Soils. Lands adjacent west and south-west of the site across Racecourse Road are mapped as Disturbed Terrain with potential for ASS between 0 and 1 m below ground level (mBGL).

Under the Central Coast LEP the site is mapped in a Class 5 area for ASS planning controls; in these areas development consent is required when “Works within 500 m of adjacent Class 1, 2, 3 or 4 land that is below 5 mAHD and by which the water table is likely to be lowered below 1 mAHD on adjacent Class 1, 2, 3 or 4 land.”

2.2.4 Mine Subsidence

Review of the NSW Government Planning Portal ‘Spatial Viewer’ web application indicates the site is not located within a known Mine Subsidence District.

3 Site Description

The investigated site of the proposed development is defined as an irregular parcel of land approximately 21,400m^2 situated within the Central Coast Council local governments area, enveloping the following 14 contiguous lots:

7A Racecourse Rd,	Lot 74/DP810836	38 Young Street,	Lot 12/DP1100110
9 Racecourse Rd,	Lot 73/DP810836	38 Young Street,	Lot 13/DP1100206
9A-11 Racecourse Rd,	Lot 72/DP810836	38 Young Street,	Lot 14/DP1100206
9A-11 Racecourse Rd,	Lot 71/DP810836	38 Young Street,	Lot 15/DP1100216
1-3 Faunce Street,	Lot 6/DP801261	38 Young Street,	Lot 16/DP1079150
38 Young Street,	Lot 1/DP651249	50 Young Street,	Lot 18/DP1100223
38 Young Street,	Lot 11/82/DP758466	50 Young Street,	Lot 20/82/DP758466

The site is bounded by Faunce Street to the north, Young Street to the east, Racecourse Road to the west, and commercial properties to the south. Gosford Racecourse is located to the west of the site beyond Racecourse Road, with commercial/industrial and the occasional residential occupancy further to the north, east and south.

Topographically the site is situated above the Narara Creek creek line to the west, at the foot of a large, steep rise (Waterview Park nature reserve) to the east, with immediate site slopes falling moderately to the south-west. It is expected surface flows will follow this trend.

Reference to the Mecone Mosaic [4] elevation contour data, elevations across the site range from approximately 16 mAHD within the north-eastern portion of the site to 6 mAHD within the south-western corner of the site.

The site had recently been subject to an intrusive contamination assessment by Stantec, which comprised the excavation of numerous test pits across the entire site and the installation of groundwater monitoring wells. This resulted in many locations of significant anthropogenic disturbance visible from the surface. The following features were also observed at the time of investigation:

- The site surface was generally covered by a combination of grass, gravel and concrete/asphalt associated with historical building slabs and roads. Gravels were observed to include anthropogenic materials such as brick, likely coal washery reject, and gravels were observed in-situ suggesting potential fill material.
- Some portions of the site were overgrown with long grass and woody trees or shrubs, therefore the ground surface could not be thoroughly inspected. Overgrown areas were generally associated with embankments along site boundaries and the edges of possible fill platforms.
- Numerous buildings / structures including:
  - Double-storey residential building
  - Garage
  - Horse arena
  - Enclosed horse stables and detached shed
  - Open horse stables
- The driveways and access roads in proximity to the buildings and structures on site were predominantly asphalt. The driveway south of the residential dwelling and cleared area in the north-east portion of the site was comprised of compacted gravels.
- Several areas of hardstand or building foundations were observed within the southern half of the site, the largest located at the south-east portion of the site.

4 Investigation Methodology

4.1 Field Investigation

Field investigation was undertaken on the 23-24th of May 2023 and comprised drilling of four (4) boreholes within the proposed building footprint, bus parking and areas of potentially deep excavation. Site investigations were undertaken by a geotechnical engineer and comprised the following:

> A site walkover and visual inspection by a geotechnical engineer from Stantec including site mapping and logging of significant site features.

> Drilling of four (4) boreholes (BH01, BH02, BH03 & BH04) using a track mounted drill rig fitted with 125 mm solid flight augers (SFA) and NMLC (diamond impregnated bit) coring where rock was encountered. Bores were excavated using Tungsten Carbide (TC) bit on Solid Flight Auger (SFA) augers to refusal on weathered rock where rock core techniques were utilised in BH01 & BH03. Final depth of the boreholes was measured at 8.8 m (BH01), 7.0 m (BH02), 8.4 m (BH03) & 9.2 m (BH04).

> Standard Penetration Tests (SPT) tests undertaken at regular intervals in all boreholes to assess subsurface soil strength and consistency properties.

> Disturbed and bulk samples of soils were taken for laboratory analysis and engineering log quality control.

4.1.1 Additional Investigation

Additional fieldwork was undertaken upon request of the client to address geotechnical related matters raised in the Statement of Facts and Contentions (SOFAC). The additional field investigation was conducted on the 25th January 2024 and comprised drilling of one (1) borehole within the proposed building footprint and area of proposed deep excavation associated with the construction of a retaining wall. Site investigations were undertaken by a geotechnical engineer and comprised the following:

> Drilling of one (1) borehole (BH05) using a track mounted drill rig fitted with 125 mm solid flight augers (SFA) and NMLC (diamond impregnated bit) coring where rock was encountered. The borehole was excavated using SFA to refusal on weathered rock at 3.0 m where rock core techniques were utilised to the target depth of 15.11 m.

> Standard Penetration Tests (SPT) tests undertaken at regular intervals in all boreholes to assess subsurface soil strength and consistency properties.

> Construction and installation of one (1) groundwater monitoring well to a depth of 14.85 m to assess groundwater levels.

> Development of groundwater monitoring well following construction, purging a minimum of three bore volumes of water utilising a steel bailer.

> A series of two (2) groundwater level monitoring events within the current (MW05) and previously installed (MW01-MW04) [1] groundwater monitoring wells to assess standing groundwater levels.

> Slug testing to assess infiltration and inflow/recharge rates for the proposed excavation and associated retaining wall.

A geotechnical engineer from Stantec carried out all fieldwork including logging of subsurface profiles and collection of samples. Logging of boreholes was undertaken in accordance with AS1726 [5]. Borehole and groundwater monitoring well locations are shown on Site Plan Figures F1 and F2 attached in Appendix A. Subsurface conditions are summarised in Section 5.1 and detailed in the engineering logs together with the explanatory notes attached as Appendix B.

4.2 Laboratory Testing

Laboratory testing undertaken on samples recovered from the site comprised the following:

- Three (3) four-day soaked California Bearing Ratio (CBR) tests on the existing site soils, including field moisture content and standard compaction testing
- Two (2) Atterberg Limits, two (2) Linear Shrinkage, and one (1) Particle Size Distribution test to assist in soil classification.
- Two (2) Shrink Swells Index tests to measure soil volume change over an extreme soil moisture content range.
- Six (6) soil aggressivity tests including pH, Electrical Conductivity (EC), Resistivity, Sulphate and Chloride.
- Point Load strength testing on numerous samples of rock core to aid rock strength classification.

All geotechnical laboratory testing was conducted at a NATA accredited construction materials testing laboratory. Aggressivity testing was undertaken at an external NATA accredited chemical testing facilities and the point load rock testing undertaken internally at Stantec's laboratory.

The results of the laboratory tests are summarised in Section 5.3 and detailed in the report sheets attached in Appendix C.

5 Investigation Findings

5.1 Geological Soil & Rock Units

The subsurface profile encountered during the investigation has been characterised into the following geotechnical units as shown below in Table 5-1, with borehole details and subsurface geotechnical unit depths summarised in Table 5-2 and Table 5-3 .

Table 5-1 Generalised Geotechnical Units

Origin	Unit (2)	Description	Consistency Range / Rock Strength 1	Moisture Condition / Rock Weathering
FILL	F1	Filling associated with previous use of the site comprising Silty / Silty Gravelly SAND and Sandy / Silty Sandy GRAVEL mixtures ranging from fine to coarse grained sand and fine to coarse angular to sub-rounded gravel components	-	D-M
RESIDUAL	R1	CL-CI(2) Sandy / Silty Sandy CLAY of low to medium plasticity, variable colour, fine to coarse grained sand. With occasional fine to coarse angular to sub-angular gravel inclusions	Stiff to Very Stiff	MC <PL to ~PL
EXTREMELY WEATHERED MATERIAL	E1	SC(2) Clayey SAND / SAND trace clay, of fine to coarse grain size, and white-grey in colour.	Dense	D-M
	E2	CL(2) Silty / Silty Sandy / Sandy CLAY of low to medium plasticity, predominately grey-white with some bands of red. Sand of fine to coarse grain size, trace inclusions of fine angular gravel. Grading towards weathered rock	Very Stiff to Hard	MC<PL
BEDROCK	W1	SANDSTONE; fine to coarse grained, grey-white with occasional red iron staining, bedded, with minor iron-stained banding.	Very Low to Low	XW-HW
	W2	SANDSTONE; fine to coarse grained, grey with red/orange iron staining, bedded.	Low to Medium	MW-SW
	W3	SILTSTONE; dark grey, laminated & with light grey SANDSTONE lenses.	Very Low to Low	XW-HW

Notes to table:
BGL: Below Ground Level
MC: Moisture Content
D: Dry
M: Moist
PL: Plastic Limit
XW: Extremely Weathered
HW: Highly Weathered
DW: Distinctly Weathered
SW: Slightly Weathered
(1) Inferred from Point Load Strength Index, Standard Penetrometer Tests (SPT) and Dynamic Cone Penetrometer (DCP) tests
(2) Refer to AS 1726-2017 [5], Tables 9 & 10 for group symbols.

Table 5-2 Summary of Borehole Details

Hole ID	Easting	Northing	Borehole Reduced Level (mAHD) (1)	Approx. Depth of Fill Materials (mBGL)	Approx Depth to Bedrock (mBGL)
BH01	344688.778	6300755.004	14.5	-	1.8
BH02	344656.961	6300713.493	10.0	0.2	6.8
BH03	344663.975	6263848.108	10.0	0.2	0.5
BH04	344656.014	6300585.766	12.0	0.3	-
BH05	344694.784	6300762.082	16.5	0.9	3.0

Notes to table:
(1) Based on available contour information and estimated to the nearest 0.5m increment
BGL: Below Ground Level
AHD: Australian Height Datum

Table 5-3 Summary of Subsurface Unit Depths

Unit ID	Depth To Base of Unit (mAHD)				
	BH01	BH02	BH03	BH04	BH05
Approximate Surface RL mAHD (1)	14.50	10.00	10.00	12.00	16.50
Unit F1	NE	9.80	9.80	11.70	15.60
Unit R1	13.40	7.20	NE	8.20	NE
Unit E1	NE	5.80	9.50	6.50	13.50
Unit E2	12.70	3.20	NE	2.80(2)	13.80
Unit W1	10.79	3.00(2)	4.80	-	12.79
Unit W2	7.63	-	3.63	-	1.39(2)
Unit W3	5.70(2)	-	1.74(2)	-	-

Notes to table:
(1) Based on available contour information and estimated to the nearest 0.5m increment.
(2) Borehole terminated
NE: Not Encountered

Despite minimal filling being encountered during this investigation, it should be noted that filling depths on the site have been observed during the concurrent DSI [1] of depths up to 2.2 m. It is noted that the deeper filling on the site is found predominately in the southwestern and southcentral portions of the site.

No groundwater was encountered during drilling exercises at the time of fieldwork. However, standing water levels were observed in groundwater monitoring wells during several monitoring events to depths of approximately 1.3 to 6.1 mBGL (4.0 to 10.5 mAHD) across the site.

It should be appreciated considering the site topography and material types encountered, groundwater levels are expected to be impacted by prolonged periods of inclement weather and changing climatic conditions.

5.2 Groundwater Monitoring

Following installation, MW05 was developed by purging with a steel bailer and groundwater levels allowed to stabilise prior to commencement of the monitoring. Standing groundwater levels (SWL) were assessed using an oil/water interface probe. SWL's within MW05 were assessed across two (2) monitoring events (30 and 31 January 2024), while MW01-MW04 SWL's were assessed over four (4) monitoring events (31 May 2023 [1], and 25, 30 & 31 January 2024). A summary of the standing groundwater levels is provided in Table 5-4 below.

Table 5-4 Summary of Groundwater Levels

Well ID	Elevation TOC (mAHD)	Standing Water Level (mAHD)		
		Minimum SWL	Maximum SWL	SWL 31/01/2024
MW01	5.92	4.58	4.58	N/E
MW02	5.85	4.11	4.51	4.12
MW03	11.93	9.59	9.71	9.59
MW04	14.40	10.70	11.1	10.71
MW05(1)	16.50	10.46	10.57	10.46

Notes to table:
mAHD: Elevation in reference to AHD.
TOC: Top of well casing
SWL: Standing water level.
N/E: Not encountered.
(1) Constructed in BH05

In addition to groundwater monitoring, infiltration testing was undertaken on 31st January 2024. Infiltration testing comprised rising-head permeability tests undertaken in MW05 to obtain a representative hydraulic conductivity (permeability) of the subsurface material.

The riding-head permeability test comprised displacement of water from the well (i.e. the removal of a 'slug') using a steel bailer. The recharge response was measured using a wireless submersible data logger/sensor. The logger was left in the well until the groundwater levels within the wells stabilised.

Monitoring of the piezometric pressure changes were undertaken using an In-Situ Rugged Troll 100. The recorded data were analysed using Win-Situ 5 software.

The data logger was attached to the underside of the well cap via stringline and inserted into the monitoring well after bailing. The logger was programmed to record the piezometric pressures immediately following insertion into the wells.

Following the completion of the monitoring, the data was retrieved from the logger and analysed using the Hvorslev method as described by M. J. Hvorslev in Time Lag and Soil Permeability in Ground-Water Observations (1951) [6] to determine an approximate permeability range. Calculation of permeability based on the rising-head results indicated a saturated hydraulic conductivity of the site subsurface profile to be in the order of $1x10^{-6}$ m/s.

It should be noted that the tests were not isolated to target discrete soil and rock layers and as such, the above value represent the average permeability of the subsurface strata and should be considered approximate. Groundwater levels are affected by factors such as site and climatic conditions, changes in the site and surrounding environment such as construction activities and are therefore subject to change.

5.3 Laboratory Test Results

5.3.1 Geotechnical

5.3.1.1 California Bearing Ratio Test Results

The previous results of the standard compaction CBR testing undertaken on representative samples of site materials, and are summarised below in Table 5-5 with the laboratory report sheets attached in Appendix C.

Table 5-5 Summary of CBR Test Results

Borehole ID	Depth (m)	Material Description	W (%)	SOMC (%)	SMDD (%)	Swell (%)	CBR (%)
BH02	0.4 – 1.3	Sandy CLAY	19.1	17.0	1.81	0.0	6.0
BH03	0.3 – 0.5	Clayey SAND, trace gravel	7.3	11.5	1.95	0.0	35.0
BH04(1)	0.3 – 1.5	Sandy CLAY, with some gravel	18.6	17.5	1.85	0.0	9.0

Notes to table:
(1) Identified on construction material testing report as TP209 as a result of an administrative error.
W: Field Moisture Content
SOMC: Standard Optimum Moisture Content
SMDD: Standard Maximum Dry Density

5.3.1.2 Shrink Swell Test Results

The results of the laboratory shrink swell tests undertaken on representative clayey soils of the site and results from relevant previous investigations are summarised below in Table 5-6 with the test report sheets attached in Appendix C.

Table 5-6 Summary of Shrink Swell Test Results

Test Location	Depth (m)	Material Description	E_{SW} (%)	E_{SH} (%)	I_{SS} (%)
BH02	0.4 – 1.3	Sandy CLAY	-0.0	3.0	1.7
BH04(1)	0.3 – 1.5	Sandy CLAY, with some gravel	-0.1	2.0	1.1

Notes to table:
E_{SW}: Swelling Strain
E_{SH}: Shrinkage Strain
I_{SS} Shrink Swell Index
(1) Identified on construction material testing report as TP209 as a result of an administrative error.

The results of the laboratory shrink-swell tests from the current investigation, summarised in Table 5-6, indicate that the tested natural clay materials generally range from slightly to moderately reactive.

5.3.1.3 Material Quality Test Results

The results of the laboratory Atterberg limits, linear shrinkage, and particle size distribution testing undertaken on representative materials encountered on site are summarised below in Table 5-7, with the test report sheets attached in Appendix C.

Table 5-7 Summary of Material Quality Test Results

Test Location	Depth (m)	Material Description	LL (%)	PL (%)	PI (%)	Linear Shrinkage (%)	Passing 2.36 mm	Passing 75 µm
BH02	0.4-1.3	Sandy CLAY	43	16	27	11.0	-	-
BH03	0.3-0.5	Clayey SAND, trace gravel	-	-	-	-	86	23
BH04(1)	0.3-1.5	Sandy CLAY, with some gravel	53	19	34	14.5	-	-

Notes to table:
LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
(1) Identified on construction material testing report as TP209 as a result of an administrative error.

The Atterberg Limits summarised in Table 5-7, indicate that the tested soil samples are of medium to high plasticity.

5.3.1.4 Point Load Testing

The results of the axial and diametric point load testing undertaken on selected rock core samples obtained from BH01, BH03 and BH05 are presented in Appendix C.

The results indicated that the sandstone formation (Unit W1) generally varied from very low to low strength, while sandstone formation (Unit W2) was generally medium strength, and interbedded sandstone & siltstone (Unit W3) formation generally very low strength.

5.3.2 Environmental Laboratory Results

5.3.2.1 Soil Aggressivity Results

The results of the soil aggressivity tests undertaken at the site on representative site soils encountered are summarised below in Table 5-8 with the report sheets attached in Appendix C. The samples have been assessed against AS 2159 for pile design [7] and AS 5100.5 for bridge design [8].

Table 5-8 Summary of Soil Aggressivity Test Results

Hole ID	Depth (m)	Geotechnical Unit	Soil Type and (Groundwater Condition) (1)	pH (1:2)	EC (µS/cm)	Resistivity (Ωcm)	Sulfate (mg/kg)	Chloride (mg/kg)	AS2159 Table 6.4.2(C) – Concrete Piles	AS2159 Table 6.5.2(C) – Steel Piles
BH01	1.1 - 1.3	Unit E2	Silty Sandy CLAY (B)	5.1	49	20000	51	<10	Mildly Aggressive	Non Aggressive
BH01	1.6 – 1.7	Unit E2	Silty Sandy CLAY (B)	5.1	51	20000	47	10	Mildly Aggressive	Non Aggressive
BH02	1.5 – 1.95	Unit R1	Silty Sandy CLAY (B)	4.4	79	210000	<10	83	Moderately Aggressive	Non Aggressive
BH03	0.05 – 0.15	Unit F1	Silty Sandy GRAVEL (B)	6.2	94	11000	39	10	Non Aggressive	Non Aggressive
BH04	0.5 – 0.95	Unit R1	Sandy CLAY (B)	4.3	190	5400	260	50	Moderately Aggressive	Non Aggressive
BH04	3.0 – 3.45	Unit R1	Sandy CLAY (B)	5.5	35	28000	35	10	Mildly Aggressive	Non Aggressive

Notes to table:

(1) Soil Condition (A) high permeability soils (e.g., sands and gravels) which are in groundwater. Soil Condition (B) for low permeability soils (e.g., silts and clays) or all soils above groundwater.

Scale of aggressivity obtained from AS2159 – 2009 [7] for piles in soil. Classification is based on the most onerous result.

Non Aggressive
Mildly Aggressive
Moderately Aggressive
Severely Aggressive
Very Severely Aggressive
– Not Tested/ Not Applicable

6 Earthworks

6.1 Overview

Based on the supplied information outlining anticipated design levels in combination with existing site reduced levels at the time of fieldwork, earthworks for the proposed development are expected to comprise a combination of cutting and filling proposed across the site to regrade existing surface levels to proposed design levels. The cut on site is approximately 7 m in the north-eastern corner, with the proposed fill approximately 3.5 m in the south-west corner.

6.2 Groundwater and Infiltration

Based on the results of the groundwater monitoring tests, groundwater was encountered at an elevation range approximately between 11.1 - 9.7 mAHD in MW03-MW05. Bulk excavations are expected to extend to roughly 9 mAHD and as such minor dewatering would be required.

Given the proposed depth of excavations in conjunction with measured site groundwater levels, it would be prudent to consider the interception of groundwater for the purpose of design and construction of the slab, foundations and retaining walls. Retaining walls should consider a hydrostatic pressure of 1/3 the wall height, or in some scenarios a hydrostatic pressure the full height of the wall, subject to the potential hydrostatic conditions behind each wall.

Groundwater levels encountered during the site investigations are expected to be impacted by prolonged periods of inclement weather and changing climatic conditions. It is recommended that the design of any structures expected to interact with the groundwater table consider a nominal hydrostatic pressure as well as potential for variation of the groundwater levels.

The extent of the dewatering would vary depending on the shoring/excavation strategy selected. Considering the infiltration testing indicated that inflows within the rock layer were 1×10^{-6} m/s, moderate groundwater inflows are expected for excavations below groundwater table. Water-tight shoring solutions such as secant piled wall or sheet piles will minimise the requirements for dewatering, however, the groundwater inflow through the base of the excavation would be expected.

Continuous dewatering would have an impact on the local hydrogeology and could potentially result in lowering the ground water table. This should be considered in the shoring wall design and construction methodology as it can result in ground settlement and potential damage to the neighbouring structures. However, it is expected that the groundwater table would not be lowered enough to impact the ASS documented as being located in the low-lying estuarine channel to the west of the site.

6.3 Excavations

Assessment of rock excavation conditions has been undertaken to provide an indication of excavation techniques required to achieve the foundation levels of the proposed structure. The assessment has been carried out based on rock strength and defect characteristics.

It should be noted a general assessment of rock mass excavatability is an indication only and is influenced by a number of factors such as:

- Excavation production rate and economic implications. For example, rock could be excavated using toothed bucket however with lower production rate compared to ripper attachment.
- Machine size and equipment used (ripper, bucket etc).
- Stability and traction of the machine during the excavation.
- Intact rock characteristics such as type, strength, weathering, density, abrasiveness and rock mass properties such as joint structure and orientation, defect spacing and seams.
- Presence of groundwater.

Generalised excavation conditions in weathered rock excavations have been carried out using methodologies outlined by Pettifer and Fookes (1994) [9], which is based on the rock point load strength and defect spacing and is summarised in Figure 6-1.

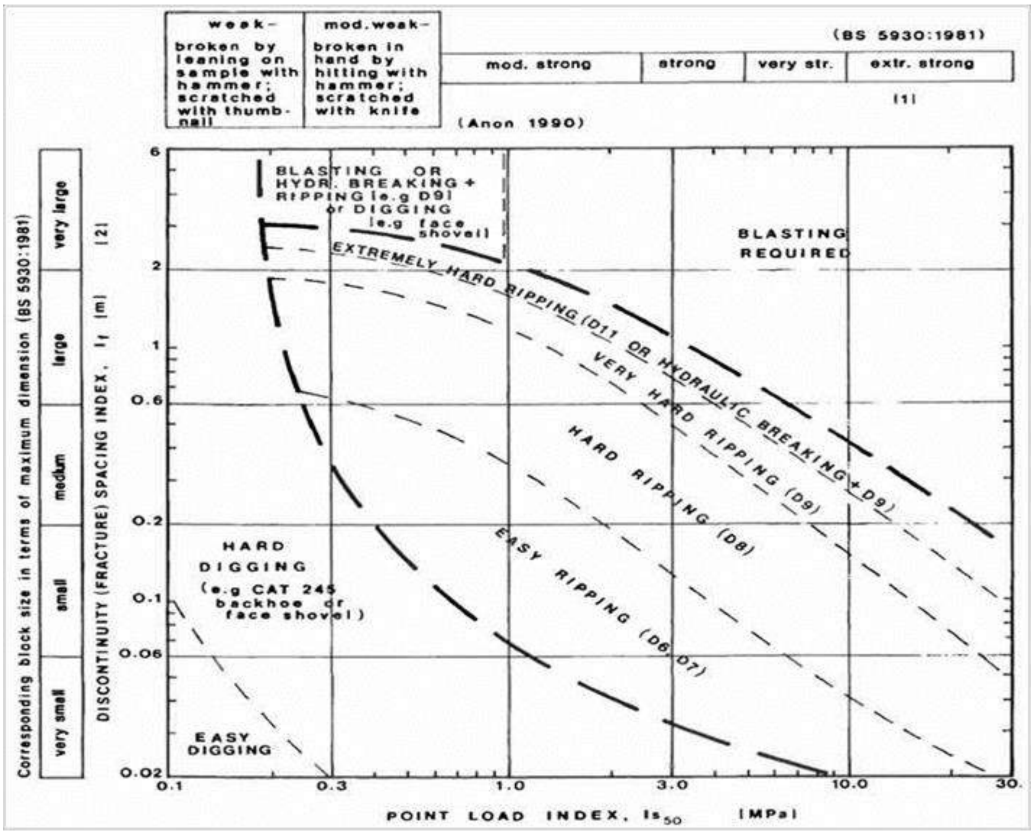

Figure 6-1 Excavatability in Relation Defect Spacing Vs $Is_{(50)}$

Based on Figure 6-1, any bulk excavations within the very low to low strength sandstone / siltstone bedrock are expected to be within the “easy digging” range, and thus will be able to be readily undertaken using a medium to large (25 tonne and above) excavator. Where deeper bulk excavations encounter low to medium strength sandstone, the excavatability is categorised as “hard digging” and “easy ripping”. This can be readily undertaken with the aforementioned machinery (backhoe or face shovel attachment) or alternatively through the use of a D8 Bulldozer. It should be noted that localised higher strength rock may be encountered during excavation. This should be considered when selected drilling and excavation equipment.

6.4 Cutting and Batters

Excavations or trenches in the residual soils (stiff or better) would be expected to stand close to vertical in the short-term, up to maximum height of 1.5 m and subject to geotechnical assessment by an experienced geotechnical consultant. Where personnel are to enter excavations, options for short-term excavations include benching or battering back of the excavations at 1H:1V or the support of excavations within the residual soil. Permanent batters in this material should be battered at 3H:1V or flatter and protected against erosion by vegetation. Where there is limited space to construct batters, the excavations will require lateral support.

Safe construction practices should be followed such as ensuring stockpiles / vehicles / plant are not placed adjacent the top of excavations, with a minimum clear horizontal distance equivalent to the depth of excavation.

6.5 Suitability of Cut Materials for Reuse or Disposal

6.5.1 Requirements for Waste Classification

Classification of the site in-situ material in accordance with the EPA guidelines "*Waste Classification Guidelines, Part 1: Classifying Waste"* [10] will be required prior to the removal off-site.

It is noted that a surface mantle of uncontrolled filling is present in sections across the site arising from the demolition of previous structures. Any existing uncontrolled filling will be reconditioned and re-used on site where appropriate, to allow for surplus of natural material which can be exported off site as VENM.

6.5.2 Requirements for Reuse in Reconstruction

Fill materials are expected to comprise of the following:

- Site won residual clays: Generally, soils excavated on site with the exception of topsoil and high silt content soils are considered suitable for reuse as engineering fill.
- Site won weathered rock: Generally, site won rock would comprise predominantly of weathered sandstone, and would be suitable for re-use. Rock is expected to be present at a design foundation level within the areas of cut. The weathered rock is considered suitable as general fill to support foundations or subgrade fill for road pavements.

6.6 Filling

Fill to be subject to structural loading must be placed and compacted in accordance with AS 3798-2007 *Guidelines on Excavation for Commercial and Residential Structures* [11]. The following procedure should be adopted for construction of filling:

- Filling should be placed on stripped surfaces which are free of uncontrolled fill, topsoil or other deleterious material. Stripped surfaces should be inspected by an experienced geotechnical consultant prior to fill placement.
- The fill material must be free of vegetation such as tree stumps, roots, root fibres or other organic matter.
- Fill should not comprise material with particle sizes of greater than 100 mm or 2/3 of the compacted layer thickness.
- Where fill is to be placed on slopes steeper than 8H:1V, benching will be required. This should comprise horizontal benches with adequate width (minimum 1.0m) to accommodate the nominated compaction equipment.
- Placement of fill in uniform horizontal layers with compaction of each layer to a minimum dry density ratio of 95% standard Compaction (AS 1289-5.5.1) at moisture contents in the order of 85-115% of SOMC or ±2% but generally as close to SOMC as practical. Over compaction should be avoided.
- Placement of fill in exceedance of 2m in height is recommended to have compaction of each uniform layer to a minimum dry density ratio of 98% Standard Compaction (AS 1289-5.5.1).
- Within the road alignment, subgrade formation should be in accordance with Section 9.2.1 and the moisture specification will need to be maintain at -2 to 0% of OMC.
- Where vibratory equipment is proposed, the potential for vibration transfer to neighbouring structures and potential damage should be considered by the contractor.

6.7 Slope Stability

It is noted that the site does not meet the requirements to be identified as having landslip potential in accordance with Chapter 3.7 of Central Coast Council's Development Control Plan (DCP) [12]. However, due to the presence of steeper site slopes and depth of proposed excavations along the north and eastern boundaries, it is recommended that slope stability considerations factor into the design and construction methodology. At a minimum, it is expected that the following be implemented:

- Footings to be founded below uncontrolled filling in competent strata (i.e. residual clays / bedrock).
- Sufficient drainage with a suitable discharge point be incorporated into the proposed infrastructure to prevent surface water from infiltrating into the ground.
- Cuttings are supported by retaining walls.
- Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill.

6.8 Acid Sulfate Soils

A preliminary Acid Sulfate Soils (ASS) assessment has been undertaken to assess the presence of ASS. The desktop assessment comprised a review of available published geological data and Acid Sulfate Soils (ASS) risk maps. Any visual or olfactory observations during the subsurface investigation were also recorded.

The desktop review and investigation has revealed the following.

- The site soils generally comprise residual and extremely weathered sand / clay, and weathered rock.
- A review of the NSW Office of Environment and Heritage, eSPADE v2.2 mapping system [2] indicate that the site is located in an area of no known occurrences of Acid Sulfate Soils. Lands adjacent west and south-west of the site across Racecourse Road are mapped as Disturbed Terrain with potential for ASS between 0 and 1 m below ground level (mBGL).
- Under the Central Coast LEP the site is mapped in a Class 5 area for ASS planning controls; in these areas development consent is required when "Works within 500 m of adjacent Class 1, 2, 3 or 4 land that is below 5 mAHD and by which the water table is likely to be lowered below 1 mAHD on adjacent Class 1, 2, 3 or 4 land."
- Site elevations range from approximately 16 mAHD within the north-eastern portion of the site to 6 mAHD within the south-western corner of the site.
- No ASS indicators were observed during the subsurface investigations.

Based on the above, it is expected that acid sulfate soils will not be encountered at the site and as such, an Acid Sulfate Soil Management Plan (ASSMP) would not be required for the proposed works.

Further commentary on the impacts of site groundwater on the high-risk ASS areas to the west of the site is documented by Stantec's contaminated lands team in *Detailed Site Investigation* report [1] (refer to Section 10.2.3).

7 Foundation Conditions & Design Recommendations

The design parameters and recommendations that are presented in the following sections should be used as guidance for the design. The detailed design of the foundations should consider the appropriate structural loads against serviceability and ultimate limit state criteria.

7.1 Aggressivity

Based on the summary of analytical results presented in Section 5.3.2 on the basis of Chlorides, Sulfates, pH and resistivity, it was found that the residual, and extremely weathered soils samples were predominately mildly to moderately aggressive towards potential buried concrete, however, the analysed materials were non-aggressive to buried steel elements based on exposure classification.

Soils can be generally categorised as exposure classification B2 when compared against AS5100.5-2017 [8].

7.2 Site Sub-Soil Classification for Earthquakes

Based on the encountered subsurface conditions in conjunction with the proposed earthworks for the site, it is expected that two subsoil classifications are required for the site.

For the purposes of earthquake design, the site has been given the following site sub-soil classifications in accordance with AS1170.4 – 2007 [13].

- **Class B_e – Rock** for the central portion of the site where cut is proposed; and
- **Class C_e – Shallow Soil Site** for the northern and eastern portion of the site where fill is proposed.

The hazard factor (Z) for Gosford, NSW is 0.09 as seen also in AS1170.4 – 2007 [13].

7.3 Shallow Foundation Design

Shallow footings designed in accordance with engineering principles and founded in R1 strata (stiff or better clay) and below uncontrolled fill or other deleterious material), may be proportioned on an allowable bearing capacity of 150kPa. Shallow foundations should be embedded a minimum of 0.5m in R1 strata.

Based on the supplied architectural plans and encountered founding conditions, it is anticipated that shallow foundations may be used to support all structural elements. As such, recommended design parameters are presented below in Table 7-1.

Table 7-1 Geotechnical Design Parameters for High Level Footings

Geotechnical Unit	Allowable Bearing Pressure (kPa)	Modulus of Subgrade Reaction (ks) (1,2,3) (kPa/m)
R1 – Residual Clay	150	20,000 - 24,000
E1 – Extremely Weathered Material (Sand)	400	50,000 – 70,000
E2 – Extremely Weathered Material (Clay)	400	50,000 – 60,000

Notes:
(1) Vesic empirical formula used to estimate modulus of subgrade reaction (ks).
(2) Preliminary ks provided, exact values are dependent on the footing size and footing stiffness.
(3) ks provided based on strip footing width and spring spacing's of 1.0 m

It should be noted that the modulus of subgrade reaction (ks) value is preliminary as it is based on elastic formulas, this value should be corrected in detailed design considering the stiffness of proposed footings. Additionally, springs should be capped to soil yielding pressure to prevent inaccurate results during finite element modelling.

All footings should be founded below any uncontrolled fill or deleterious materials. All footings for the same structure should be founded on strata of similar stiffness and reactivity to minimise the risk of differential movements.

All footings excavations should be inspected prior to installation of structural steel by a suitably experienced engineer or geotechnical consultant to confirm that the founding conditions are as described in this report. All loose material should be cleared from the footing excavations before concrete is poured.

It is recommended that detailed modelling be undertaken during structural design to assess the feasibility of high-level foundations, to analyse expected settlements and soil-structure interaction.

7.4 Deep Foundation Design

Where shallow foundations are found to be unsuitable for support of the loads, deep foundations would be a viable option. Bored concrete pile foundations embedded into the underlying sedimentary bedrock would be appropriate to support the proposed site structures.

General design parameters and recommendations are presented in the following sections and should be used as guidance for the design. The detailed design of the foundations should consider the appropriate structural loads against serviceability and ultimate limit state criteria.

7.4.1 Design Criteria

Design of the proposed structure foundations should be undertaken in accordance with the requirements of the following:

- AS 2159 (2009) Piling – Design & Installation [7]
- AS 5100 (2017) Bridge Design Set (Parts) [14]
- Other relevant Australian and international standards
- Engineering principals

The foundation detailed design should include assessments of both strength and serviceability limit states. General design parameters are presented in the following sections and should be used as guidance for the design.

7.4.2 Foundation Material

Based on the subsurface profile encountered in the boreholes drilled, the subsurface profile across the founding conditions is expected to generally comprise:

- Unit R1: Stiff to very stiff residual silty clays are present below the surficial filling.
- Unit E1: Dense residual clayey sands containing sandstone fragments grading towards extremely weathered rock.
- Unit E2: Very stiff to hard residual clays containing siltstone / sandstone fragments and grading towards extremely weathered rock.
- Unit W: Sedimentary bedrock of Gosford Subgroup formation is present from below Units E1 / E2 and comprises:
  - Unit W1: Very low to low strength interbedded sandstone and siltstone with defect spacing of greater than 60mm is present below E1 to approximately 4.8 mAHD. This bedrock corresponds approximately to Class V Sandstone as per as P.J.N Pells [15].
  - Unit W2: Low to medium strength sandstone with defect spacing of generally greater than 60mm is present below Unit W1 to the depths of approximately 3.6 mAHD. This bedrock corresponds approximately to Class IV Sandstone as per as P.J.N Pells [15].
  - Unit W3: Very low to low strength siltstone with defect spacing of generally greater than 60mm is present below Units W1 & W2 to the depths of investigation. This bedrock corresponds approximately to Class IV Shale as per as P.J.N Pells [15].

7.4.3 Bored Piles

7.4.3.1 Bored Pile Design

For the pile foundations, AS 2159-2009 [7] requires that the ultimate design geotechnical strength ($R_{d,g}$) is not less than the design action effect (E_d). The design geotechnical strength is calculated as the ultimate geotechnical strength ($R_{d,ug}$) multiplied by a geotechnical strength reduction factor (ϕ_g).

The value of the geotechnical strength reduction factor is influenced by the following factors:

- ϕ_{gb} – Basic geotechnical strength reduction factor, which is influenced by an assessment of the various risk factors relating to the site, design methodology and the method of pile instillation.
- ϕ_{tf} – Intrinsic testing factor based on the type of pile testing to be undertaken; and
- K – Testing benefit factor dependant on the percentage of piles to be tested.

The assessment of individual risk ratings for risk factors as set out in Table 4.3.2 (A) of AS 2159-2009 [7] will need to be undertaken by the designer of the foundations. However, to assist in the design of foundations, an assessment of the average risk rating has been undertaken based on the following factors and assumptions:

- A level and quality of the geotechnical investigation that has been undertaken to date which includes in-situ testing including boreholes, rock coring and laboratory assessment of the rock strength properties;
- No pile load testing will be undertaken;
- Similar experience with the design of foundations with socket into sedimentary bedrock; and
- A competent and locally experienced piling contractor to install the piles.

Based on the assessment of the above factors and assumptions, an Average Risk Rating (ARR) for the design of the foundations into the weathered bedrock of 2.8 could be adopted.

Based on Table 4.3.2 (C) of AS 2159-2009 [7], an ARR of 2.5 to 3.0 is defined as moderate risk. The basic geotechnical strength reduction factor (ϕ_g) for single isolated piles (low redundancy system) founded into the weathered bedrock profile within the site is assessed to be 0.52. This reduction factor should also be applied for ultimate limit state design of the shallow foundations.

An increase in the geotechnical strength reduction factor could be adopted by adopting the following procedures:

- Inspection and certification of pile sockets by a suitably experienced geotechnical engineer.
- Pile testing regime depending on the type and extent of the testing. Dynamic testing of bored piles is not typically undertaken due the magnitude of column loads. Therefore, an increase on the basic geotechnical strength reduction factor by dynamic testing is not recommended. Osterberg, static or statnamic tests could be utilised to increase the geotechnical reduction factor.

For all piles where the basic geotechnical strength reduction factor is greater than 0.40, AS2159-2009 [7] requires the integrity of the pile shaft to be assessed by testing and inspection.

Consideration should be given towards Section 4.4.3 of AS2159-2009 [7] when considering the design of pile groups and that the ultimate design geotechnical strength ($R_{d,ug}$) of a group of piles in compression or uplift should take into account the effects of pile group action. It is recommended that the ultimate geotechnical strength shall be taken as the lesser of:

(a) The sum of the ultimate geotechnical strength capacities of the individual piles in the group; and
(b) The design ultimate geotechnical strength of an equivalent rigid block containing the piles and the soil between them.

Spacing of piles within a pile group should generally be not be less than 2.5 times the pile diameters unless a comprehensive assessment of group interaction is undertaken and as a result it’s confirmed this does not adversely affect the overall pile group.

For piles subject to uplift loads, the geotechnical design strength shall be modified by multiplying by a factor of 0.7 in addition to the geotechnical strength reduction factor. A cone pull-out mode of failure shall be considered where appropriate for single piles.

With regards to serviceability limit state, the design of rock sockets (in compression) shall address the vertical slip displacements between concrete shaft and rock. In addition, the side shear resistance is coupled with the end bearing load displacement behaviour in order to predict load displacement behaviour of the complete socket.

7.4.3.2 Bored Pile Parameters

Interpretation of the foundation conditions has been undertaken and presented in Section 7.4.2 based on the subsurface conditions encountered. The following section details design parameters for bored concrete piles and provides associated construction recommendations.

Design values presented in Table 7-2 assume:

- Pile foundations comprise centrally loaded piles suitably embedded into bedrock.
- Piles are constructed using appropriate construction practice.
- Serviceability limit state design is undertaken for the foundation to consider the settlement of the various foundation types and structural tolerances.

Inspection of the foundation conditions and pile excavations shall be undertaken by experienced geotechnical engineer to confirm the founding conditions and above values. All foundation excavations should be kept free of fall-ins and water ponding.

The proposed piling methodology must consider equipment sufficient for drilling into the described subsurface conditions and account for locally higher strength rock.

Table 7-2 Geotechnical Design Parameters for Pile Foundations

Description	Inferred Rock Class[1]	Design UCS (MPa)[5]	Serviceability End Bearing Pressure (MPa) [4]	Ultimate[6] End Bearing (MPa) [3]	Ultimate[6] Shaft Adhesion (Compression) within layer (kPa) [2]	Rock Mass Elastic Modulus (MPa)
Unit W1	Class V	2.0	1.0	4	150	100
Unit W2	Class IV	7.0	3.0	10	600	500
Unit W3	Class IV	2.0	1.0	3	150	200

Notes:
1- The inferred rock classifications are based on P.J.N Pells et al [15].
2- The shaft adhesion value is based on clean socket roughness of R2 [15] or better which must comprise grooves of depth 1-4mm, width greater than 2mm at spacing 50mm to 200mm.
3- At ultimate bearing pressure, large settlements greater than 5% of the minimum foundation dimensions are expected.
4- Serviceability bearing pressure is expected to cause settlement of <1% of footing dimension for foundations embedded in weathered rock.
5- Design UCS values based on interpretation of $I_{s(50)}$ and representative rock UCS values based on an assumed correlation factor of 20.
6- Ultimate loads shall be reduced by a Basic geotechnical strength reduction factor of 0.52 to obtain allowable pile loads.

The above design parameters are subject to inspection of the foundation conditions by experienced geotechnical engineer to confirm the founding conditions. All foundation excavations should be kept free of cave-ins and water.

An estimation of the required pile sockets and expected settlement estimation should be undertaken as part of the detail design of the piles.

8 Retaining Structures

8.1 Design Criteria

This section outlines design criteria and parameters for the purpose of retaining structures design. The following design criteria should be adopted for the design of the retaining structures and ground anchors:

- AS 4678 (2002) – Earth Retaining Structures [7];
- AS 3798 (2007) – Guideline on Earthworks for Commercial and Residential Developments [11]; and
- An accepted industry practice for global stability factors of safety (FOS) for slopes of 1.5 for long-term conditions and 1.3 for short term construction conditions.

For a simplified or preliminary design, a triangular earth-pressure distribution could be adopted. During detailed design, the designer should select earth pressure coefficients based on the specific geotechnical and geometrical situation under consideration. The retaining walls design should comprise an assessment of stability checks (internal, external, global) where applicable while the ground anchor design should comprise an assessment of pull-out capacity.

A geotechnical reduction factor (ϕ_g) of 0.5 is recommended to be applied to the estimated ultimate geotechnical strength (not parameters) for ultimate limit state design calculations.

8.2 Permanent Excavation Retention

The subsurface profile to be retained by the shoring structure is generally anticipated to comprise:

- Residual clays overlying weathered rock within the north and eastern borders of the site.
- Structural fill overlying residual clays in areas in the south-western corner of the site where filling may be required to reach design level.

It should be noted the above conditions are inferred from the discrete borehole locations and variation of the subsurface conditions should be considered in the design.

Soldier piles with shotcrete panel could be utilised for the shoring system, however, considering the presence of groundwater within the retained height of the proposed retaining structure, inflow into the excavation would be likely. To avoid this, contiguous or secant piled walls could be utilised. Given the presence of shallow bedrock within the excavation levels, it is likely that sheet piles would be infeasible.

Regardless of the shoring wall type selection, the deflection of the shoring wall must be considered during the design to prevent damage to the neighbouring structures. The design should also incorporate surcharge loading from the road and neighbouring structures as well as earth and groundwater pressures on the wall.

Given the retaining walls are expected to be up to 7m high in some sections of the site, it is likely that the walls will need to be permanently laterally restrained to avoid excessive lateral deflections. These lateral restraints would likely comprise ground anchors, however it is expected that the restraint type would be selected and designed during the detailed design of the retaining walls.

It should be noted that where the lateral restraints extend beyond the lot boundary, landowners’ consent would be required.

8.3 Retaining Wall Design Parameters

It is recommended to calculate the lateral earth pressure coefficient values based on the wall geometry, type and backfill/ground surface slopes using the values provided in the following table. The designer should reference to the requirements of AS 4678 (2002) – Earth Retaining Structures [7] for the selection of appropriate groundwater level for the design purpose. It should be noted groundwater was encountered in varying depths across the site, and levels can fluctuate with seasonal variations in climate.

Recommended design parameters for retaining walls and ground anchors are presented below in below in Table 8-1.

Table 8-1 Retaining Wall Design Parameters

Parameter	Unit R1 / Structural Fill(1)	E1	E2	Unit W1 / SANDSTONE	Unit W2 / SANDSTONE	Unit W3 / SILTSTONE
Drained Friction Angle (ϕ')	26°	40°	28°	28° (2)	33° (2)	21° (2)
Drained Cohesion (c')	5kPa	1 kPa	10 kPa	80 kPa	380 kPa	60 kPa
Bulk unit weight (kN/m^3)	18	20	20	22	22	22
At-Rest Earth Pressure Coefficient (K_0)	0.56	0.36	0.53	0.53	0.46	0.64
Active Earth Pressure Coefficient (K_A)	0.39	0.22	0.36	0.36	0.29	0.47
Passive Earth Pressure Coefficient (K_P)	2.56	4.60	2.77	2.77	3.39	2.1

Notes to table:
NA: Not Applicable
(1) Assumes structural fill is of similar material to existing site clays and compacted in accordance with AS 3798-2007 [11].
(2) Please note that parameters provided in Table 8-1 are based for Rankine Theory for earth pressures. This theory is typically only applicable to soils and not rock mass. However, it is understood retaining wall design is sometimes undertaken by idealising a rock mass using soil parameters. As such, the parameters for the extremely weathered rock have been calculated using known correlations and relationships between rock mass and soil profiles.

8.4 Construction Recommendations

- Retaining wall backfill should comprise granular free-draining material with appropriate separation geofabric placed between the wall and granular backfill;
- All foundations should be founded on similar strata to limit the effects of differential settlement or detailed analysis should be carried out to confirm expected movements are within design limits;
- Subsurface drainage lines should be placed behind the permanent and temporary (depending on the type) retaining wall, to direct seepage to appropriate points of discharge. Subsurface lines should be installed with consideration of maintenance and flush-out points;
- Additional surcharge loading from adjoining structures and roads should be taken into consideration when designing retaining walls; and
- Retaining wall foundations should be inspected by experienced geotechnical engineer.

9 Design Pavement Subgrade

Pavement subgrade assessment has been undertaken based on the findings of the geotechnical investigation and Central Coast Council (CCC) requirements. The following guidelines should be adopted for the design of the internal roads:

- Subgrade evaluation has been performed in accordance with Austroads AGPT02-17 Guide to Pavement Technology, Part 2: Pavement Structural Design [16]; and
- Cement and Concrete Association of Australia (C&CAA) (T51) Guide to Residential Streets and Paths [17].

9.1 Design Subgrade

Based on the supplied limited architectural plans, cut and fill depths to pavements could be estimated based on the interpolated levels of the bore locations. Subgrade conditions along the proposed internal roads, car/bus parking and areas of concrete hardstand are seen to generally comprise a mixture of residual sandy / silty sandy clays and subgrade fill to form proposed design subgrade levels.

Any general fill subgrade design CBR would be dependent on the material utilised. The results of the CBR tests previously undertaken on potential subgrade material indicate that the residual sandy clay soils encountered produced CBR values of 6 to 9%, while the extremely weathered material to weathered rock encountered produced CBR values of 35%.

With reference to above, a design CBR of 5% should be adopted for design.

9.2 Construction Notes

9.2.1 Subgrade Preparation

Where construction of a new pavement is proposed, subgrade preparation should be in general accordance with the relevant council construction specifications and the following procedures.

- Excavation to design subgrade level, with the stockpiling of the excavated material for reuse as filling (if acceptable) following the reconditioning and removal of organics and oversized material (if present). Material to be removed offsite for disposal or recycling where not required or not acceptable as fill. Where material is to be removed offsite it will require classification in accordance with relevant EPA guidelines.
- Excavation of loose and soft natural soils, and elimination of abrupt changes between subgrade conditions i.e. cohesive soils (clays) and granular soils (sands gravel).
- Fill material to be used as subgrade shall conform to the appropriate specifications as detailed in this report and Council specifications.
- Static proof-rolling of the exposed subgrade using a heavy (minimum 10 tonne) roller under the direction of an experienced geotechnical consultant.
- Loose or yielding areas should be excavated and replaced with compacted select fill or suitable subgrade replacement comprising of material of similar consistency to the subgrade.
- Where filling or subgrade replacement is required, the materials employed should be free of organics or other deleterious material and could compromise the existing site-won soils. For general subgrade filling the material should have a soaked CBR ≥ 3%.
- Compaction of the subgrade, filling or select should be to a minimum 100% of SMDD (or 70% Density Index for non-cohesive materials) in layers of not greater than 250mm loose thickness. Moisture contents should be within 70% to 90% of SOMC.

Following satisfactory preparation of the subgrade, the pavement should be placed in accordance with the requirements of the appropriate section of this report, depending on the proposed pavement type.

9.2.2 Pavement Drainage

The moisture regime associated with a pavement has a significant influence on the performance of the pavement since the stiffness/strength of the pavement materials and subgrade is dependent on the moisture content of the materials. Accordingly, to protect the pavement materials and subgrade from wetting up and softening, particular care would be required to provide a waterproof seal for the pavement materials and adequate surface and sub-surface drainage of the pavement and adjacent area.

It is suggested that an intra-pavement drain should be provided at the interface between any sections of variable pavements, and where new pavements join to existing pavements. Intra-pavement subsoil drains should be in accordance with RMS QA Specification R37 [18] or equivalent and should penetrate to the subgrade or to the base of any replaced subgrade material.

9.2.3 Subsoil Drainage

It is recommended that subsoil drainage be installed at subgrade level along both sides of constructed pavements where the road is in cut, to intercept any subsurface flows. Detailing of subsoil drainage should be in accordance with Austroads 2017.

The subgrade should be constructed with sufficient cross fall (normally 3%) to assist with any moisture entering the pavement not becoming trapped. The drains should be located below or behind the kerb to intercept any moisture ingress from outside and within the road alignment. Where there is no kerb or gutter the subsoil drain should be placed at the edge of the pavement formation. Subsoil drains will require flush-out points and regular maintenance to ensure their correct operation.

Attention to detail in drainage design and construction is essential for optimum performance. Expensive drainage systems can be blocked or otherwise prevented from operating by inappropriate construction procedures or drainage design. Poor performance of a drainage system can, in turn result in major deficiencies in pavement performance. It is acknowledged that provision of adequate surface and subsoil drainage in low-lying areas can be difficult; however, the provision of adequate pavement drainage is essential to performance. In these circumstances, the selection, construction and maintenance of appropriate drainage mechanisms is essential.

The suitability of subsoil drainage systems is dependent on the ability to adequately drain the pavement. Where there is insufficient fall to allow drainage, other pavement drainage measures such as drainage blankets and high permeability non-moisture sensitive pavement materials should be considered. The pavement design provided assumes drained pavement conditions.

The selection of appropriate construction materials that are insensitive to moisture change is essential in areas subject to periodic inundation and/or wet ground conditions.

9.2.4 Pavement Interface and Tie-in

It is recommended that where new pavement sections abut existing sections, the pavement should have a vertical construction joint to match the existing section. It should be noted that when variable pavements are abutted then the potential for localised failure is greater. Care should be exercised in the placement and compaction of the subgrade and pavements in this area to maximise the performance of the pavement.

Consideration should also be given to sealing any cracks that may develop between existing and new pavements, benching to tie in pavements and the use of a strain relieving membranes at the interface may be appropriate. The need for an intra-pavement drain can be assessed at the time of construction.

9.2.5 Construction Inspections

The subgrade will require inspection by an experienced geotechnical consultant after boxing out or filling to design subgrade level. The purpose of inspections is to confirm design parameters, assess the suitability of the subgrade to support the pavement and delineate areas which may require subgrade replacement / select and areas requiring remedial treatment prior to rehabilitation.

9.2.6 References

All works and materials used in construction should be designed and constructed in accordance with Council Specifications or as specified in this report. Where discrepancies may occur, clarification should be sought from Council.

Earthworks and testing should generally be undertaken in accordance with AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments [11] where not otherwise specified.

10 Limitations

Stantec have performed investigation and consulting services for this project in general accordance with current professional and industry standards. The extent of testing was limited to discrete test locations and variations in ground conditions can occur between test locations that cannot be inferred or predicted.

A geotechnical consultant or qualified engineer shall provide inspections during construction to confirm assumed conditions in this assessment. If subsurface conditions encountered during construction differ from those given in this report, further advice shall be sought without delay.

Stantec, or any other reputable consultant, cannot provide unqualified warranties nor does it assume any liability for the site conditions not observed or accessible during the investigations. Site conditions may also change subsequent to the investigations and assessment due to ongoing use.

This report and associated documentation were undertaken for the specific purpose described in the report and shall not be relied on for other purposes. This report was prepared solely for the use by Waluya Pty Ltd and any reliance assumed by other parties on this report shall be at such parties’ own risk.

References

[1] Stantec Australia Pty Ltd, “Detailed Site Investigation - 7A -11 Racecourse Road, 1-3 Faunce Street & 38-50 Young Street, West Gosford,” Stantec Australia Pty Ltd, July 2023.

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APPENDIX

A

FIGURES

DATE PLOTTED: 8 February 2024 2:20 PM BY : MCDONALD, NICK

NOTES:
Image underlay adapted from nearmaps aerial imagery (June 2023.

LEGEND:

BHXX	Approx. borehole locations and numbers from current investigation.
MWXX	Approx. groundwater monitoring well locations - Detailed Site Investigation (ref. 300304375_DSI_R002, July 2023)
🟦	Indicative site boundary.

Stantec Australia Pty Ltd | ABN 17 007 820 322
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Web: www.stantec.com

Drawn NM	Date 6/02/2024
Checked	Date
Designed	Date
Verified	Date
Approved	

Client: Waluya Pty Ltd

Project: Geotechnical Investigation
Racecourse Rd Bus Depot
West Gosford, NSW

Title: Geotechnical Testing Locations

Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

Project Number	Scale	Size
300304375-400	1:600	A3

Figure Number	Revision
F1	02

XREF's:
CAD File: U:\300304375_Data-In\Drawing\site _plan\Racecourse Rd Gosford West.v2.dwg

DATE PLOTTED: 8 February 2024 2:21 PM BY : MCDONALD, NICK

NOTES:

Image underlay adapted from supplied architectural plans.

LEGEND:

BHXX	Approx. borehole locations and numbers from current investigation.
MWXX	Approx. groundwater monitoring well locations - Detailed Site Investigation (ref. 300304375_DSI_R002, July 2023)
▭	Indicative site boundary.

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Drawn NM	Date 6/02/2024
Checked	Date
Designed	Date
Verified	Date
Approved	

Client: Waluya Pty Ltd

Project: Geotechnical Investigation
Racecourse Rd Bus Depot
West Gosford, NSW

Title: Geotechnical Testing Locations

Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

Project Number	Scale	Size
300304375-400	1:600	A3

Figure Number	Revision
F2	02

XREF's:
CAD File: U:\300304375_Data-In\Drawings\site_plan\Racecourse Rd Gosford West v2.dwg

APPENDIX

B

ENGINEERING LOG SHEETS

Stantec

BOREHOLE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW
Job No: 300304375-400.1

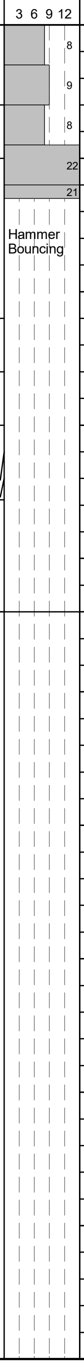
Hole No: BH01

Sheet: 1 of 3

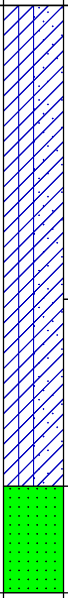
Position: Refer to Site Plan
Angle from Horizontal: 90°
Surface Elevation:
Rig Type: Massenza MI2
Mounting: Track
Driller: MG
Casing Diameter: HQ
Contractor: Stratacore Drilling P/L
Date Started: 5/23/23
Date Completed: 5/23/23
Logged By: NM
Checked By: TB

Depth (m)	Method	Resistance	Casing	Water	Sample or Field Test	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
0.00	125mm AD/T		HQ	Groundwater Not Encountered	D 0.30 - 0.50 m		Silty Sandy CLAY; low to medium plasticity, mottled red, yellow & white, fine to medium grained sand	M (≈PL) - M (<PL)	VSt - H	RESIDUAL SOIL
1.10m					D 1.10 - 1.30 m SPT 1.50 - 1.78 m 14, 6/130mm N*=R D 1.60 - 1.70 m		Silty Sandy CLAY; low plasticity, red-pink, fine to medium grained sand as above, white	M (<PL)	H	EXTREMELY WEATHERED 1.50 m: SPT Recovery: 0.28 m
1.80m							SANDSTONE; fine to coarse grained, red (Iron indurated), highly weathered as above, brown			WEATHERED ROCK
2.20m							Continued as Cored Drill Hole			

DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm



Graphic Log



METHOD
- EX Excavator bucket
- R Ripper
- HA Hand auger
- PT Push tube
- SON Sonic drilling
- AH Air hammer
- PS Percussion sampler
- AS Short spiral auger
- AD/V Solid flight auger: V-Bit
- AD/T Solid flight auger: TC-Bit
- HFA Hollow flight auger
- WB Washbore drilling
- RR Rock roller

PENETRATION
- VE Very Easy (No Resistance)
- E Easy
- F Firm
- H Hard
- VH Very Hard (Refusal)

WATER
- ▽ Water Level on Date shown
- ▶ water inflow
- ◀ water outflow

FIELD TESTS
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer
- DCP - Dynamic Cone Penetrometer
- PSP - Perth Sand Penetrometer
- MC - Moisture Content
- PBT - Plate Bearing Test
- IMP - Borehole Impression Test
- PID - Photoionisation Detector
- VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
- B - Bulk disturbed sample
- D - Disturbed sample
- ES - Environmental sample
- U - Thin wall tube 'undisturbed'

MOISTURE
- D - Dry
- M - Moist
- W - Wet
- PL - Plastic limit
- LL - Liquid limit
- *w* - Moisture content

SOIL CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

Stantec

CORE LOG SHEET

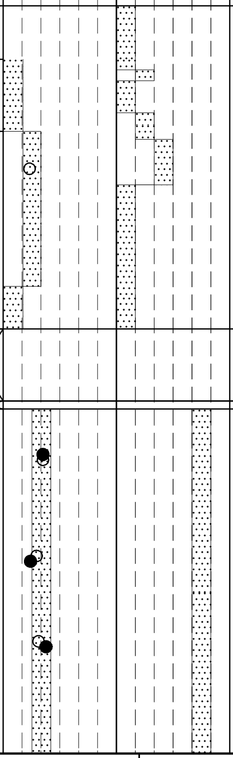
Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH01

Job No: 300304375-400.1
Sheet: 2 of 3

Position: Refer to Site Plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Massenza MI2	**Mounting:** Track	**Driller:** MG
Casing Diameter: HQ **Bit Type:**	**Bit Condition:**	**Contractor:** Stratacore Drilling P/L
Date Started: 5/23/23 **Date Completed:** 5/23/23	**Logged By:** NM	**Checked By:** TB

Method	Fluid	TCR (%)	RQD (%)	RL (m AHD)	Depth (m)	Material Description: SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components	Weathering	Defect Description: Additional Data DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other
					0.5			
					1.0			
					1.5			
					2.0			
					2.20m	START CORING AT 2.20m		~~2.20: Practical Refusal (slow drilling~~ progress)
NMLC	Water	82	25		2.20 - 2.40m	SANDSTONE; disturbed spoil recompacted and extracted in drill bit		2.40 - 2.44 m: SMXW
					2.40m	SANDSTONE; fine to coarse grained, grey-white, bedded	HW	2.48 - 2.60 m: SMXW 2.65 m: BP, 10°, PR, RF 2.70 m: BP, 20°, IR, RF, SN
						2.67 - 2.86 m: as above, iron indurated, red-orange	HW - MW	2.77 m: DB 2.87 - 3.29 m: FZ, IR, RF, organic infilling (roots/rootlets) 3.29 - 3.41 m: SMXW
					3.41m	CORE LOSS 0.27m (3.41-3.68)		
					3.68m 3.71m	CORE LOSS 0.03m (3.68-3.71)		3.71 m: DB
		99	91		3.71m	SANDSTONE; fine to coarse grained, red-orange, bedded	MW	4.00 m: DB
						4.17 - 4.24 m: as above, fine to medium angular to sub-angular gravel inclusions		4.33 m: DB 4.40 m: BP, 10°, PR, RF 4.62 m: DB 4.97 m: HB



DRILLING

AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller
PQ	Rotary core (85mm)
HQ	Rotary core (63.5mm)
NMLC	Rotary core (51.94mm)
DT	Diatube concrete coring
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
AH	Air hammer

WATER

▽ Water Level on date shown
► water inflow
◄ water outflow

ROCK QUALITY DESCRIPTIONS

RQD	Rock Quality Designation (%)
TCR	Total Core Recovery (%)

ROCK STRENGTH

EH	Extremly High
VH	Very High
H	High
M	Medium
L	Low
VL	Very Low

ROCK WEATHERING

FR	Fresh
SW	Slightly Weathered
DW	Distinctly Weathered
MW	Moderately Weathered
HW	Highly Weathered
XW	Extremly Weathered

DEFECT TYPE

JT	Joint
SZ	Sheared zone
BP	Bedding Parting
SM	Seam
FL	Foliation
VN	Vein
CL	Cleavage
CS	Crushed Seam
FZ	Fracture Zone
DL	Drift Lift
HB	Handing Break
DB	Drilling Break

PLANARITY

CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

ROUGHNESS

VR	Very Rough
RF	Rough
S	Smooth
SL	Slockensided
POL	Polished

COATING

CN	Clean
SN	Stained
VNR	Veneer (thin or patchy)
CT	Coating (up to 1mm)

INFILL MATERIALS

X	Carbonaceus
MU	Unidentified mineral
MS	Secondary mineral
KT	Chlorite
CA	Calcite
Fe	Iron Oxide
Qz	Quartz

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

CORE LOG SHEET

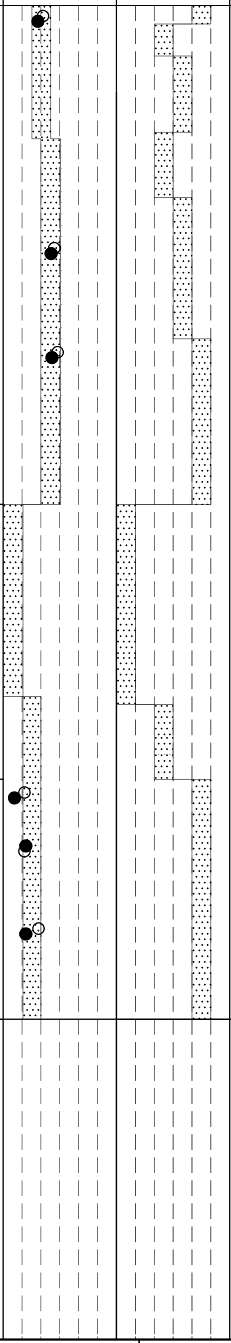
Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW
Job No: 300304375-400.1

Hole No: BH01

Sheet: 3 of 3

Position: Refer to Site Plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Massenza MI2	**Mounting:** Track	**Driller:** MG
Casing Diameter: HQ **Bit Type:**	**Bit Condition:**	**Contractor:** Stratacore Drilling P/L
Date Started: 5/23/23 **Date Completed:** 5/23/23	**Logged By:** NM	**Checked By:** TB

Coring						Material Description			
Method	Fluid	TCR (%)	RQD (%)	RL (m AHD)	Depth (m)	Graphic Log	SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components	Weathering
NMLC	Water	99	91				SANDSTONE; fine to coarse grained, red-orange, bedded *(continued)*	MW
					5.5		as above, grey with some orange staining	
		92	72		6.0			
					6.5	6.87m		
					7.0		SILTSTONE; dark grey, with minor interbedded light grey fine to medium grained SANDSTONE	HW
					7.5		7.44 - 7.59 m: granular infilled seam, colour, some indurated rock fragments	
							as above, fine to medium angular to sub-angular gravel inclusions	
					8.0			HW - MW
					8.5	8.80m		
					9.0		TERMINATED AT 8.80 m Target depth	
					9.5			



Defect Description

Additional Data
DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other

- 5.00 m: HB
- 5.07 m: BP, 0 - 5°, IR, RF
- 5.19 m: BP, 0 - 15°, IR, RF
- 5.21 m: HB
- 5.48 m: BP, 10°, UN, RF
- 5.56 m: BP, 10°, PR, RF
- 5.72 m: BP, 15°, PR, RF
- 5.80 m: DB
- 6.00 m: HB
- 6.25 m: BP, 15°, PR, RF
- 6.87 m: BP, 0°, PR, RF
- 6.87 - 7.44 m: SMXW
- 7.44 m: BP, 5 - 10°, PR, RF, SN
- 7.44 - 7.62 m: CS, /FZ
- 7.62 m: BP, 10°, PR, RF
- 7.74 m: BP, 20 - 25°, CU, RF
- 7.78 m: DB
- 7.81 m: BP, 10°, PR, RF
- 7.90 m: BP, 10°, IR, RF
- 7.93 m: DB
- 8.00 m: HB
- 8.13 m: HB

DRILLING

AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller
PQ	Rotary core (85mm)
HQ	Rotary core (63.5mm)
NMLC	Rotary core (51.94mm)
DT	Diatube concrete coring
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
AH	Air hammer

WATER

▽	Water Level on date shown
►—	water inflow
—◄	water outflow

ROCK QUALITY DESCRIPTIONS

RQD	Rock Quality Designation (%)
TCR	Total Core Recovery (%)

ROCK STRENGTH

EH	Extremly High
VH	Very High
H	High
M	Medium
L	Low
VL	Very Low

ROCK WEATHERING

FR	Fresh
SW	Slightly Weathered
DW	Distinctly Weathered
MW	Moderately Weathered
HW	Highly Weathered
XW	Extremly Weathered

DEFECT TYPE

JT	Joint
SZ	Sheared zone
BP	Bedding Parting
SM	Seam
FL	Foliation
VN	Vein
CL	Cleavage
CS	Crushed Seam
FZ	Fracture Zone
DL	Drift Lift
HB	Handing Break
DB	Drilling Break

PLANARITY

CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

ROUGHNESS

VR	Very Rough
RF	Rough
S	Smooth
SL	Slockensided
POL	Polished

COATING

CN	Clean
SN	Stained
VNR	Veneer (thin or patchy)
CT	Coating (up to 1mm)

INFILL MATERIALS

X	Carbonaceus
MU	Unidentified minteral
MS	Secondary mineral
KT	Chlorite
CA	Calcite
Fe	Iron Oxide
Qz	Quartz

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

DATE PLOTTED: 20 September 2023 11:10 AM BY : MCDONALD, NICK

CLIENT:	Waluya Pty Ltd	**BOREHOLE ID:**	BH01
PROJECT:	Geotechnical Investigation	**CORED DEPTH:**	2.2 - 8.8 m
LOCATION:	Racecourse Rd West Gosford, NSW	**CORE TRAYS:**	2
PROJECT NO.:	300304375	**DATE:**	23/05/2023

Stantec

Stantec Australia Pty Ltd | ABN 17 007 820 322
Level 2, 22 Honeysuckle Drive
Newcastle NSW 2300
Tel: +61 2 4940 4100
Web: www.stantec.com

NM 10.07.2023
Designed

WALUYA PTY LTD
RACECOURSE RD
GEOTECHNICAL INVESTIGATION
WEST GOSFORD, NSW
ROCK CORE PHOTOGRAPHY
BH01: 2.2 - 8.8M

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

300304375-400 -

- A

XREF's:
CAD File: \\AU2021-PPFSS01\workgroup\3040\temporary\00XXX_Racecourse_Data-In\Drawing\core_photo_figures\Racecourse Rd Core Photos.dwg

BOREHOLE LOG SHEET

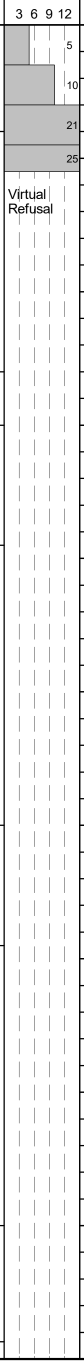
Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW
Job No: 300304375-400.1

Hole No: BH02

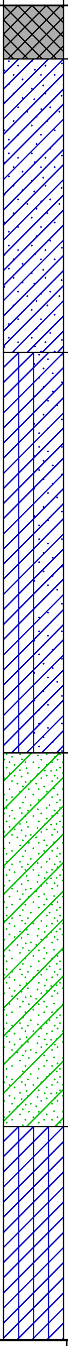
Sheet: 1 of 2

Position: Refer to Site Plan
Angle from Horizontal: 90°
Surface Elevation:
Rig Type: Massenza MI2
Mounting: Track
Driller: MG
Casing Diameter:
Contractor: Stratacore Drilling P/L
Date Started: 5/23/23
Date Completed: 5/23/23
Logged By: NM
Checked By: TB

Drilling				Sampling & Testing			Material Description					
Method	Resistance	Casing	Water	Sample or Field Test	DCP TEST (AS 1289.6. 3.2-1997) Blows/ 150 mm	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
125mm AD/T			Groundwater Not Encountered		5 10	0.20m			FILL: Silty SAND; fine to coarse grained, brown, trace fine to medium angular to sub-rounded gravel, trace organics (rootlets)	M		FILL
				B 0.40 - 1.30 m	21 25 Virtual Refusal	1.30m			Sandy CLAY; low to medium plasticity, red mottled white, fine to coarse grained sand	M (≈PL) - M (<PL)	VSt	RESIDUAL SOIL
				D 1.30 - 1.50 m SPT 1.50 - 1.95 m 4, 7, 12 N*=19		2.80m			Silty Sandy CLAY; low to medium plasticity, white mottled pale red, fine to medium grained sand	M (≈PL) - M (<PL)	VSt	1.50 m: SPT Recovery: 450 m
				SPT 3.00 - 3.45 m 10, 18, 14 N*=32		4.20m			Clayey SAND; fine to coarse grained, white-grey, with silt	D - M	D	EXTREMELY WEATHERED 3.00 m: SPT Recovery: 450 m
				SPT 4.50 - 4.94 m 6, 13, 17/135mm N*=R					Silty CLAY; medium plasticity, grey-white some banded red	M (<PL)	H	4.50 m: SPT Recovery: 435 m



Depth (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5



METHOD	
EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION	
VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

▽ Water Level on Date shown
▶ water inflow
◀ water outflow

FIELD TESTS		
SPT	-	Standard Penetration Test
HP	-	Hand/Pocket Penetrometer
DCP	-	Dynamic Cone Penetrometer
PSP	-	Perth Sand Penetrometer
MC	-	Moisture Content
PBT	-	Plate Bearing Test
IMP	-	Borehole Impression Test
PID	-	Photoionisation Detector
VS	-	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES		
B	-	Bulk disturbed sample
D	-	Disturbed sample
ES	-	Environmental sample
U	-	Thin wall tube 'undisturbed'

MOISTURE		
D	-	Dry
M	-	Moist
W	-	Wet
PL	-	Plastic limit
LL	-	Liquid limit
w	-	Moisture content

SOIL CONSISTENCY		
VS	-	Very Soft
S	-	Soft
F	-	Firm
St	-	Stiff
VSt	-	Very Stiff
H	-	Hard

RELATIVE DENSITY		
VL	-	Very Loose
L	-	Loose
MD	-	Medium Dense
D	-	Dense
VD	-	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

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BOREHOLE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH02

Job No: 300304375-400.1
Sheet: 2 of 2

Position: Refer to Site Plan
Angle from Horizontal: 90°
Surface Elevation:
Rig Type: Massenza MI2
Mounting: Track
Driller: MG
Casing Diameter:
Contractor: Stratacore Drilling P/L
Date Started: 5/23/23
Date Completed: 5/23/23
Logged By: NM
Checked By: TB

Drilling				Sampling & Testing			Material Description					
Method	Resistance	Casing	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm 3 6 9 12	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
125mm AD/T			Groundwater Not Encountered			6.00m	▨		Silty CLAY; medium plasticity, grey-white some banded red *(continued)*	M (<PL)	H	EXTREMELY WEATHERED
						6.80m	▨		Sandy CLAY; low plasticity, dark red mottled white, fine to corse grained sand	M (<PL)		
				D 6.90 - 7.00 m		7.00m	🟩		SANDSTONE; fine to coarse grained, mottled dark red & white, highly weathered			WEATHERED ROCK 6.80 m: Slow progress
									TERMINATED AT 7.00 m Target depth			

Depth scale: 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

▽ Water Level on Date shown
▶ water inflow
◀ water outflow

FIELD TESTS

SPT	- Standard Penetration Test
HP	- Hand/Pocket Penetrometer
DCP	- Dynamic Cone Penetrometer
PSP	- Perth Sand Penetrometer
MC	- Moisture Content
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IMP	- Borehole Impression Test
PID	- Photoionisation Detector
VS	- Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	- Bulk disturbed sample
D	- Disturbed sample
ES	- Environmental sample
U	- Thin wall tube 'undisturbed'

MOISTURE

D	- Dry
M	- Moist
W	- Wet
PL	- Plastic limit
LL	- Liquid limit
w	- Moisture content

SOIL CONSISTENCY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard

RELATIVE DENSITY

VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

STANTEC 2.02.0 LIB.GLB Log CARDNO NON-CORED 300304375 - RACECOURSE RD WEST GOSFORD_BUS DEPOT.GPJ <<DrawingFile>> 22/09/2023 09:45 10.03.00.09 Datgel AGS RTA, Photo, Monitoring Tools

BOREHOLE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH03

Job No: 300304375-400.1
Sheet: 1 of 3

Position: Refer to Site Plan
Angle from Horizontal: 90°
Surface Elevation:
Rig Type: Massenza MI2
Mounting: Track
Driller: MG
Casing Diameter: HQ
Contractor: Stratacore Drilling P/L
Date Started: 5/24/23
Date Completed: 5/24/23
Logged By: NM
Checked By: TB

Drilling				Sampling & Testing			Material Description					
Method	Resistance	Casing	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/ 150 mm 3 6 9 12	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
125mm AD/T		HQ	Groundwater Not Encountered	D 0.05 - 0.15 m	7		▨	0.20m	FILL: Silty Sandy GRAVEL; fine to coarse angular to sub-angular, dark brown-black, fine to coarse grained sand	M		FILL
				D 0.20 - 0.30 m B 0.30 - 0.50 m	18 Hammer Bouncing			0.50m	Clayey SAND; fine to coarse grained, yellow, trace fine to coarse angular to sub-angular gravel as above, orange in colour	D - M	D	EXTREMELY WEATHERED
				SPT 0.50 - 0.60 m 10/100mm N*=R D 0.70 - 0.90 m		0.5 1.0	🟩	1.40m	SANDSTONE; fine to coarse grained, white, highly weathered as above, orange in colour as above, white in colour			WEATHERED ROCK 0.50 m: SPT Recovery: 0.1 m 0.80 m: Slow progress
						1.5 2.0 2.5 3.0 3.5 4.0 4.5			Continued as Cored Drill Hole			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

Water Level on Date shown
▶ water inflow
◀ water outflow

FIELD TESTS

SPT -	Standard Penetration Test
HP -	Hand/Pocket Penetrometer
DCP -	Dynamic Cone Penetrometer
PSP -	Perth Sand Penetrometer
MC -	Moisture Content
PBT -	Plate Bearing Test
IMP -	Borehole Impression Test
PID -	Photoionisation Detector
VS -	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B -	Bulk disturbed sample
D -	Disturbed sample
ES -	Environmental sample
U -	Thin wall tube 'undisturbed'

MOISTURE

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M -	Moist
W -	Wet
PL -	Plastic limit
LL -	Liquid limit
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VS -	Very Soft
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L -	Loose
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D -	Dense
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Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

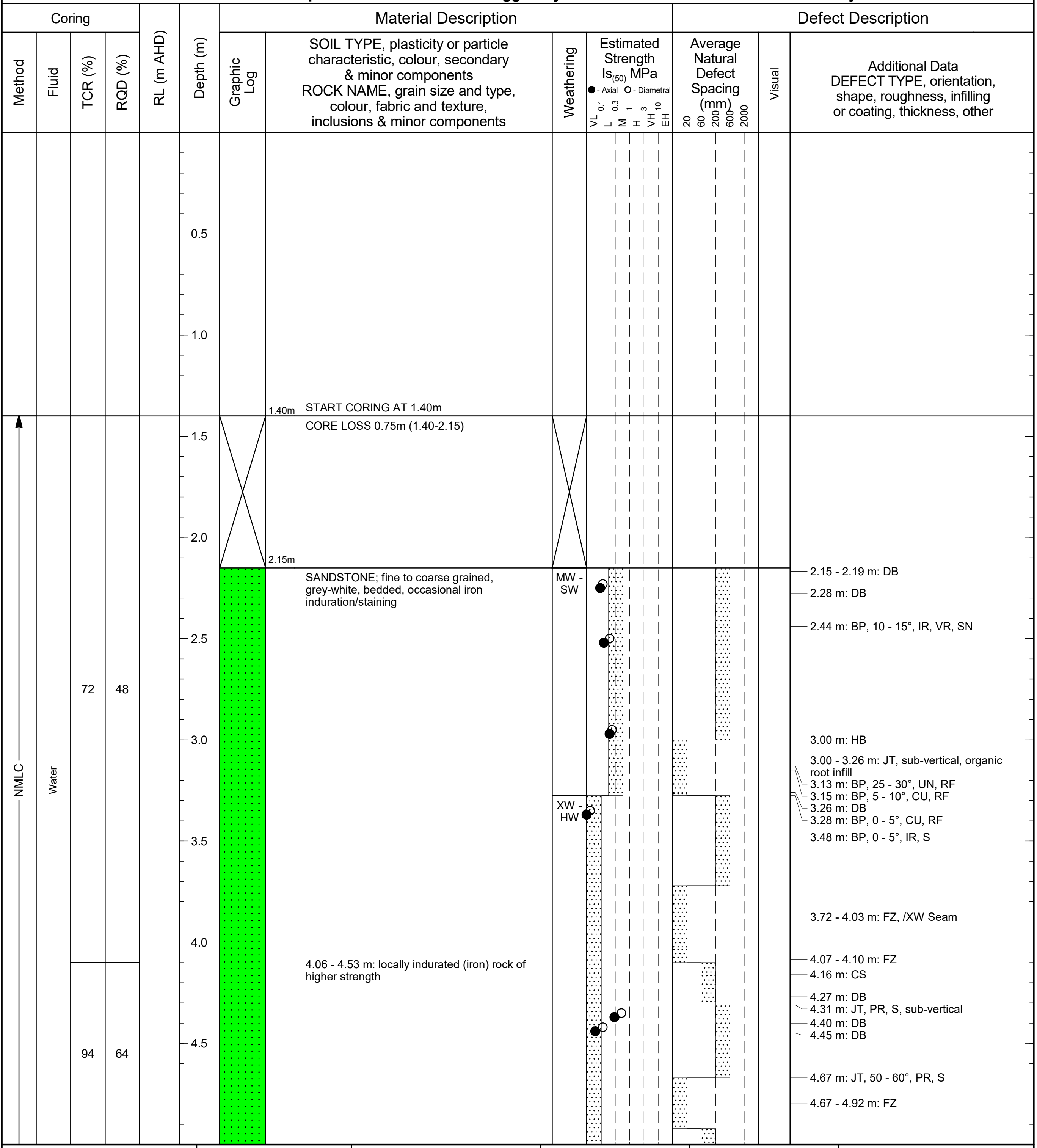
CORE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH03

Job No: 300304375-400.1
Sheet: 2 of 3

Position: Refer to Site Plan
Angle from Horizontal: 90°
Surface Elevation:
Rig Type: Massenza MI2
Mounting: Track
Driller: MG
Casing Diameter: HQ
Bit Type:
Bit Condition:
Contractor: Stratacore Drilling P/L
Date Started: 5/24/23
Date Completed: 5/24/23
Logged By: NM
Checked By: TB



SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components
ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components

START CORING AT 1.40m

CORE LOSS 0.75m (1.40-2.15)

SANDSTONE; fine to coarse grained, grey-white, bedded, occasional iron induration/staining

4.06 - 4.53 m: locally indurated (iron) rock of higher strength

Additional Data
DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other

2.15 - 2.19 m: DB
2.28 m: DB
2.44 m: BP, 10 - 15°, IR, VR, SN
3.00 m: HB
3.00 - 3.26 m: JT, sub-vertical, organic root infill
3.13 m: BP, 25 - 30°, UN, RF
3.15 m: BP, 5 - 10°, CU, RF
3.26 m: DB
3.28 m: BP, 0 - 5°, CU, RF
3.48 m: BP, 0 - 5°, IR, S
3.72 - 4.03 m: FZ, /XW Seam
4.07 - 4.10 m: FZ
4.16 m: CS
4.27 m: DB
4.31 m: JT, PR, S, sub-vertical
4.40 m: DB
4.45 m: DB
4.67 m: JT, 50 - 60°, PR, S
4.67 - 4.92 m: FZ

DRILLING

AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller
PQ	Rotary core (85mm)
HQ	Rotary core (63.5mm)
NMLC	Rotary core (51.94mm)
DT	Diatube concrete coring
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
AH	Air hammer

WATER

▽	Water Level on date shown
►	water inflow
◄	water outflow

ROCK QUALITY DESCRIPTIONS

RQD	Rock Quality Designation (%)
TCR	Total Core Recovery (%)

ROCK STRENGTH

EH	Extremly High
VH	Very High
H	High
M	Medium
L	Low
VL	Very Low

ROCK WEATHERING

FR	Fresh
SW	Slightly Weathered
DW	Distinctly Weathered
MW	Moderately Weathered
HW	Highly Weathered
XW	Extremly Weathered

DEFECT TYPE

JT	Joint
SZ	Sheared zone
BP	Bedding Parting
SM	Seam
FL	Foliation
VN	Vein
CL	Cleavage
CS	Crushed Seam
FZ	Fracture Zone
DL	Drift Lift
HB	Handing Break
DB	Drilling Break

PLANARITY

CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

ROUGHNESS

VR	Very Rough
RF	Rough
S	Smooth
SL	Slockensided
POL	Polished

COATING

CN	Clean
SN	Stained
VNR	Veneer (thin or patchy)
CT	Coating (up to 1mm)

INFILL MATERIALS

X	Carbonaceus
MU	Unidentified minteral
MS	Secondary mineral
KT	Chlorite
CA	Calcite
Fe	Iron Oxide
Qz	Quartz

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

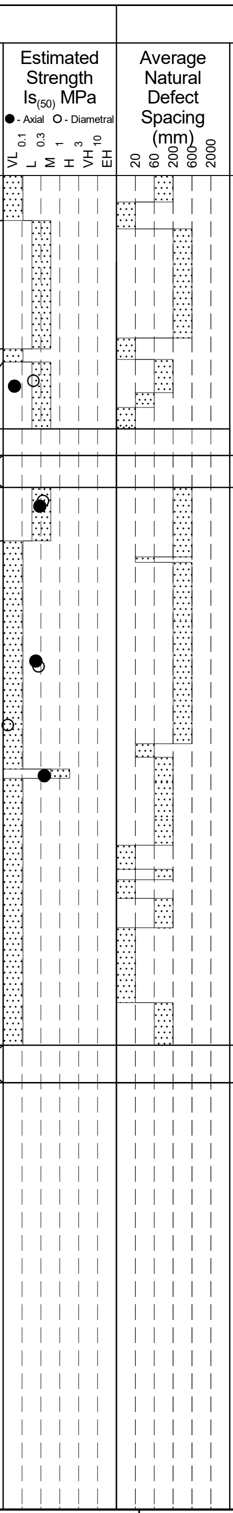
CORE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH03
Job No: 300304375-400.1
Sheet: 3 of 3

Position: Refer to Site Plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Massenza MI2	**Mounting:** Track	**Driller:** MG
Casing Diameter: HQ **Bit Type:**	**Bit Condition:**	**Contractor:** Stratacore Drilling P/L
Date Started: 5/24/23 **Date Completed:** 5/24/23	**Logged By:** NM	**Checked By:** TB

Method	Fluid	TCR (%)	RQD (%)	RL (m AHD)	Depth (m)	Graphic Log	SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components	Weathering	Additional Data DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other
NMLC	Water	94	64		5.5 6.0	6.05m	SANDSTONE; fine to coarse grained, grey-white, bedded, occasional iron induration/staining *(continued)* as above, fine to coarse grained, red, bedded	XW - HW MW HW MW XW	5.00 - 5.04 m: HB 5.10 - 5.20 m: FZ 5.61 m: BP, CU, RF, SN 5.61 - 5.69 m: FZ 5.82 m: BP, 10°, PR, RF 5.85 m: BP, 10°, PR, RF 5.87 - 5.94 m: JT, PR, RF, sub-vertical 5.94 - 6.00 m: FZ 6.05 m: DB
						6.17m	CORE LOSS 0.12m (6.05-6.17)		
		89	70			6.37m	SANDSTONE; fine to coarse grained, red, laminated	MW	6.17 m: DB 6.19 m: DB 6.25 m: DB 6.33 - 6.37 m: DB
					6.5 7.0 7.5 8.0	8.26m	SILTSTONE; dark grey, with minor interbedded light grey, fine to medium grained SANDSTONE, occasional iron induration/staining locally indurated (iron) rock of higher strength	XW - HW	6.43 m: BP, 5°, PR, RF, CT 6.45 m: BP, 15 - 20°, PR, RF 6.67 m: BP, 5 - 10°, PR, RF 6.81 m: DB 7.00 m: HB 7.02 m: HB 7.13 m: BP, 0 - 5°, ST, RF 7.18 m: JT, 85°, IR, RF 7.27 m: CS 7.41 m: JT, 60 - 70°, IR, RF 7.51 - 7.60 m: FZ 7.64 - 7.71 m: FZ 7.82 - 8.10 m: FZ 8.18 m: DB 8.21 m: DB
						8.40m	CORE LOSS 0.14m (8.26-8.40)		
					8.5 9.0 9.5		TERMINATED AT 8.40 m Target depth		



DRILLING

AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller
PQ	Rotary core (85mm)
HQ	Rotary core (63.5mm)
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PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
AH	Air hammer

WATER

▽	Water Level on date shown
▶	water inflow
◀	water outflow

ROCK QUALITY DESCRIPTIONS

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TCR	Total Core Recovery (%)

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H	High
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BP	Bedding Parting
SM	Seam
FL	Foliation
VN	Vein
CL	Cleavage
CS	Crushed Seam
FZ	Fracture Zone
DL	Drift Lift
HB	Handing Break
DB	Drilling Break

PLANARITY

CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

ROUGHNESS

VR	Very Rough
RF	Rough
S	Smooth
SL	Slockensided
POL	Polished

COATING

CN	Clean
SN	Stained
VNR	Veneer (thin or patchy)
CT	Coating (up to 1mm)

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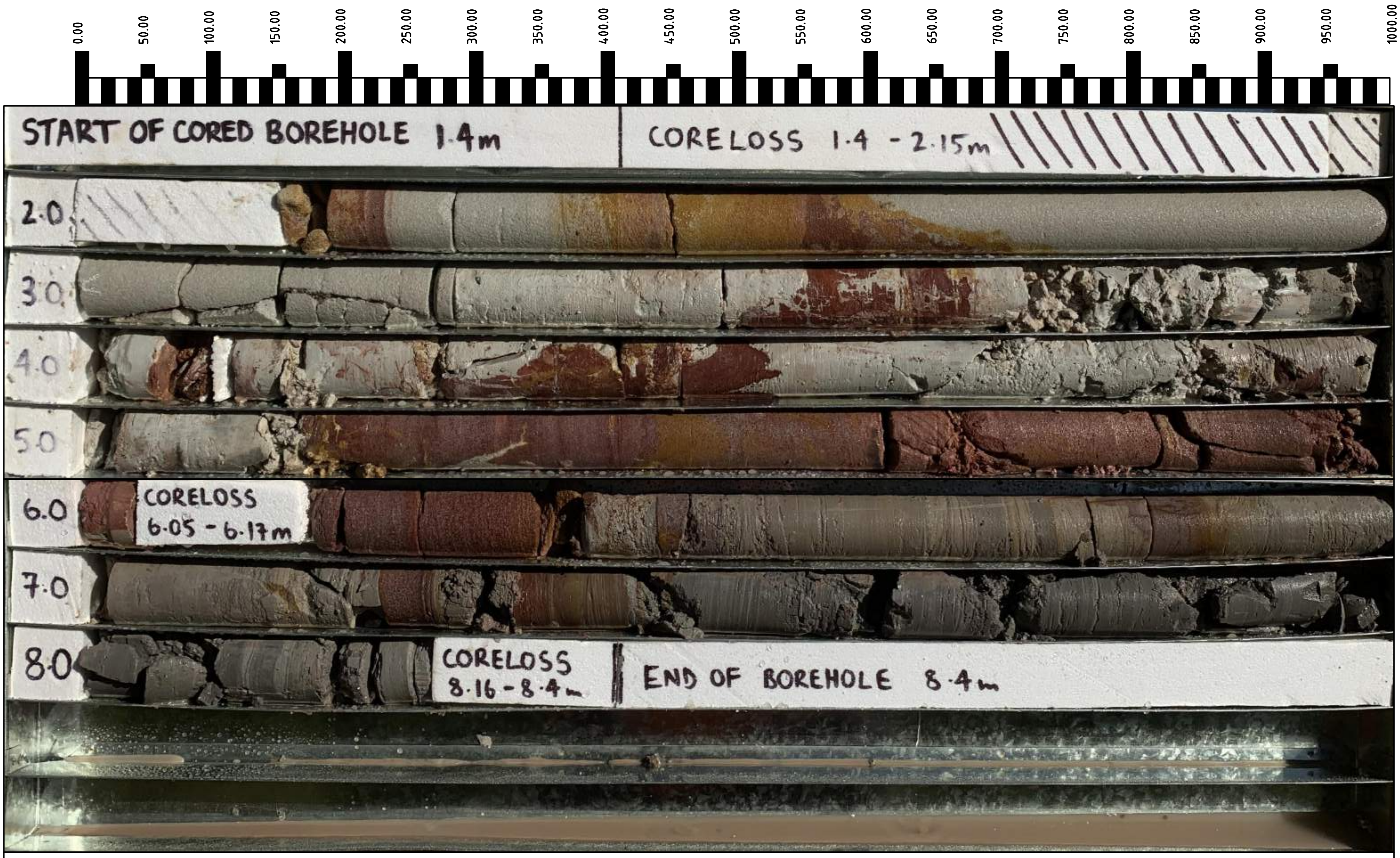
MU	Unidentified minteral
MS	Secondary mineral
KT	Chlorite
CA	Calcite
Fe	Iron Oxide
Qz	Quartz

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

CLIENT:	Waluya Pty Ltd	**BOREHOLE ID:**	BH03
PROJECT:	Geotechnical Investigation	**CORED DEPTH:**	1.4 - 8.4 m
LOCATION:	Racecourse Rd West Gosford, NSW	**CORE TRAYS:**	2
PROJECT NO.:	300304375	**DATE:**	24/05/2023



Stantec
Stantec Australia Pty Ltd | ABN 17 007 820 322
Level 2, 22 Honeysuckle Drive
Newcastle NSW 2300
Tel: +61 2 4940 4100
Web: www.stantec.com

NM 10.07.2023
Designed

WALUYA PTY LTD
RACECOURSE RD
GEOTECHNICAL INVESTIGATION
WEST GOSFORD, NSW
ROCK CORE PHOTOGRAPHY
BH01: 1.4 - 8.4M

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

300304375 -

- A

DATE PLOTTED: 20 September 2023 11:11 AM BY : MCDONALD, NICK

XREF's:
CAD File: \\AU2021-PPFSS01\workgroup\3040\temporary\00XXX_Racecourse_Data-In\Drawing\core_photo_figures\Racecourse Rd Core Photos.dwg

Stantec

BOREHOLE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH04

Job No: 300304375-400.1
Sheet: 1 of 2

Position: Refer to Site Plan
Angle from Horizontal: 90°
Surface Elevation:
Rig Type: Massenza MI2
Mounting: Track
Driller: MG
Casing Diameter:
Contractor: Stratacore Drilling P/L
Date Started: 5/24/23
Date Completed: 5/24/23
Logged By: NM
Checked By: TB

Drilling – Method: 125mm AD/T (0.00 m to base of sheet); Resistance: –; Casing: –
Water: Groundwater Not Observed

Depth (m)	Sample or Field Test	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
0.00		▩		FILL: Silty Gravelly SAND, fine to coarse grained, dark-brown, fine to coarse grained angular to sub-rounded gravel	D - M		FILL
0.10m		▩		Sandy GRAVEL; fine to coarse angular to sub-rounded, dark-brown/black, fine to coarse grained sand	D - M		
0.30m	B 0.30 - 1.50 m	▨		Sandy CLAY; low to medium plasticity, brown-orange, fine to coarse grained sand, with fine to coarse angular to sub-angular gravel	M (≈PL) - M (<PL)	St	RESIDUAL SOIL
0.5	SPT 0.50 - 0.95 m 5, 4, 6 N*=10	▨					0.50 m: SPT Recovery: 450 m
1.0		▨					
		▨		as above, red mottled brown-orange		VSt	
1.5	SPT 1.50 - 1.95 m 5, 10, 10 N*=20	▨					1.50 m: SPT Recovery: 450 m
2.0		▨					
2.5		▨		as above, white, increasing sand content, becoming friable			2.70 m: borderline Clayey SAND
3.0	SPT 3.00 - 3.45 m 4, 8, 9 N*=17	▨					3.00 m: SPT Recovery: 450 m
3.5		▨					
3.80m		▧		Clayey SAND; fine to coarse grained, white-grey	D - M	D	EXTREMELY WEATHERED
4.0		▧					
4.5	SPT 4.50 - 4.63 m 20/125mm N*=R	▧					4.50 m: SPT Recovery: 450 m

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

- Water Level on Date shown
- water inflow
- water outflow

FIELD TESTS

SPT	Standard Penetration Test
HP	Hand/Pocket Penetrometer
DCP	Dynamic Cone Penetrometer
PSP	Perth Sand Penetrometer
MC	Moisture Content
PBT	Plate Bearing Test
IMP	Borehole Impression Test
PID	Photoionisation Detector
VS	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	Bulk disturbed sample
D	Disturbed sample
ES	Environmental sample
U	Thin wall tube 'undisturbed'

MOISTURE

D	Dry
M	Moist
W	Wet
PL	Plastic limit
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VS	Very Soft
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Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

STANTEC 2.02.0 LIB.GLB Log CARDNO NON-CORED 300304375 - RACECOURSE RD WEST GOSFORD_BUS DEPOT.GPJ <<DrawingFile>> 22/09/2023 09:48 10.03.00.09 Datgel AGS RTA, Photo, Monitoring Tools

Stantec

BOREHOLE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH04

Job No: 300304375-400.1
Sheet: 2 of 2

Position: Refer to Site Plan
Angle from Horizontal: 90°
Surface Elevation:
Rig Type: Massenza MI2
Mounting: Track
Driller: MG
Casing Diameter:
Contractor: Stratacore Drilling P/L
Date Started: 5/24/23
Date Completed: 5/24/23
Logged By: NM
Checked By: TB

Drilling				Sampling & Testing		Material Description					
Method	Resistance	Casing	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
125mm AD/T			Groundwater Not Observed					Clayey SAND; fine to coarse grained, white-grey *(continued)*	D - M	D	EXTREMELY WEATHERED
					5.5			5.50m Silty Sandy CLAY; low to medium plasticity, white-grey, fine to coarse grained sand	M (≈PL) - M (>PL)	VSt	
				SPT 6.00 - 6.45 m 3, 6, 10 N*=16	6.0			as above, medium plasticity, fine grained sand	M (≈PL) - M (<PL)		6.00 m: SPT Recovery: 450 m
					6.5						
					7.0						
								7.30m Silty CLAY; low plasticity, grey-white	M (<PL)	H	
				SPT 7.50 - 7.80 m 11, 20 N*=R	7.5						7.50 m: SPT Recovery: 450 m
					8.0						
					8.5			as above, dark grey, trace fine to coarse angular gravel (sandstone/siltstone rock fragments)			8.50 m: zones of weathered sandstone/siltstone
				SPT 9.00 - 9.20 m 12, 10/50mm N*=R	9.0						9.00 m: SPT Recovery: 450 m
								9.20m TERMINATED AT 9.20 m Target depth			
					9.5						

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

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WATER

- ▽ Water Level on Date shown
- ▶ water inflow
- ◀ water outflow

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SPT	Standard Penetration Test
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VL	Very Loose
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MD	Medium Dense
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VD	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

BOREHOLE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW
Job No: 300304375-400.1

Hole No: BH05/MW05

Sheet: 1 of 5

Position: Refer to Site Plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Geoprobe 7822dt	**Mounting:** Track	**Driller:** JT
Casing Diameter: HW		**Contractor:** Tuck Enviro. Drilling
Date Started: 25/1/24 **Date Completed:** 25/1/24	**Logged By:** NM	**Checked By:** GA

Drilling				Sampling & Testing		Material Description						
Method	Resistance	Casing	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations	Monitoring Well Details
125mm SFA AD/V	E	HW			0.15m	▩		TOPSOIL FILL: Silty SAND; fine to coarse grained, dark brown, trace fine to coarse sub-angular to sub-rounded gravel, trace organics	D		FILL	
					0.50m	▩		FILL: Sandy CLAY / Clayey SAND; low to medium plasticity, brown-orange, fine to coarse grained sand	M (<PL) / D			
	H				0.5 0.70m	▩		FILL: Clayey Gravelly SAND; dark brown, fine to coarse grained sand, fine to medium sub-angular to angular gravel	D - M			
					0.90m	▩		FILL: Clayey SAND; brown, fine to coarse grained sand, with fine to medium angular to rounded gravel	D - M			
				SPT 1.00 - 1.45 m 12, 24, 17 N*=41	1.0 1.10m	▨		Sandy CLAY; low plasticity, mottled orange and brown, fine to medium grained sand	M (<PL)	H	EXTREMELY WEATHERED 1.00 m: SPT Recovery: 450 m	
					1.5 2.0 2.20m	░		SAND; fine to coarse grained, red, yellow and white, with clay, trace fine to coarse angular gravel (parent rock fragments)	D	D		
				SPT 2.50 - 2.85 m 5, 31, 20/50mm N*=R	2.5 2.70m	▨		Sandy CLAY; low to medium plasticity, light grey mottled orange, fine to medium grained sand	M (<PL) - M (≈PL)	H	2.50 m: SPT Recovery: 350 m	
					3.00m	░		SAND; fine to medium grained, light grey mottled red and orange, trace clay	D	D - VD		
					3.0			Continued as Cored Drill Hole				
					3.5 4.0 4.5							

METHOD	
EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
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- Water Level on Date shown
- ▶ water inflow
- ◀ water outflow

FIELD TESTS	
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HP	- Hand/Pocket Penetrometer
DCP	- Dynamic Cone Penetrometer
PSP	- Perth Sand Penetrometer
MC	- Moisture Content
PBT	- Plate Bearing Test
IMP	- Borehole Impression Test
PID	- Photoionisation Detector
VS	- Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES	
B	- Bulk disturbed sample
D	- Disturbed sample
ES	- Environmental sample
U	- Thin wall tube 'undisturbed'

MOISTURE	
D	- Dry
M	- Moist
W	- Wet
PL	- Plastic limit
LL	- Liquid limit
w	- Moisture content

SOIL CONSISTENCY	
VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard

RELATIVE DENSITY	
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

CORE LOG SHEET

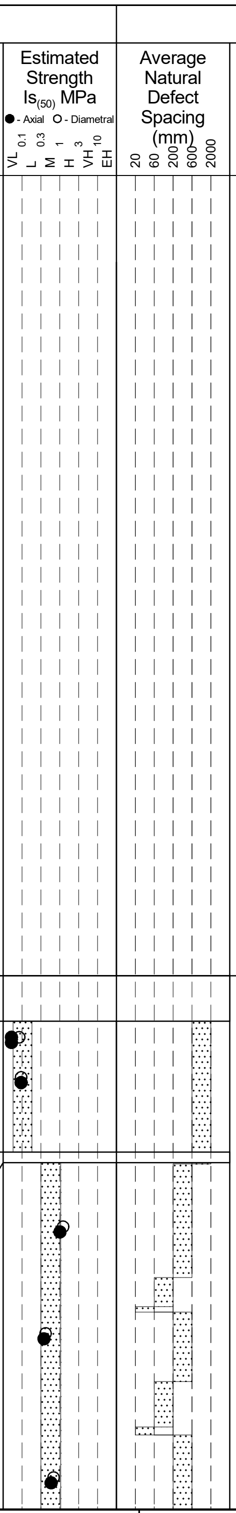
Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH05/MW05

Job No: 300304375-400.1
Sheet: 2 of 5

Position: Refer to Site Plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Geoprobe 7822dt	**Mounting:** Track	**Driller:** JT
Casing Diameter: HW **Bit Type:**	**Bit Condition:**	**Contractor:** Tuck Enviro. Drilling
Date Started: 25/1/24 **Date Completed:** 25/1/24	**Logged By:** NM	**Checked By:** GA

Method	Fluid	TCR (%)	RQD (%)	RL (m AHD)	Depth (m)	Graphic Log	Material Description	Weathering	Additional Data
					0.5				
					1.0				
					1.5				
					2.0				
					2.5				
					3.00m		START CORING AT 3.00m		
NMLC	Polymer				3.0	🟩	SANDSTONE; fine to medium grained, light grey with red and orange staining, bedded	XW	
								HW - MW	3.26 m: DB 3.29 m: DB
					3.5				3.60 m: DB 3.62 m: DB
		100	97					XW MW	3.71 m: BP, 0°, PR, VR, CN 3.87 m: DB
					4.0				4.00 m: DB 4.13 m: DB 4.13 - 4.24 m: JT, 65°, PR, RF, FILLED 4.26 m: BP, 5 - 15°, UN, VR, SN, (Fe) 4.39 m: DB
					4.5				4.52 m: BP, 35°, IR, VR, CN 4.62 m: DB 4.69 m: BP, 20 - 40°, IR, VR, CN 4.72 m: DB
		100	92						



Monitoring Well Details

DRILLING		WATER		ROCK STRENGTH		DEFECT TYPE		PLANARITY		COATING	
AD/V	Solid flight auger: V-Bit	▽	Water Level on date shown	EH	Extremly High	JT	Joint	CU	Curved	CN	Clean
AD/T	Solid flight auger: TC-Bit	►—	water inflow	VH	Very High	SZ	Sheared zone	DIS	Discontinuous	SN	Stained
HFA	Hollow flight auger	—◄	water outflow	H	High	BP	Bedding Parting	IR	Irregular	VNR	Veneer (thin or patchy)
WB	Washbore drilling			M	Medium	SM	Seam	PR	Planar	CT	Coating (up to 1mm)
RR	Rock roller			L	Low	FL	Foliation	ST	Stepped	**INFILL MATERIALS**	
PQ	Rotary core (85mm)			VL	Very Low	VN	Vein	UN	Undulose	X	Carbonaceus
HQ	Rotary core (63.5mm)	**ROCK QUALITY DESCRIPTIONS**		**ROCK WEATHERING**		CL	Cleavage	**ROUGHNESS**		MU	Unidentified minteral
NMLC	Rotary core (51.94mm)	RQD	Rock Quality Designation (%)	FR	Fresh	CS	Crushed Seam	VR	Very Rough	MS	Secondary mineral
DT	Diatube concrete coring	TCR	Total Core Recovery (%)	SW	Slightly Weathered	FZ	Fracture Zone	RF	Rough	KT	Chlorite
PT	Push tube			DW	Distinctly Weathered	DL	Drift Lift	S	Smooth	CA	Calcite
PS	Percussion sampling			MW	Moderately Weathered	HB	Handing Break	SL	Slockensided	Fe	Iron Oxide
SON	Sonic drilling			HW	Highly Weathered	DB	Drilling Break	POL	Polished	Qz	Quartz
AH	Air hammer			XW	Extremly Weathered						

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

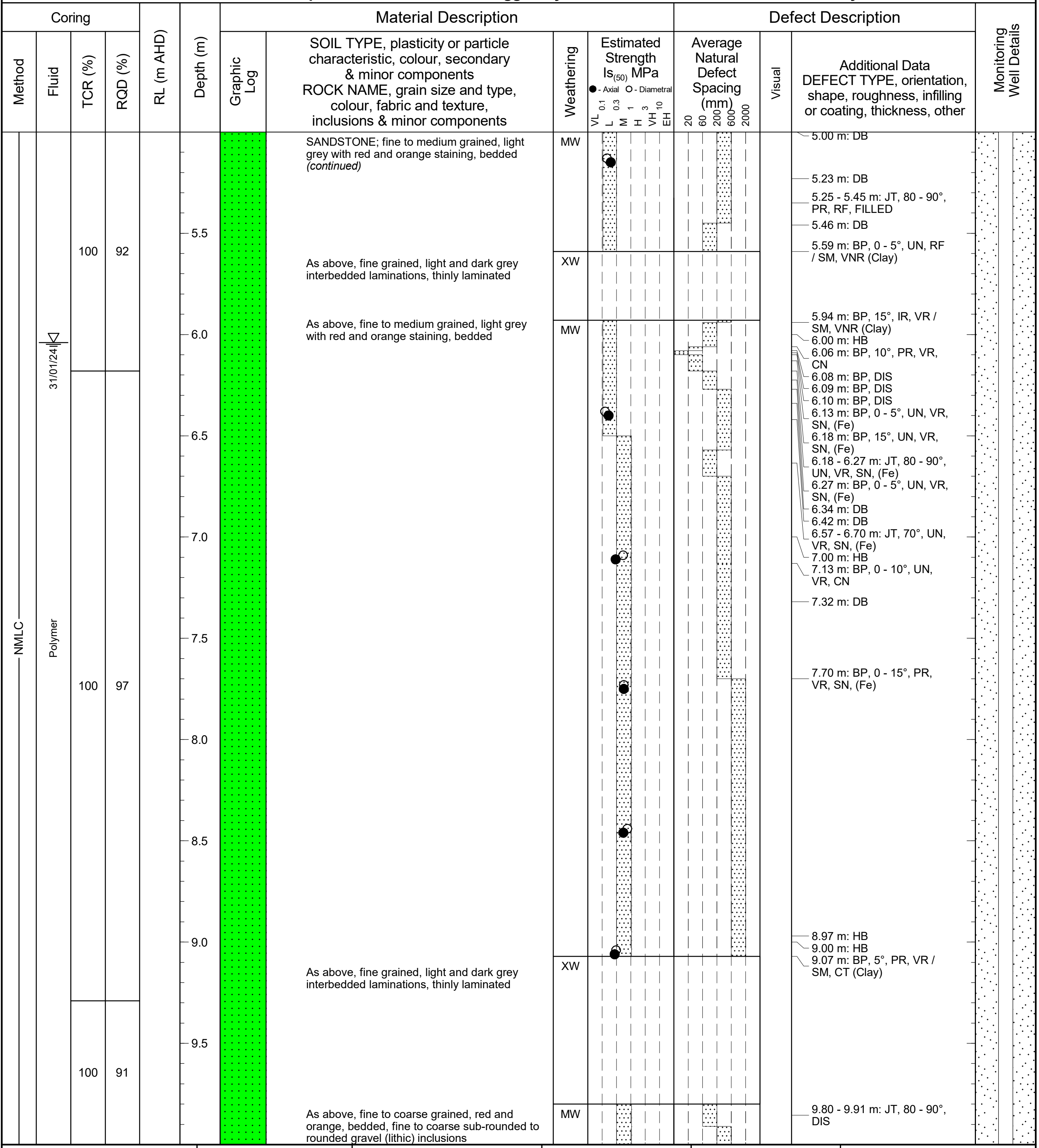
CORE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH05/MW05

Job No: 300304375-400.1
Sheet: 3 of 5

Position: Refer to Site Plan		**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Geoprobe 7822dt		**Mounting:** Track	**Driller:** JT
Casing Diameter: HW	**Bit Type:**	**Bit Condition:**	**Contractor:** Tuck Enviro. Drilling
Date Started: 25/1/24	**Date Completed:** 25/1/24	**Logged By:** NM	**Checked By:** GA



TCR (%)	RQD (%)
100	92
100	97
100	91

Material Description	Weathering
SANDSTONE; fine to medium grained, light grey with red and orange staining, bedded *(continued)*	MW
As above, fine grained, light and dark grey interbedded laminations, thinly laminated	XW
As above, fine to medium grained, light grey with red and orange staining, bedded	MW
As above, fine grained, light and dark grey interbedded laminations, thinly laminated	XW
As above, fine to coarse grained, red and orange, bedded, fine to coarse sub-rounded to rounded gravel (lithic) inclusions	MW

Additional Data:

- 5.00 m: DB
- 5.23 m: DB
- 5.25 - 5.45 m: JT, 80 - 90°, PR, RF, FILLED
- 5.46 m: DB
- 5.59 m: BP, 0 - 5°, UN, RF / SM, VNR (Clay)
- 5.94 m: BP, 15°, IR, VR / SM, VNR (Clay)
- 6.00 m: HB
- 6.06 m: BP, 10°, PR, VR, CN
- 6.08 m: BP, DIS
- 6.09 m: BP, DIS
- 6.10 m: BP, DIS
- 6.13 m: BP, 0 - 5°, UN, VR, SN, (Fe)
- 6.18 m: BP, 15°, UN, VR, SN, (Fe)
- 6.18 - 6.27 m: JT, 80 - 90°, UN, VR, SN, (Fe)
- 6.27 m: BP, 0 - 5°, UN, VR, SN, (Fe)
- 6.34 m: DB
- 6.42 m: DB
- 6.57 - 6.70 m: JT, 70°, UN, VR, SN, (Fe)
- 7.00 m: HB
- 7.13 m: BP, 0 - 10°, UN, VR, CN
- 7.32 m: DB
- 7.70 m: BP, 0 - 15°, PR, VR, SN, (Fe)
- 8.97 m: HB
- 9.00 m: HB
- 9.07 m: BP, 5°, PR, VR / SM, CT (Clay)
- 9.80 - 9.91 m: JT, 80 - 90°, DIS

DRILLING

AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller
PQ	Rotary core (85mm)
HQ	Rotary core (63.5mm)
NMLC	Rotary core (51.94mm)
DT	Diatube concrete coring
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
AH	Air hammer

WATER

▽	Water Level on date shown
▶—	water inflow
—◀	water outflow

ROCK QUALITY DESCRIPTIONS

RQD	Rock Quality Designation (%)
TCR	Total Core Recovery (%)

ROCK STRENGTH

EH	Extremly High
VH	Very High
H	High
M	Medium
L	Low
VL	Very Low

ROCK WEATHERING

FR	Fresh
SW	Slightly Weathered
DW	Distinctly Weathered
MW	Moderately Weathered
HW	Highly Weathered
XW	Extremly Weathered

DEFECT TYPE

JT	Joint
SZ	Sheared zone
BP	Bedding Parting
SM	Seam
FL	Foliation
VN	Vein
CL	Cleavage
CS	Crushed Seam
FZ	Fracture Zone
DL	Drift Lift
HB	Handing Break
DB	Drilling Break

PLANARITY

CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

ROUGHNESS

VR	Very Rough
RF	Rough
S	Smooth
SL	Slockensided
POL	Polished

COATING

CN	Clean
SN	Stained
VNR	Veneer (thin or patchy)
CT	Coating (up to 1mm)

INFILL MATERIALS

X	Carbonaceus
MU	Unidentified minterral
MS	Secondary mineral
KT	Chlorite
CA	Calcite
Fe	Iron Oxide
Qz	Quartz

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

CORE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW
Job No: 300304375-400.1

Hole No: BH05/MW05

Sheet: 4 of 5

Position: Refer to Site Plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Rig Type: Geoprobe 7822dt	**Mounting:** Track	**Driller:** JT
Casing Diameter: HW / **Bit Type:**	**Bit Condition:**	**Contractor:** Tuck Enviro. Drilling
Date Started: 25/1/24 / **Date Completed:** 25/1/24	**Logged By:** NM	**Checked By:** GA

Coring: Method | Fluid | TCR (%) | RQD (%) — RL (m AHD) — Depth (m) — Graphic Log

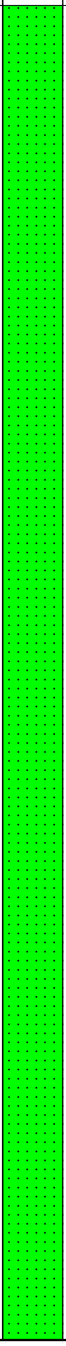
Material Description: SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components — Weathering — Estimated Strength $Is_{(50)}$ MPa (● - Axial ○ - Diametral; VL 0.1 L 0.3 M 1 H 3 VH 10 EH) — Average Natural Defect Spacing (mm) (20 60 200 600 2000)

Defect Description: Visual — Additional Data DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other — Monitoring Well Details

Method: NMLC
Fluid: Polymer

TCR (%)	RQD (%)
100	91
100	100
100	84

Depth (m): 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5



SANDSTONE; fine to medium grained, light grey with red and orange staining, bedded *(continued)*

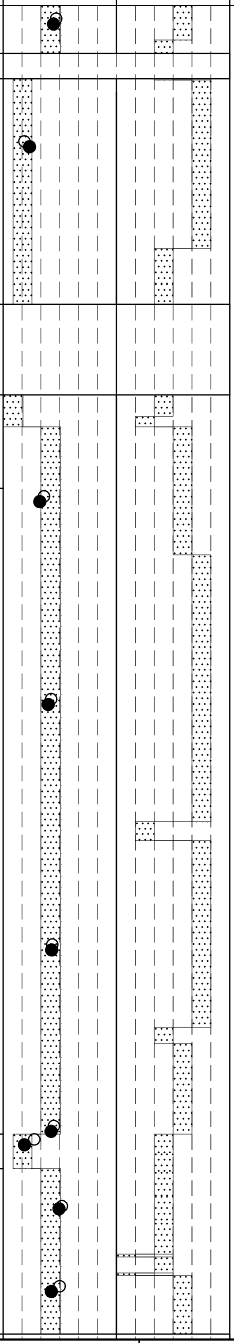
As above, fine to medium grained, light and dark grey interbedded laminations, thinly laminated

As above, fine to medium grained, grey, bedded

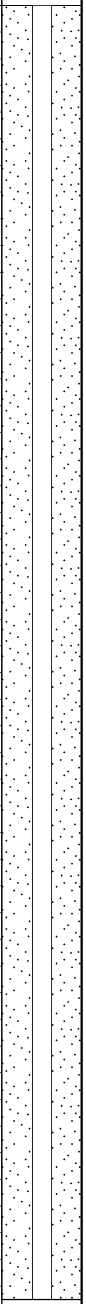
As above, fine grained, dark grey, bedded

As above, fine to medium grained, grey, bedded

Weathering: MW, XW, HW, XW, HW - MW, SW, HW, SW



10.00 m: HB
10.13 - 10.28 m: FZ
10.32 m: DB
10.40 m: HB
10.47 m: HB
10.61 m: HB
10.91 m: BP, 0°, PR, RF, CT, (Clay)
10.93 m: HB
11.00 m: HB
11.04 m: BP, 5°, PR, RF, CT, (Clay)
11.04 - 11.12 m: JT, 45 - 50°, PR, RF, CT, (Clay)
11.46 - 11.54 m: FZ
11.58 m: DB
11.81 m: DB
12.00 m: HB
12.06 m: DB
12.57 m: DB
12.85 m: HB
12.97 m: DB
13.00 m: DB
13.06 m: BP, 0 - 15°, UN, VR, SN, (Fe)
13.10 m: BP, 0 - 5°, UN, VR, SN, (Fe)
13.13 m: BP, 10°, UN, VR, SN, (Fe)
13.83 m: BP, 15°, PR, VR, SN, (Fe)
13.83 - 13.89 m: JT, 75°, UN, VR, CN
13.89 m: BP, 15°, UN, VR, CN
13.92 m: DB
13.95 m: DB
14.00 m: HB
14.23 m: BP, 0 - 5°, PR, VR, VNR, (Clay)
14.30 - 14.37 m: FZ
14.46 m: BP, 0 - 10°, PR, VR, CN
14.56 m: BP, 10°, PR, VR, CN
14.68 - 14.69 m: SM, FILLED
14.75 m: BP, 0 - 10°, UN, VR, VNR, (Clay)



DRILLING

AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller
PQ	Rotary core (85mm)
HQ	Rotary core (63.5mm)
NMLC	Rotary core (51.94mm)
DT	Diatube concrete coring
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
AH	Air hammer

WATER

- Water Level on date shown
- ▶— water inflow
- —◀ water outflow

ROCK QUALITY DESCRIPTIONS

RQD	Rock Quality Designation (%)
TCR	Total Core Recovery (%)

ROCK STRENGTH

EH	Extremely High
VH	Very High
H	High
M	Medium
L	Low
VL	Very Low

ROCK WEATHERING

FR	Fresh
SW	Slightly Weathered
DW	Distinctly Weathered
MW	Moderately Weathered
HW	Highly Weathered
XW	Extremly Weathered

DEFECT TYPE

JT	Joint
SZ	Sheared zone
BP	Bedding Parting
SM	Seam
FL	Foliation
VN	Vein
CL	Cleavage
CS	Crushed Seam
FZ	Fracture Zone
DL	Drift Lift
HB	Handing Break
DB	Drilling Break

PLANARITY

CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

ROUGHNESS

VR	Very Rough
RF	Rough
S	Smooth
SL	Slockensided
POL	Polished

COATING

CN	Clean
SN	Stained
VNR	Veneer (thin or patchy)
CT	Coating (up to 1mm)

INFILL MATERIALS

X	Carbonaceus
MU	Unidentified minteral
MS	Secondary mineral
KT	Chlorite
CA	Calcite
Fe	Iron Oxide
Qz	Quartz

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

CORE LOG SHEET

Client: Waluya Pty Ltd
Project: Geotechnical Investigation
Location: Racecourse Rd, West Gosford NSW

Hole No: BH05/MW05

Job No: 300304375-400.1
Sheet: 5 of 5

Position: Refer to Site Plan		**Angle from Horizontal: 90°**	**Surface Elevation:**
Rig Type: Geoprobe 7822dt		**Mounting: Track**	**Driller: JT**
Casing Diameter: HW	**Bit Type:**	**Bit Condition:**	**Contractor: Tuck Enviro. Drilling**
Date Started: 25/1/24	**Date Completed: 25/1/24**	**Logged By: NM**	**Checked By: GA**

Coring				RL (m AHD)	Depth (m)	Material Description			Defect Description				Monitoring Well Details
Method	Fluid	TCR (%)	RQD (%)			Graphic Log	SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components	Weathering	Estimated Strength Is$_{(50)}$ MPa ● - Axial ○ - Diametral VL 0.1 L 0.3 M 1 H 3 VH 10 EH	Average Natural Defect Spacing (mm) 20 60 200 600 2000	Visual	Additional Data DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other	
↓		100	84			🟩	15.11m As above, fine to medium grained, light and dark grey interbedded laminations, thinly laminated TERMINATED AT 15.11 m Target depth	XW MW - HW				14.76 m: BP, 0 - 10°, UN, VR, SN, (Fe) 15.07 m: BP, 0 - 5°, PR, VR, CN	
					15.5								
					16.0								
					16.5								
					17.0								
					17.5								
					18.0								
					18.5								
					19.0								
					19.5								

DRILLING

AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller
PQ	Rotary core (85mm)
HQ	Rotary core (63.5mm)
NMLC	Rotary core (51.94mm)
DT	Diatube concrete coring
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
AH	Air hammer

WATER

▽	Water Level on date shown
►—	water inflow
—◄	water outflow

ROCK QUALITY DESCRIPTIONS

RQD	Rock Quality Designation (%)
TCR	Total Core Recovery (%)

ROCK STRENGTH

EH	Extremly High
VH	Very High
H	High
M	Medium
L	Low
VL	Very Low

ROCK WEATHERING

FR	Fresh
SW	Slightly Weathered
DW	Distinctly Weathered
MW	Moderately Weathered
HW	Highly Weathered
XW	Extremly Weathered

DEFECT TYPE

JT	Joint
SZ	Sheared zone
BP	Bedding Parting
SM	Seam
FL	Foliation
VN	Vein
CL	Cleavage
CS	Crushed Seam
FZ	Fracture Zone
DL	Drift Lift
HB	Handing Break
DB	Drilling Break

PLANARITY

CU	Curved
DIS	Discontinuous
IR	Irregular
PR	Planar
ST	Stepped
UN	Undulose

ROUGHNESS

VR	Very Rough
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S	Smooth
SL	Slockensided
POL	Polished

COATING

CN	Clean
SN	Stained
VNR	Veneer (thin or patchy)
CT	Coating (up to 1mm)

INFILL MATERIALS

X	Carbonaceus
MU	Unidentified minteral
MS	Secondary mineral
KT	Chlorite
CA	Calcite
Fe	Iron Oxide
Qz	Quartz

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

CLIENT:	Waluya Pty Ltd	**BOREHOLE ID:**	BH05
PROJECT:	Geotechnical Investigation	**CORED DEPTH:**	3.00 - 15.11 m
LOCATION:	Racecourse Rd West Gosford, NSW	**CORE TRAYS:**	3
PROJECT NO.:	300304375	**DATE:**	25/01/2024

Stantec
Stantec Australia Pty Ltd | ABN 17 007 820 322
Level 2, 22 Honeysuckle Drive
Newcastle NSW 2300
Tel: +61 2 4940 4100
Web: www.stantec.com

NM 29/01/2024
Designed

WALUYA PTY LTD
RACECOURSE RD
GEOTECHNICAL INVESTIGATION
WEST GOSFORD, NSW
ROCK CORE PHOTOGRAPHY
BH05: 3.00 - 15.11M

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

300304375 -
- A

DATE PLOTTED: 29 January 2024 3:44 PM BY : MCDONALD, NICK
XREF's:
CAD File: U:\300304375_Data-In\Drawing\core_photo_figures\Racecourse Rd Core Photos_v2024.dwg

Explanatory Notes

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. Material descriptions are deduced from field observation or engineering examination, and may be appended or confirmed by in situ or laboratory testing. The information is dependent on the scope of investigation, the extent of sampling and testing, and the inherent variability of the conditions encountered.

Subsurface investigation may be conducted by one or a combination of the following methods.

Method	
Test Pitting: excavation/trench	
BH	Backhoe bucket
EX	Excavator bucket
R	Ripper
H	Hydraulic Hammer
X	Existing excavation
N	Natural exposure
Manual drilling: hand operated tools	
HA	Hand Auger
Continuous sample drilling	
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
Hammer drilling	
AH	Air hammer
AT	Air track
Spiral flight auger drilling	
AS	Auger screwing
AD/V	Continuous flight auger: V-bit
AD/T	Continuous spiral flight auger: TC-Bit
HFA	Continuous hollow flight auger
Rotary non-core drilling	
WB	Washbore drilling
RR	Rock roller
Rotary core drilling	
PQ	85mm core (wire line core barrel)
HQ	63.5mm core (wire line core barrel)
NMLC	51.94mm core (conventional core barrel)
NQ	47.6mm core (wire line core barrel)
DT	Diatube (concrete coring)

Sampling is conducted to facilitate further assessment of selected materials encountered.

Sampling method	
Soil sampling	
B	Bulk disturbed sample
D	Disturbed sample
C	Core sample
ES	Environmental soil sample
SPT	Standard Penetration Test sample
U	Thin wall tube 'undisturbed' sample
Water sampling	
WS	Environmental water sample

Field testing may be conducted as a means of assessment of the in situ conditions of materials.

Field testing		
SPT	Standard Penetration Test	
HP/PP	Hand/Pocket Penetrometer	
Dynamic Penetrometers (blows per noted increment)		
	DCP	Dynamic Cone Penetrometer
	PSP	Perth Sand Penetrometer
MC	Moisture Content	
VS	Vane Shear	
PBT	Plate Bearing Test	
IMP	Borehole Impression Test	
PID	Photo Ionization Detector	

If encountered, refusal (R), virtual refusal (VR) or hammer bouncing (HB) of penetrometers may be noted.

The quality of the rock can be assessed by the degree of natural defects/fractures and the following.

Rock quality description	
TCR	Total Core Recovery (%) (length of core recovered divided by the length of core run)
RQD	Rock Quality Designation (%) (sum of axial lengths of core greater than 100mm long divided by the length of core run)

Notes on groundwater conditions encountered may include.

Groundwater	
Not Encountered	Excavation is dry in the short term
Not Observed	Water level observation not possible
Seepage	Water seeping into hole
Inflow	Water flowing/flooding into hole

Perched groundwater may result in a misleading indication of the depth to the true water table. Groundwater levels are also likely to fluctuate with variations in climatic and site conditions.

Notes on the stability of excavations may include.

Excavation conditions	
Stable	No obvious/gross short term instability noted
Spalling	Material falling into excavation (minor/major)
Unstable	Collapse of the majority, or one or more face of the excavation

Explanatory Notes: General Soil Description

The methods of description and classification of soils used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. In practice, a material is described as a soil if it can be remoulded by hand in its field condition or in water. The dominant component is shown in upper case, with secondary components in lower case. In general descriptions cover: soil type, plasticity or particle size/shape, colour, strength or density, moisture and inclusions.

In general, soil types are classified according to the dominant particle on the basis of the following particle sizes.

Soil Classification		**Particle Size (mm)**
CLAY		< 0.002
SILT		0.002 0.075
SAND	fine	0.075 to 0.21
	medium	0.21 to 0.6
	coarse	0.6 to 2.36
GRAVEL	fine	2.36 to 6.7
	medium	6.7 to 19
	coarse	19 to 63
COBBLES		63 to 200
BOULDERS		> 200

Soil types may be qualified by the presence of minor components on the basis of field examination methods and/or the soil grading.

Terminology	**In coarse grained soils**		**In fine soils**
	% fines	**% coarse**	**% coarse**
Trace	≤5	≤15	≤15
With	>5, ≤12	>15, ≤30	>15, ≤30

The strength of cohesive soils is classified by engineering assessment or field/lab testing as follows.

Strength	**Symbol**	**Undrained shear strength**
Very Soft	VS	≤12kPa
Soft	S	12kPa to ≤25kPa
Firm	F	25kPa to ≤50kPa
Stiff	St	50kPa to ≤100kPa
Very Stiff	VSt	100kPa to ≤200kPa
Hard	H	>200kPa

Cohesionless soils are classified on the basis of relative density as follows.

Relative Density	**Symbol**	**Density Index**
Very Loose	VL	<15%
Loose	L	15% to ≤35%
Medium Dense	MD	35% to ≤65%
Dense	D	65% to ≤85%
Very Dense	VD	>85%

The plasticity of cohesive soils is defined by the Liquid Limit (LL) as follows.

Plasticity	**Silt LL**	**Clay LL**
Low plasticity	≤ 35%	≤ 35%
Medium plasticity	N/A	> 35% ≤ 50%
High plasticity	> 50%	> 50%

The moisture condition of soil (*w*) is described by appearance and feel and may be described in relation to the Plastic Limit (PL), Liquid Limit (LL) or Optimum Moisture Content (OMC).

Moisture condition and description	
Dry	Cohesive soils: hard, friable, dry of plastic limit. Granular soils: cohesionless and free-running
Moist	Cool feel and darkened colour: Cohesive soils can be moulded. Granular soils tend to cohere
Wet	Cool feel and darkened colour: Cohesive soils usually weakened and free water forms when handling. Granular soils tend to cohere

The structure of the soil may be described as follows.

Zoning	**Description**
Layer	Continuous across exposure or sample
Lens	Discontinuous layer (lenticular shape)
Pocket	Irregular inclusion of different material

The structure of soil layers may include: defects such as softened zones, fissures, cracks, joints and root-holes; and coarse grained soils may be described as strongly or weakly cemented.

The soil origin may also be noted if possible to deduce.

Soil origin and description	
Fill	Anthropogenic deposits or disturbed material
Topsoil	Zone of soil affected by roots and root fibres
Peat	Significantly organic soils
Colluvial	Transported down slopes by gravity/water
Aeolian	Transported and deposited by wind
Alluvial	Deposited by rivers
Estuarine	Deposited in coastal estuaries
Lacustrine	Deposited in freshwater lakes
Marine	Deposits in marine environments
Residual soil	Soil formed by in situ weathering of rock, with no structure/fabric of parent rock evident
Extremely weathered material	Formed by in situ weathering of geological formations, with the structure/fabric of parent rock intact but with soil strength properties

The origin of the soil generally cannot be deduced solely on the appearance of the material and the inference may be supplemented by further geological evidence or other field observation. Where there is doubt, the terms ‘possibly’ or ‘probably’ may be used

Explanatory Notes: General Rock Description

The methods of description and classification of rocks used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. In practice, if a material cannot be remoulded by hand in its field condition or in water, it is described as a rock. In general, descriptions cover: rock type, grain size, structure, colour, degree of weathering, strength, minor components or inclusions, and where applicable, the defect types, shape, roughness and coating/infill.

Rock types are generally described according to the predominant grain or crystal size, and in groups for each rock type as follows.

Rock type	Groups
Sedimentary	Deposited, carbonate (porous or non), volcanic ejection
Igneous	Felsic (much quartz, pale), Intermediate, or mafic (little quartz, dark)
Metamorphic	Foliated or non-foliated
Duricrust	Cementing minerology (iron oxides or hydroxides, silica, calcium carbonate, gypsum)

Reference should be made to AS1726 for details of the rock types and methods of classification.

The classification of rock weathering is described based on definitions in AS1726 and summarised as follows.

Term and symbol		Definition
Residual Soil	RS	Soil developed on rock with the mass structure and substance of the parent rock no longer evident
Extremely weathered	XW	Weathered to such an extent that the rock has ‘soil-like’ properties. Mass structure and substance still evident
Distinctly weathered	DW	The strength is usually changed and may be highly discoloured. Porosity may be increased by leaching, or decreased due to deposition in pores. May be distinguished into MW (Moderately Weathered) and HW (Highly Weathered).
Slightly weathered	SW	Slightly discoloured; little or no change of strength from fresh rock
Fresh Rock	FR	The rock shows no sign of decomposition or staining

The rock material strength can be defined based on the point load index as follows.

Term and symbol		Point Load Index I_s50 (MPa)
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1.0
High	H	1.0 to 3
Very High	VH	3 to 10
Extremely High	EH	> 10

It is important to note that the rock material strength as above is distinct from the rock mass strength which can be significantly weaker due to the effect of defects.

A preliminary assessment of rock strength may be made using the field guide detailed in AS1726, and this is conducted in the absence of point load testing.

The defect spacing measured normal to defects of the same set or bedding, is described as follows.

Definition	Defect Spacing (mm)
Thinly laminated	< 6
Laminated	6 to 20
Very thinly bedded	20 to 60
Thinly bedded	60 to 200
Medium bedded	200 to 600
Thickly bedded	600 to 2000
Very thickly bedded	> 2000

Terms for describing rock and defects are as follows.

Defect Terms			
Joint	JT	Sheared zone	SZ
Bedding Parting	BP	Seam	SM
Foliation	FL	Vein	VN
Cleavage	CL	Drill Lift	DL
Crushed Seam	CS	Handling Break	HB
Fracture Zone	FZ	Drilling Break	DB

The shape and roughness of defects in the rock mass are described using the following terms.

Planarity		Roughness	
Planar	PR	Very Rough	VR
Curved	CU	Rough	RF
Undulose	UN	Smooth	S
Irregular	IR	Slickensided	SL
Stepped	ST	Polished	POL
Discontinuous	DIS		

The coating or infill associated with defects in the rock mass are described as follows.

Infill and Coating		
Clean	CN	
Stained	SN	
Carbonaceous	X	
Minerals	MU	Unidentified mineral
	MS	Secondary mineral
	KT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
Veneer	VNR	Thin or patchy coating
Coating	CT	Infill up to 1mm

Graphic Symbols Index

- ▨ CLAY
- ▨ Silty CLAY
- ▨ Sandy CLAY
- ▨ Gravelly CLAY
- ▨ Silty Gravelly CLAY
- ▨ Silty Sandy CLAY
- ▨ Sandy Gravelly CLAY

- ▨ SILT
- ▨ Clayey SILT
- ▨ Sandy SILT
- ▨ Gravelly SILT
- ▨ Clayey Sandy SILT
- ▨ Clayey Gravelly SILT
- ▨ Sandy Gravelly SILT

- ▨ SAND
- ▨ Clayey SAND
- ▨ Silty SAND
- ▨ Gravelly SAND
- ▨ Clayey Silty SAND
- ▨ Clayey Gravelly SAND
- ▨ Silty Gravelly SAND

- ▨ GRAVEL
- ▨ Clayey GRAVEL
- ▨ Silty GRAVEL
- ▨ Sandy GRAVEL
- ▨ Clayey Silty GRAVEL
- ▨ Clayey Sandy GRAVEL
- ▨ Silty Sandy GRAVEL

- ▨ COBBLES & BOULDERS
- ▨ PEAT, highly organic soil
- ▨ TOPSOIL
- ▨ FILL
- ■ FILL: Asphalt or Bituminous Seal
- ▨ FILL: Ballast
- ▨ FILL: Concrete
- ▨ FILL: Roadbase

- ▨ Sedimentary rock: fine, mostly clay (CLAYSTONE)
- ▨ Sedimentary rock: fine, mostly silt (SILTSTONE)
- ▨ Sedimentary rock: fine, silt and clay (MUDSTONE, SHALE, LAMINITE)
- ▨ Sedimentary rock: medium (SANDSTONE, GREYWACKE)
- ▨ Sedimentary rock: fine to coarse, angular (BRECCIA)
- ▨ Sedimentary rock: coarse, rounded (CONGLOMERATE)
- ▨ Sedimentary rock: Organic (COAL)
- ▨ Sedimentary rock: Carbonate (LIMESTONE, DOLOMITE)
- ▨ Sedimentary rock: Volcanic (TUFF, VOLCANIC BRECCIA, AGGLOMERATE)

- ▨ Igneous rock: Felsic, fine (RHYOLITE)
- ▨ Igneous rock: Felsic, coarse (GRANITE)
- ▨ Igneous rock: Mafic, fine to medium (BASALT, DOLERITE)
- ▨ Igneous rock: Mafic, coarse (GABBRO)
- ▨ Metamorphic rock: Foliated, fine to medium (SLATE, PHYLLITE, SHIST)
- ▨ Metamorphic rock: Foliated, coarse (GNEISS)
- ▨ Metamorphic rock: Non-foliated (QUARTZITE, HORNFELS, MARBLE)

APPENDIX

C

LABORATORY TEST RESULTS

now

Stantec

CHAIN OF CUSTODY RECORD

Stantec

LAB Name Envirolab
Address

Client Stantec Australia Pty Ltd
suite 2 level 2, 22 honey suckle drive
Newcastle NSW 2300

Contact Numbers
Phone 0401 972 634
Fax

Contact Nicholas McDonald

E-mail nicholas.mcdonald@cardno.com.au george.ashworth@cardno.com.au
(invoice to sapinvoices@stantec.com)

Sampled by Nicholas McDonald

NOTE: Aggressivity = Soil Aggressivity & Resistivity test please

Project Ref: 300304375

Date Results Required Standard TAT

Laboratory LIMS ID	Client Sample ID	Date Sampled	Matrix: Soil	Matrix: Water	Containers/Preservation: Soil Jar (G) Nat. Orange	Purple JAR	Orange Jar	50mL VOA Vial (G) H_2SO_4 Maroon	0.1-1.0 litre (P) H_2SO_4 Maroon	0.2-1.0 litre (G) H_2SO_4 Maroon	0.1-0.2 (P) Filtered?? Y=Yes, N=No (HNO3) Red	0.2l (P) NaOH Blue	Other - Zip Lock Bag	Analysis Required: Aggressivity					
1	BH01 0.3 - 0.5 m	23/05/2023	☒										☒						
2	BH01 1.1 - 1.3 m	23/05/2023	☒										☒	☒					
3	BH01 SPT 1.5 m	23/05/2023	☒										☒						
4	BH01 1.6 - 1.7 m	23/05/2023	☒										☒	☒					
NR.	BH02 1.3 - 1.5 m	23/05/2023	☒										☒	☒					
5	BH02 SPT 1.5 m	23/05/2023	☒										☒						
6	BH02 SPT 3.0 m	23/05/2023	☒										☒						
7	BH02 SPT 4.5 m	23/05/2023	☒										☒						
8	BH03 0.05 - 0.15	24/05/2023	☒										☒	☒					
9	BH03 0.2 - 0.3 m	24/05/2023	☒										☒						
10	BH03 SPT 0.5 m	24/05/2023	☒										☒						
11	BH03 0.7 - 0.9 m	24/05/2023	☒										☒						
12	BH04 SPT 0.5 m	24/05/2023	☒										☒	☒					
13	BH04 SPT 1.5 m	24/05/2023	☒										☒						
14	BH04 SPT 3.0 m	24/05/2023	☒										☒	☒					
15	BH04 SPT 4.5 m	24/05/2023	☒										☒						
16	BH04 SPT 6.0 m	24/05/2023	☒										☒						
17	BH04 SPT 7.5 m	24/05/2023	☒										☒						
18	BH04 SPT 9.0 m	24/05/2023	☒										☒						
Extra: 19	BH02 6.9-7.0m.																		

All samples chilled immediately after sampling event and kept < 6 degrees

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 325767.

EW/VC 20 BH04.

Relinquished by Nicholas McDonald Signature Date/Time 15/06/2023

Received by EMILY W Signature EW Date/Time 16/6/23 1040. Custody Seals Intact? / Samples Received Chilled? Y Y

21 Ⓐ
22. Ⓑ

Date Received: 16/6/23.
Time Received: 1040
Received By: EW.
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack] 8·C
Security: Intact/Broken/[✓ None]

1225

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 325767

Client Details

Client	Cardno (NSW/ACT) Pty Ltd
Attention	Nicholas McDonald
Address	PO Box 19, St Leonards, NSW, 1590

Sample Details

Your Reference	**300304375**
Number of Samples	22 Soil
Date samples received	16/06/2023
Date completed instructions received	16/06/2023

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	23/06/2023
Date of Issue	23/06/2023

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Diego Bigolin, Inorganics Supervisor

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference	UNITS	325767-2	325767-4	325767-5	325767-8	325767-12
Your Reference		BH01 1.1 - 1.3 m	BH01 1.6 - 1.7 m	BH02 SPT 1.5 m	BH03 0.05 - 0.15	BH04 SPT 0.5 m
Date Sampled		23/05/2023	23/05/2023	23/05/2023	24/05/2023	24/05/2023
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	21/06/2023	21/06/2023	21/06/2023	21/06/2023	21/06/2023
Date analysed	-	21/06/2023	21/06/2023	21/06/2023	21/06/2023	21/06/2023
pH 1:5 soil:water	pH Units	5.2	5.1	4.4	6.2	4.3
Electrical Conductivity 1:5 soil:water	µS/cm	48	51	79	94	190
Chloride, Cl 1:5 soil:water	mg/kg	<10	10	83	10	50
Sulphate, SO4 1:5 soil:water	mg/kg	51	47	<10	39	260
Resistivity in soil*	ohm m	210	200	2,100	110	54

Misc Inorg - Soil		
Our Reference	UNITS	325767-14
Your Reference		BH04 SPT 3.0 m
Date Sampled		24/05/2023
Type of sample		Soil
Date prepared	-	21/06/2023
Date analysed	-	21/06/2023
pH 1:5 soil:water	pH Units	5.5
Electrical Conductivity 1:5 soil:water	µS/cm	35
Chloride, Cl 1:5 soil:water	mg/kg	10
Sulphate, SO4 1:5 soil:water	mg/kg	35
Resistivity in soil*	ohm m	280

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			21/06/2023	2	21/06/2023	21/06/2023		21/06/2023	[NT]
Date analysed	-			21/06/2023	2	21/06/2023	21/06/2023		21/06/2023	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	2	5.2	5.1	2	100	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	2	48	49	2	102	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	<10	<10	0	105	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	51	51	0	100	[NT]
Resistivity in soil*	ohm m	1	Inorg-002	<1	2	210	200	5	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Samples were out of the recommended holding time for this analysis pH/EC in soil.

Material Test Report

Report Number: **SC2366-1**
Issue Number: 1
Date Issued: 22/06/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: SC2366
Project Name: West Gosford Bus Depot
Project Location: Racecourse Road, West Gosford
Client Reference: 300304375
Work Request: 6144
Sample Number: M23-6144A
Date Sampled: 01/06/2023
Dates Tested: 02/06/2023 - 16/06/2023
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: **BH02, Depth: 0.4 - 1.3m**

QUALITY GEOTECHNICAL SERVICES
QGS Quality Geotechnical Services Pty Ltd
8/34 Alliance Avenue Morisset NSW 2264
Phone: 0475 008 651
Email: steve.waugh@qgslabs.com

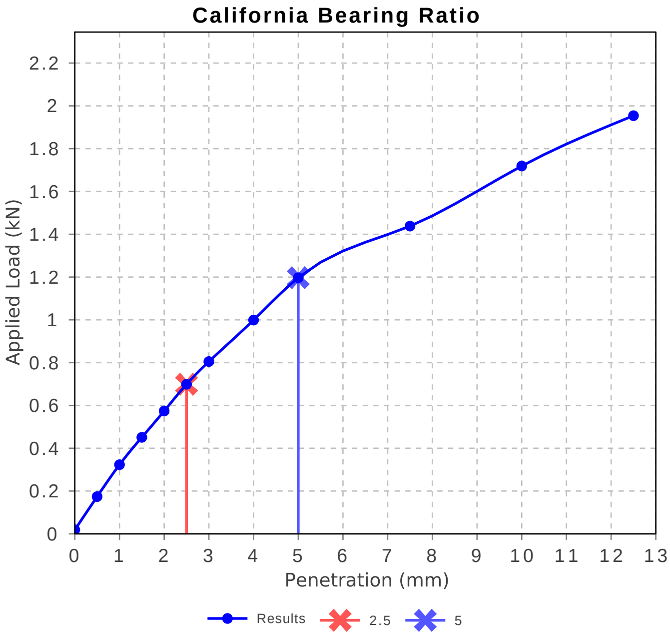
Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Steve Waugh
Managing Director
NATA Accredited Laboratory Number: 21234

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**6**		
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)	1.81		
Optimum Moisture Content (%)	17.0		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	99.5		
Dry Density after Soaking (t/m^3)	1.80		
Field Moisture Content (%)	19.1		
Moisture Content at Placement (%)	16.7		
Moisture Content Top 30mm (%)	18.2		
Moisture Content Rest of Sample (%)	17.4		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	96.0		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	43		
Plastic Limit (%)	16		
Plasticity Index (%)	**27**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**11.0**		
Cracking Crumbling Curling	Curling		



Material Test Report

QUALITY GEOTECHNICAL SERVICES

QGS Quality Geotechnical Services Pty Ltd
8/34 Alliance Avenue Morisset NSW 2264
Phone: 0475 008 651
Email: steve.waugh@qgslabs.com

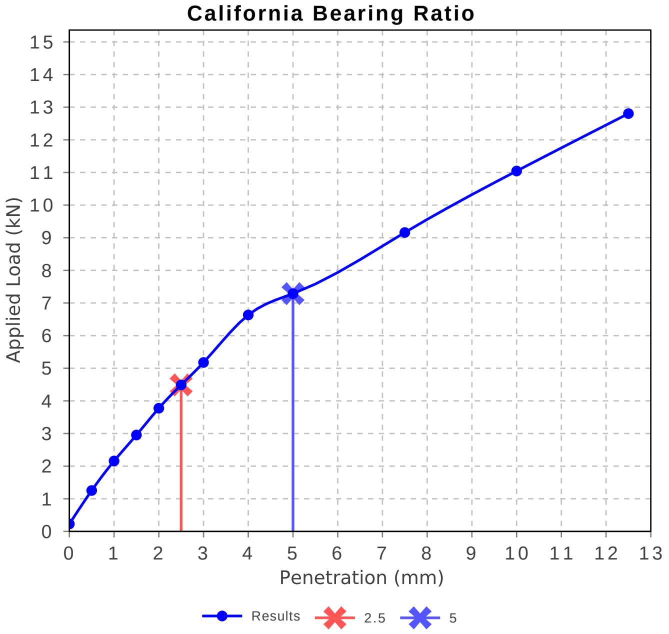
Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Steve Waugh
Managing Director
NATA Accredited Laboratory Number: 21234

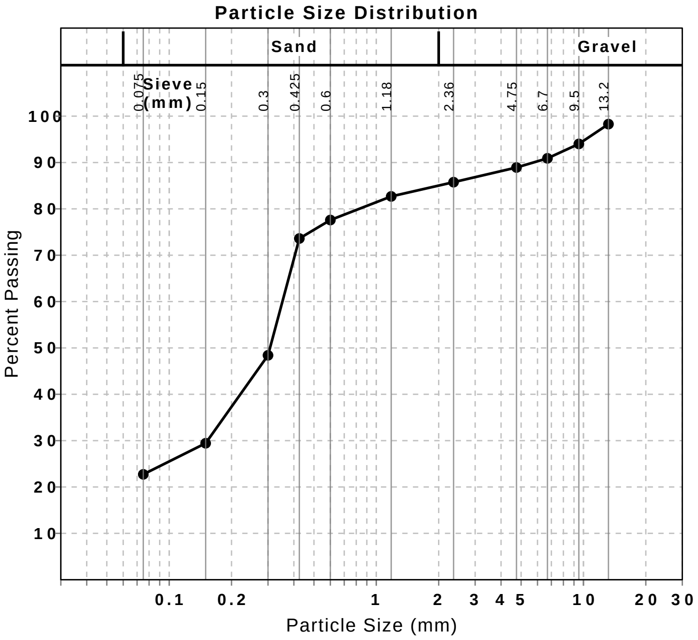
Report Number: **SC2366-1**
Issue Number: 1
Date Issued: 22/06/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: SC2366
Project Name: West Gosford Bus Depot
Project Location: Racecourse Road, West Gosford
Client Reference: 300304375
Work Request: 6144
Sample Number: M23-6144B
Date Sampled: 01/06/2023
Dates Tested: 02/06/2023 - 15/06/2023
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: **BH03, Depth: 0.3 - 0.5m**

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**35**		
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)	1.95		
Optimum Moisture Content (%)	11.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	98.5		
Dry Density after Soaking (t/m^3)	1.95		
Field Moisture Content (%)	7.3		
Moisture Content at Placement (%)	11.2		
Moisture Content Top 30mm (%)	12.7		
Moisture Content Rest of Sample (%)	12.2		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	72.0		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
13.2 mm	**98**			2		
9.5 mm	**94**			4		
6.7 mm	**91**			3		
4.75 mm	**89**			2		
2.36 mm	**86**			3		
1.18 mm	**83**			3		
0.6 mm	**78**			5		
0.425 mm	**74**			4		
0.3 mm	**48**			25		
0.15 mm	**29**			19		
0.075 mm	**23**			7		



Material Test Report

Report Number:	**SC2366-1**
Issue Number:	1
Date Issued:	22/06/2023
Client:	Stantec Pty Ltd
Contact:	Ian Piper
Project Number:	SC2366
Project Name:	West Gosford Bus Depot
Project Location:	Racecourse Road, West Gosford
Client Reference:	300304375
Work Request:	6144
Sample Number:	M23-6144C
Date Sampled:	01/06/2023
Dates Tested:	02/06/2023 - 16/06/2023
Sampling Method:	Sampled by Client - Tested as Received *The results apply to the sample as received*
Sample Location:	**TP209, Depth: 0.3 - 1.5m**

QUALITY GEOTECHNICAL SERVICES

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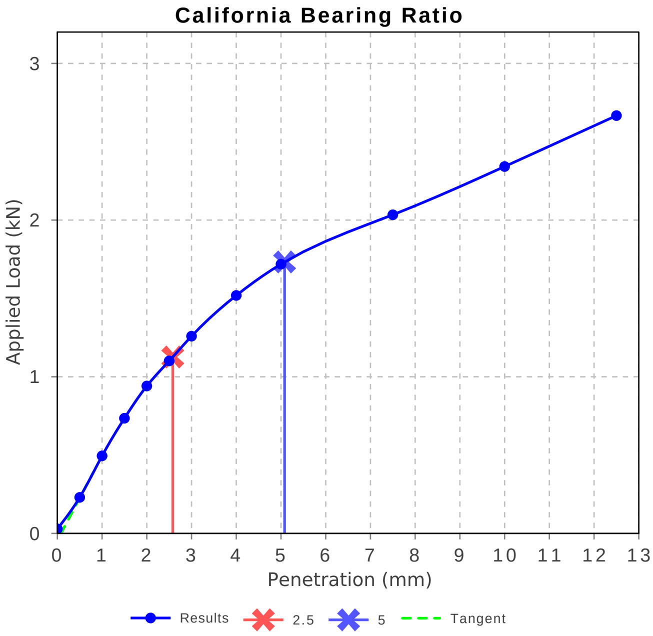
Accredited for compliance with ISO/IEC 17025 - Testing

NATA WORLD RECOGNISED ACCREDITATION

Approved Signatory: Steve Waugh
Managing Director
NATA Accredited Laboratory Number: 21234

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	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)	1.85		
Optimum Moisture Content (%)	17.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.5		
Dry Density after Soaking (t/m^3)	1.84		
Field Moisture Content (%)	18.6		
Moisture Content at Placement (%)	17.7		
Moisture Content Top 30mm (%)	19.6		
Moisture Content Rest of Sample (%)	18.3		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	96.0		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	53		
Plastic Limit (%)	19		
Plasticity Index (%)	**34**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**14.5**		
Cracking Crumbling Curling	Curling		

Material Test Report

QGS Quality Geotechnical Services Pty Ltd
8/34 Alliance Avenue Morisset NSW 2264
Phone: 0475 008 651
Email: steve.waugh@qgslabs.com

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Steve Waugh
Managing Director
NATA Accredited Laboratory Number: 21234

Report Number: **SC2366-1**
Issue Number: 1
Date Issued: 22/06/2023
Client: Stantec Pty Ltd

Contact: Ian Piper
Project Number: SC2366
Project Name: West Gosford Bus Depot
Project Location: Racecourse Road, West Gosford
Client Reference: 300304375
Work Request: 6144
Dates Tested: 02/06/2023 - 15/06/2023
Location: West Gosford Bus Depot

Shrink Swell Index AS 1289 7.1.1 & 2.1.1						
Sample Number	M23-6144A	M23-6144C				
Date Sampled	01/06/2023	01/06/2023				
Date Tested	15/06/2023	15/06/2023				
Material Source	insitu	insitu				
Sample Location	BH02 (0.4 - 1.3m)	TP209 (0.3 - 1.5m)				
Inert Material Estimate (%)	0	0				
Pocket Penetrometer before (kPa)	**	**				
Pocket Penetrometer after (kPa)	**	**				
Shrinkage Moisture Content (%)	18.2	16.8				
Shrinkage (%)	**3.0**	**2.0**				
Swell Moisture Content Before (%)	18.6	17.2				
Swell Moisture Content After (%)	19.9	21.0				
Swell (%)	**-0.0**	**-0.1**				
Shrink Swell Index Iss (%)	**1.7**	**1.1**				
Visual Description	Refer to Client logs	Refer to Client logs				
Cracking	SC	UC				
Crumbling	No	No				
Remarks	Sample remoulded at Field Moisture with 100% Standard compactive effort	Sample remoulded at Field Moisture with 100% Standard compactive effort				

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.

POINT LOAD STRENGTH TEST RESULTS

CLIENT: Busways Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: Racecourse Rd, West Gosford NSW

DATE:
PROJECT No: 300304375
CLIENT REF:

Bore	Depth (m)	Test Number	Sample length (mm)	Sample diameter (mm)	Minimum cross-sectional area of plane (mm)	Separation at failure (mm)	Orientation A = axial D = diametrical I = irregular AS = Anisotropic rock	Load at failure (kN)	Point load strength, I_s	Point load index, $I_{s(50)}$	Rock type & structure	Moisture content & storage history	Failure mechanism M = massive B = bedded J = jointed	Strength
BH03	2.23	1	90.0	52.0	2124	50.5	D	0.32	0.1	0.1		Moist, core tray	b	Very Low
BH03	2.25	2	37.0	52.0	1924	36.0	A	0.34	0.1	0.1		Moist, core tray	b	Very Low
BH03	2.50	3	180.0	52.0	2124	49.0	D	0.50	0.2	0.2		Moist, core tray	b	Very Low
BH03	2.52	4	45.0	52.0	2340	43.0	A	0.44	0.1	0.2		Moist, core tray	b	Very Low
BH03	2.95	5	250.0	52.0	2124	49.5	D	0.57	0.2	0.2		Moist, core tray	b	Very Low
BH03	2.97	6	50.0	52.0	2600	49.0	A	0.62	0.2	0.2		Moist, core tray	b	Very Low
BH03	3.35	7	140.0	52.0	2124	25.0	D	0.11	0.2	0.1		Moist, core tray	b	Very Low
BH03	3.37	8	28.0	52.0	1456	17.5	A	0.06	0.03	0.03		Moist, core tray	b	Extremely Low
BH03	4.42	9	47.0	52.0	2124	43.5	D	0.26	0.1	0.1		Moist, core tray	b	Very Low
BH03	4.44	10	18.0	52.0	936	16.7	A	0.17	0.1	0.1		Moist, core tray	b	Very Low
BH03	4.35	11	180.0	52.0	2124	49.0	D	1.31	0.5	0.5		Moist, core tray	b	Medium
BH03	4.37	12	37.0	52.0	1924	38.0	A	0.89	0.4	0.4		Moist, core tray	b	Medium
BH03	5.77	13	90.0	52.0	2124	50.0	D	0.45	0.2	0.2		Moist, core tray	b	Very Low
BH03	5.79	14	39.0	52.0	2028	37.0	A	0.22	0.09	0.09		Moist, core tray	b	Extremely Low
BH03	6.22	15	52.0	52.0	2124	49.5	D	0.93	0.4	0.4		Moist, core tray	b	Medium
BH03	6.24	16	22.0	52.0	1144	24.0	A	0.90	0.6	0.5		Moist, core tray	b	Medium
BH03	6.84	17	82.0	52.0	2124	49.5	D	0.74	0.3	0.3		Moist, core tray	b	Medium
BH03	6.82	18	45.0	52.0	2340	43.0	A	0.67	0.2	0.2		Moist, core tray	b	Very Low
BH03	7.06	19	57.0	52.0	2124	48.0	D	0.05	0.02	0.02		Moist, core tray	j	Extremely Low
BH03	7.25	20	35.0	52.0	1820	32.5	A	1.19	0.5	0.5		Moist, core tray	b	Medium

AS4133.4.1-1993 Cl 3.3 - Axial test

AS4133.4.1-1993 Cl 3.5 - Anisometrical rock test

Stantec Australia
Office: Newcastle

Calculated by: NM
Checked by: GA

POINT LOAD STRENGTH TEST RESULTS

CLIENT: Busways Pty Ltd
PROJECT: Geotechnical Investigation
LOCATION: Racecourse Rd, West Gosford NSW

DATE:
PROJECT No: 300304375
CLIENT REF:

Bore	Depth (m)	Test Number	Sample length (mm)	Sample diameter (mm)	Minimum cross-sectional area of plane (mm)	Separation at failure (mm)	Orientation A = axial D = diametrical I = irregular AS = Anisotropic rock	Load at failure (kN)	Point load strength, I_s	Point load index, $I_{s(50)}$	Rock type & structure	Moisture content & storage history	Failure mechanism M = massive B = bedded J = jointed	Strength
BH01	2.81	1	90.0	52.0	2124	48.5	D	0.36	0.2	0.2		Moist, core tray	j	Very Low
BH01	-			52.0	0		A					Moist, core tray	b	
BH01	3.90	2	126.0	52.0	2124	51.0	D	0.89	0.3	0.3		Moist, core tray	b	Medium
BH01	3.88	3	42.0	52.0	2184	41.0	A	1.09	0.4	0.4		Moist, core tray	b	Medium
BH01	4.26	4	52.0	52.0	2124	48.5	D	0.59	0.3	0.2		Moist, core tray	b	Very Low
BH01	4.28	5	18.0	52.0	936	17.5	A	0.48	0.4	0.3		Moist, core tray	b	Medium
BH01	4.58	6	82.0	52.0	2124	50.0	D	0.68	0.3	0.3		Moist, core tray	b	Very Low
BH01	4.60	7	42.0	52.0	2184	39.5	A	1.30	0.5	0.5		Moist, core tray	b	Medium
BH01	5.04	8	65.0	52.0	2124	50.0	D	0.89	0.4	0.4		Moist, core tray	b	Medium
BH01	5.06	9	27.0	52.0	1404	25.5	A	0.81	0.5	0.4		Moist, core tray	b	Medium
BH01	5.91	10	170.0	52.0	2124	49.0	D	1.79	0.7	0.7		Moist, core tray	b	Medium
BH01	5.93	11	40.0	52.0	2080	37.0	A	1.81	0.7	0.7		Moist, core tray	b	Medium
BH01	6.30	12	145.0	52.0	2124	49.5	D	2.19	0.9	0.9		Moist, core tray	b	Medium
BH01	6.32	13	47.0	52.0	2444	45.5	A	1.88	0.6	0.6		Moist, core tray	b	Medium
BH01	7.95	14	60.0	52.0	2124	48.0	D	0.31	0.1	0.1		Moist, core tray	b	Very Low
BH01	7.97	15	20.0	52.0	1040	17.0	A	0.21	0.2	0.1		Moist, core tray	b	Very Low
BH01	8.17	16	85.0	52.0	2124	47.0	D	0.29	0.1	0.1		Moist, core tray	b	Very Low
BH01	8.15	17	44.0	52.0	2288	41.0	A	0.35	0.1	0.1		Moist, core tray	b	Very Low
BH01	8.46	18	110.0	52.0	2124	47.5	D	0.67	0.3	0.3		Moist, core tray	b	Very Low
BH01	8.48	19	37.0	52.0	1924	33.0	A	0.40	0.2	0.2		Moist, core tray	b	Very Low
BH01				52.0	2124		D		0.3	0.3		Moist, core tray	b	Medium

AS4133.4.1-1993 Cl 3.3 - Axial test

AS4133.4.1-1993 Cl 3.5 - Anisometrical rock test

Stantec Australia
Office: Newcastle

Calculated by: NM
Checked by: GA

APPENDIX

D

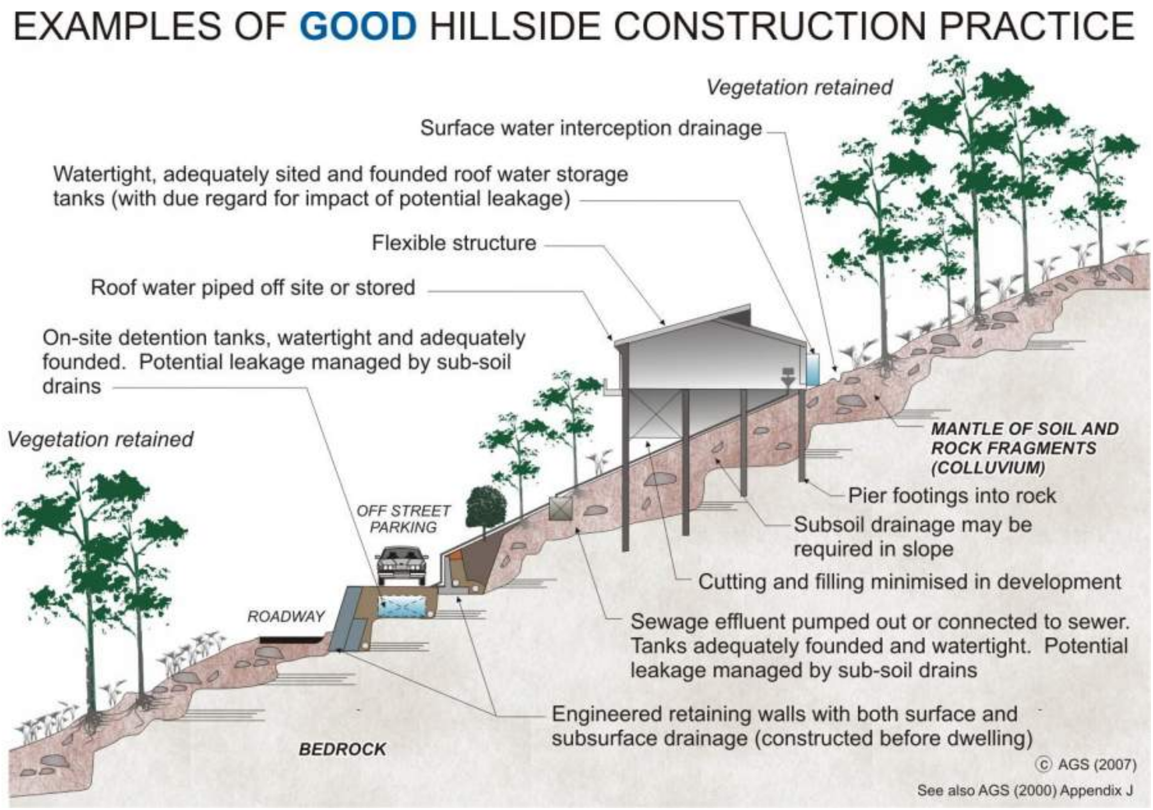
HILLSIDE CONSTRUCTION PRACTICE

now

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

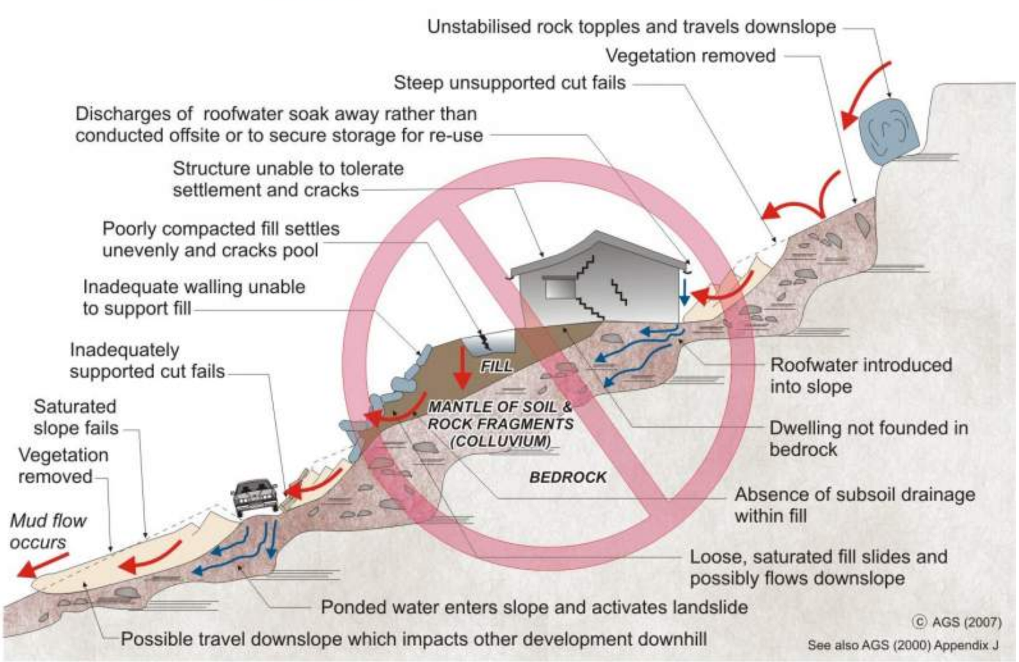
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF POOR HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal

GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.