Geotechnical Investigation Report

DA1 - 381 Anambah Road, Anambah NSW

Prepared for: DB20 Pty Ltd (Roche Group)

EP3487.002 23 May 2025

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EP RISK

Geotechnical Investigation Report

DA1 - 381 Anambah Road, Anambah NSW

DB20 Pty Ltd (Roche Group)
365 New South Head Road
Double Bay NSW 2028
23 May 2025

Our Ref: EP3487.002

LIMITATIONS

This Geotechnical Investigation Report was conducted on the behalf of DB20 Pty Ltd (Roche Group) for the purpose/s stated in **Section 1**.

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QUALITY CONTROL

Version	Author	Date	Reviewer	Date	Quality Review	Date
draft	O. Pruteanu	28/02/2024	J. Young	23/06/2024	O. Pruteanu	31/07/2024
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DOCUMENT CONTROL

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draft	*31/07/2024*	*Geotechnical Investigation Report*	*DB20 Pty Ltd (Roche Group)*
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1 Introduction

EP Risk Management Pty Ltd (EP Risk) was engaged by DB20 Pty Ltd (Roche Group) to undertake a Geotechnical Investigation at the proposed residential subdivision development including new roads and stormwater management and other associated works referred to as DA1 – 381 Anambah Road, Anambah NSW 2320. The development is located north of Windella and on the western side of Anambah Road.

The geotechnical investigation was undertaken in line with the conditions of engagement and the investigation scope as outlined in our proposal EP17482 dated 8 December 2023.

1.1 Objectives and Scope of Works

It is understood that the geotechnical investigation is required to inform the preliminary site classification, pavement design, rock excavatability and general construction notes. The extend of the proposed development is shown in **Appendix A – Proposed Development DA1**.

EP Risk carried out the following scope of works for the geotechnical investigation:

- Desktop study – collection and review of available information related to the site.
- Advanced seventeen (17) test pits within the footprint of the proposed residential subdivision and two (2) test pits outside of the footprint.
- Dynamic Cone Penetrometer (DCP) was undertaken adjacent to the test pits to inform the strata consistency.
- Collection of representative disturbed and bulk soil samples for laboratory testing.

This Geotechnical Report includes the findings of the investigation scope along with:

- Interpretation of the investigation results.
- Identification of the relevant geological units on site.
- Laboratory testing results.
- Preliminary pavement design.
- Retaining/shoring recommendations.
- Excavatability and earthworks guidelines.

2 Site Location and Description

The proposed residential subdivision development DA1 is in Anambah northeast of Windella, surrounded by undeveloped land on east, south and west and an ephemeral creek. The terrain elevations across the development range from approximate Reduced Level (R.L) 56m AHD in the southeast at the boundary with the proposed extension of Wyndella Road (Western Link Road) to approximately R.L 20m AHD at the northern boundary towards the ephemeral creek.

Topographically the site is situated in an area of gently undulating terrain, consisting of broad, convex hills covered by established low grass (improved pasture) for grazing. The drainage lines are broad and shallow with sediment filled ephemeral gullies, that drain usually in a north-east direction. Two water dams associated with the farming activities were observed in the same drainage line / watercourse in the proposed development. Generally, the slopes within the development are from 0° to 5° with gentle sloped in the gullies that drain to the northeast. Photographs collected during site investigation are included in **Appendix B – Photolog**.

An extract from Six Maps showing the site location is presented in Figure 1.

Figure 1 - Indicative Site Location DA1

3 Desktop Study

3.1 Regional Geology

Based on geological data sourced from NSW Government website (www.minview.geoscience.nsw.gov.au), the Site is underlain by:

- Permian Aged Lochinvar Formation (Pdal) – know to contain basalt, siltstone, and sandstone.
- Permian Aged Rutherford Formation (Pdar) – containing siltstone, marl, and minor sandstone.
- Quaternary Aged Alluvial valley deposits (Q_av)-comprising of silt, clay, (fluvially deposited) lithic to quartz-lithic sand, gravel.

An excerpt of the geological map is shown in Figure 2.

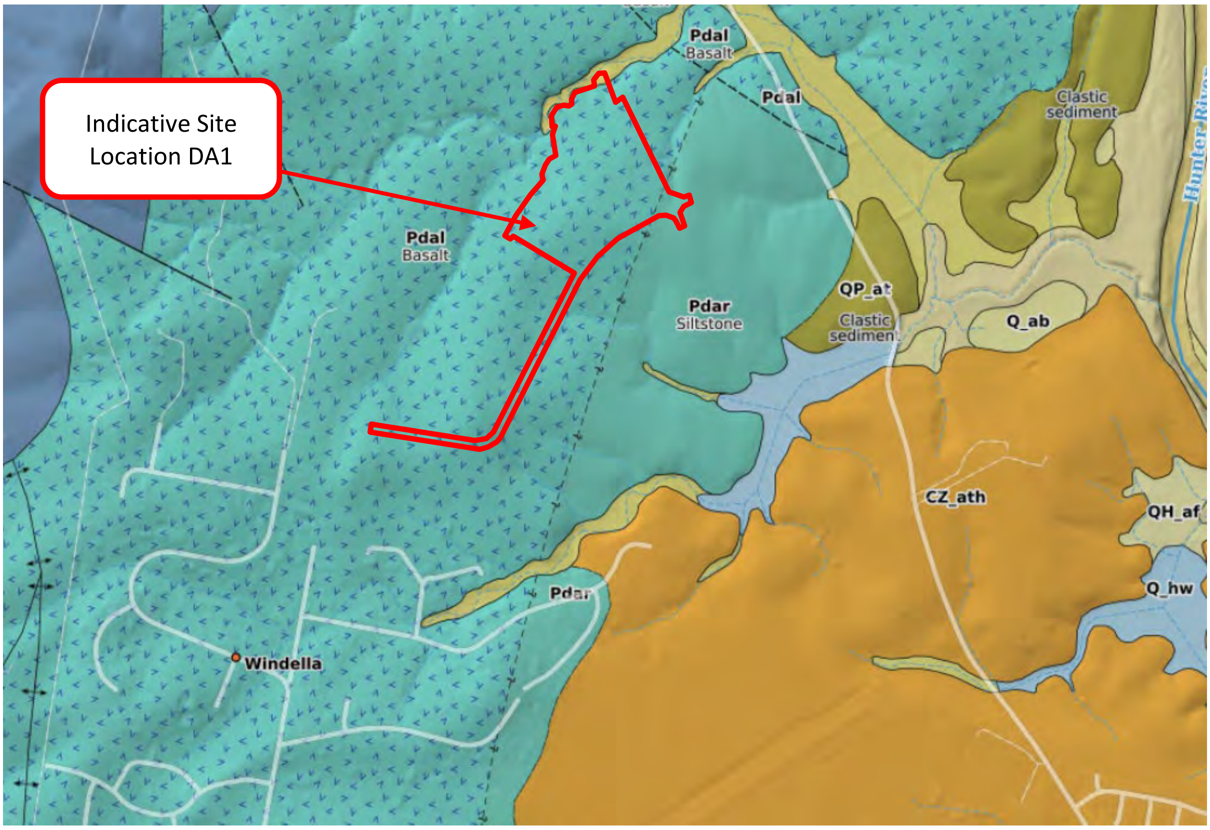


Figure 2 - Geological Map Excerpt

3.2 Soil Landscape

NSW Department of Industry, Resources and Energy (www.environment.nsw.gov.au), onsite soil landscapes have been identified to comprise of Branxton (SI5601bx).

Undulating rises to low hills and creek flats. Elevations range from 50 – 80 m, and slopes from 3 – 5%. Slope lengths are up to 600 m. Local relief is 10 – 40 m. Much of this landscape has drainage lines, spaced at 400 – 1,500 m intervals. Tunnel and gully erosion is encountered due to high dispersibility. Light erosion is associated with alluvial and siliceous sands.

3.3 Mine Subsidence

Reference to the Mine Subsidence District Data Source, the Site is not located within a Mine Subsidence District.

3.4 Acid Sulphate Soils

The NSW Government data available on www.geo.seed.nsw.gov.au indicates the site is located within Class 5 acid sulphate soil classification. Works within 500m of adjacent Class 1, 2, 3, or 4 land that is below 5m AHD and by which the water table is likely to be lowered below 1m AHD on adjacent Class 1, 2, 3, or 4 land, present and environmental risk. An extract of the acid sulphate soil map is shown in Figure 3.

Figure 3 – Acid Sulphate Soil Map Excerpt

4 Geotechnical Investigation

4.1 Investigation Methodology

The site investigation was carried out on 24th and 25th January 2024 under full supervision of an experienced EP Risk Geotechnical Professional in accordance with AS1726-2017 Geotechnical Site Investigation Standard and comprised the following:

- Preparation of a Safe Work Method Statement (SWMS) for all fieldwork.
- Excavating seventeen (17) test pits at locations of interest within the footprint of the proposed residential subdivision development. Two (2) test pits were excavated at the client's request outside of the residential subdivision development footprint to assess the excavatability.
- Logging of soil/rocks encountered and collection of representative soil and rock samples to be tested by a NATA-accredited laboratory.
- Reinstatement test pits with spoil. Upon completion the soil placed in test pits was compacted by the excavator bucket and by excavator run over.

The test pits were excavated using a Kobelco Geospec 24T excavator fitted with a 400mm bucket. Ripper attachment was used to advance the test pits in medium to high strength bedrock. The locations of the test pits are presented in **Appendix C- Geotechnical Investigation Locations**.

4.2 Subsurface Profile

A project geological classification has been developed based on the results of the investigation and a summary of the units and their distribution is presented in Table 1 and Table 2. The borehole logs and accompanying explanatory notes are presented in **Appendix D – Test Pit Logs**.

Table 1 - Observed Geotechnical Units

Unit #	Origin	Material	Description
Unit 1	Topsoil	Silty/Sandy CLAY	Low to medium plasticity, grey, fine to coarse grained sand
Unit 2	Slopewash	Sandy CLAY	Low to medium plasticity, grey, fine to coarse grained sand
Unit 3	Residual soil	Sandy/Silty CLAY	Low to high plasticity, grey, brown, fine to coarse grained sand
Unit 4a	XW* Material	SILTSTONE	Silty/Sandy CLAY/Sandy SILT, medium to high plasticity, white and brown, low liquid limit, fine to coarse grained
Unit 4b		SANDSTONE	Sandy CLAY/ Clayey SAND, low to high plasticity, brown, fine to coarse grained sand
Unit 5a	Bedrock	SILTSTONE	Thinly to thickly bedded, stained, and coated
Unit 5b		SANDSTONE	Fine to coarse grained, thinly to medium bedded, brown, yellow, white
XW-extremely weathered.			

Table 2 – Distribution of Subsurface Geological Units Across the Investigated Locations

TP ID	Depth Below the Ground Level (m BGL)						
	Topsoil	Slopewash	Residual Soil	XW Material		Bedrock	
	Unit 1	Unit 2	Unit 3	Unit 4a	Unit 4b	Unit 5a	Unit 5b
DA1-TP01	0.0-0.18	NE	0.18-1.7	1.7-3.0*	NE	NE	NE
DA1-TP02	0.0-0.14	NE	0.14-0.7	0.7-2.0	NE	2.0-2.8*	NE
DA1-TP03	0.0-0.16	NE	0.16-0.6	0.6-3.1*	NE	NE	NE
DA1-TP04	0.0-0.13	NE	0.13-0.4	0.4-1.3	NE	1.3-1.9**	NE
DA1-TP05	0.0-0.2	NE	0.2-0.6	NE	0.6-2.4	NE	2.4-3.0*
DA1-TP06	0.0-0.17	NE	0.17-0.5	NE	0.5-2.1*	NE	NE
DA1-TP07	0.0-0.1	NE	0.1-0.8	NE	0.8-2.0*	NE	NE
DA1-TP08	0.0-0.15	NE	0.15-0.6	NE	0.6-3.0*	NE	NE
DA1-TP09	0.0-0.15	NE	0.15-0.5	NE	0.5-3.0*	NE	NE
DA1-TP10	0.0-0.12	NE	0.12-0.6	NE	0.6-2.7*	NE	NE
DA1-TP11	0.0-0.12	NE	0.12-0.6	NE	0.6-2.5*	NE	NE
DA1-TP12	0.0-0.14	NE	0.14-0.4	NE	0.4-2.0*	NE	NE
DA1-TP13	0.0-0.15	NE	0.15-0.7	NE	0.7-2.1	NE	2.1-2.5*
DA1-TP14	0.0-0.15	NE	0.15-0.6	NE	0.6-3.0*	NE	NE
DA1-TP15	0.0-0.1	NE	0.15-0.5	NE	0.5-1.2	NE	1.2-1.8**
DA1-TP16	0.0-0.14	0.19-0.7	0.14-0.5	NE	0.5-3.1*	NE	NE
DA1-TP17	0.0-0.19	NE	0.7-2.5	NE	2.5-3.1*	NE	NE
DA1-TP18	0.0-0.2	NE	0.2-0.4	NE	0.4-2.5	NE	2.5-3.0*
DA1-TP19	0.0-0.15	NE	0.15-0.5	NE	0.5-3.0*	NE	NE

NE-not encountered.
*-limit of the investigation.
**-refusal.

4.3 Groundwater

Groundwater was not encountered during the investigation. It should be noted that the groundwater conditions will vary with seasonal and weather conditions along with construction related Site conditions.

4.4 Laboratory Test Results

Geotechnical laboratory testing was carried out on selected bulk, disturbed and undisturbed samples collected during the site investigation. All testing was performed by Coffey Testing (Newcastle) and Eurofins - NATA accredited laboratories in accordance with the relevant Australian Standards and technical procedures. The detailed results of laboratory testing are presented in **Appendix E – Laboratory Test Results** and are summarised in the following sections.

4.4.1 Atterberg Limits

A summary of Atterberg Limits and Linear Shrinkage test results are presented in Table 3 and are plotted graphically in Figure 4. Testing indicates that clayey materials are from medium to high plasticity.

Table 3 - Atterberg Limits Test Results

Test Pit ID	Soil	Classification	Depth (m BGL)	Atterberg Limits			LS (%)	Iss Correlation with LS*
				LL (%)	PL (%)	PI (%)		
DA1-TP01	Silty CLAY	CI-CH	2.5-3.0	53	17	36	14.5	2.6
DA1-TP17	Sandy CLAY	CL-CI	0.7-1.2	45	21	24	12.5	2.0

LL – Liquid Limit
PL – Plastic Limit
PI – Plasticity Index
LS - Linear Shrinkage
*Reynolds (2013)

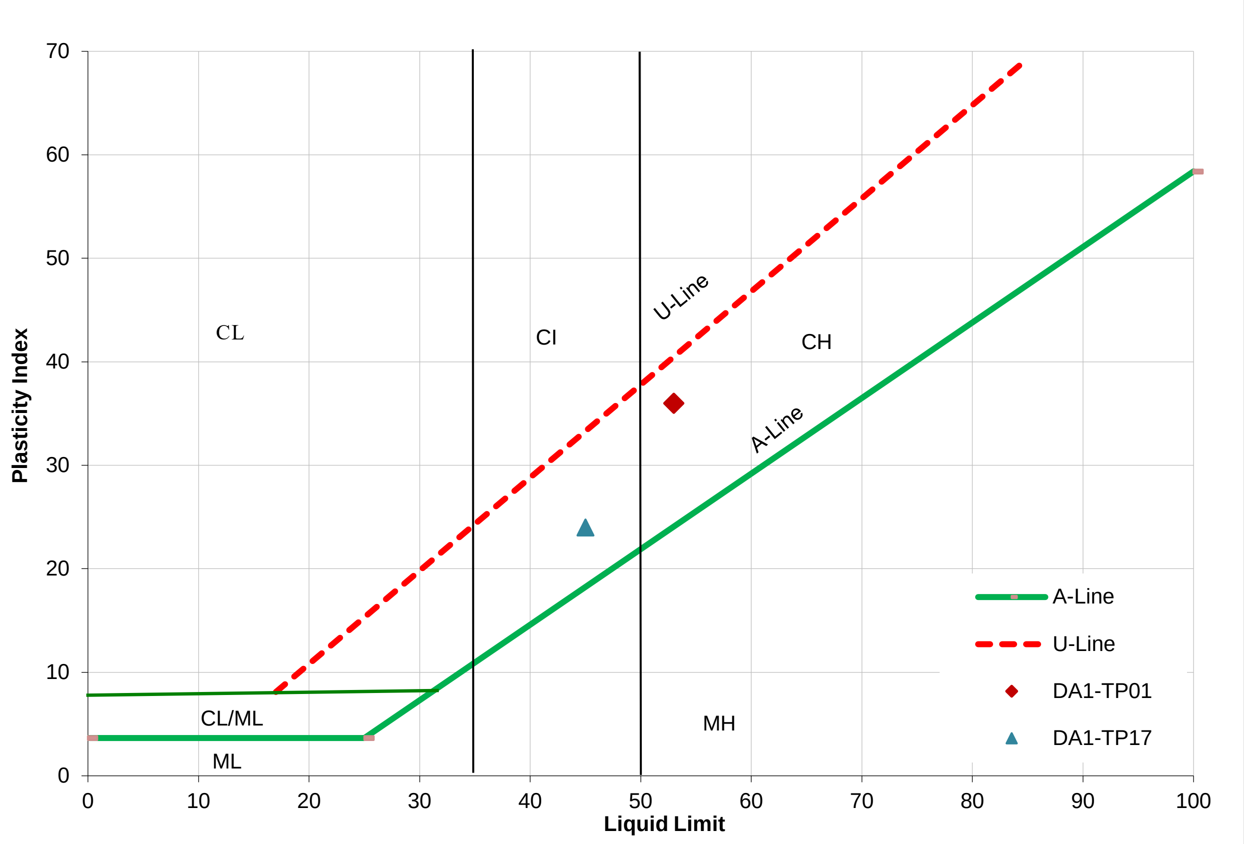


Figure 4 – Atterberg Limit Plot

4.4.2 Particle Size Distribution (PSD)

Particle Size Distribution (PSD) test results undertaken on samples of subgrade containing Residual Soils are presented in Table 4 and confirms the material description on the test pit logs.

Table 4 - Particle Size Distribution Test Results

Test Pit ID	Depth (m BGL)	% passing 2.36 mm sieve	% passing 75 µm sieve	Sample Description
DA1-TP01	2.5-3.0	83	62	Sandy CLAY with gravel
DA1-TP17	0.7-1.2	96	35	Sandy CLAY

4.4.3 Shrink-Swell

Due to dry conditions on the site only one soil sample was collected and tested for Shrink-Swell, and the results are summarised in Table 5.

Table 5 - Shrink-Swell Index Test Results

Test Pit ID	Soil Type	Depth (m BGL)	Shrinkage		Swell			Shrink – Swell Index (Iss%)
			Shrinkage moisture content (%)	Shrink on drying (%)	Moisture content before (%)	Moisture content after (%)	Swell on saturation (%)	
DA1-TP01	Silty CLAY	0.5-1.0	19.5	4.0	20.0	29.6	6.2	**4.0**

4.4.4 California Bearing Ratio (%)

CBR tests were undertaken on four (4) soil samples to inform the design CBR for the proposed pavement areas. The results of the testing are summarised in Table 6.

Table 6 - California Bearing Ratio Test Results

Test ID	Depth (m BGL)	Sample Description	W[1] (%)	SOMC[2] (%)	SMDD[3] (t/m^3)	Swell (%)	CBR (%)
DA1-TP04	1.0-1.5	SILTSTONE and SANDSTONE	9.4	15.0	1.68	0.0	50[5]
DA1-TP13	1.0-1.4	XW* SANDSTONE	9.5	16.5	1.83	0.0	30[5]
DA1-TP15	0.5-1.0	XW* SANDSTONE	10.1	16.0	1.78	0.5	17[5]

[1] Field Moisture Content
[2] Standard Optimum Moisture Content
[3] Standard Maximum Dry Density
[4] CBR at 2.5mm (%)
[5] CBR at 5mm (%)
*)-XW-extremely weathered

CBR samples were remoulded to a target of 100% relative density at approximately standard optimum moisture content (SOMC). The samples were surcharged with 4.5kg and soaked for four days prior to penetration. According to Table 5.2: Guide to classification of expansive soils (Austroads, 2017) the soil samples tested for CBR have a low potential for expansive volume change.

4.4.5 Point Load Testing

It is noted the rock samples collected from test pits are competent bedrock fragments as the lower strength bedrock was broken down into soil during excavation. All the rock samples were collected dry and were tested dry which could potentially contribute to a higher strength rock interpretation. Point load testing has been conducted on selected rock samples collected from DA1-TP04 and DA1-TP15 and the test results are shown Table 7.

Table 7 - Point Load Test Results

TP ID	Rock	Depth (m BGL)	Moisture condition	Peak Load (kN)	Is (50) MPa	Rock strength
DA1-TP04	Sandstone	1.0-1.5	Dry	0.16	0.21	Low Strength
DA1-TP04	Sandstone	1.0-1.5	Dry	0.34	0.45	Medium Strength
DA1-TP04	Sandstone	1.0-1.5	Dry	0.39	0.51	Medium Strength
DA1-TP04	Sandstone	1.0-1.5	Dry	0.13	0.19	Low Strength
DA1-TP04	Sandstone	1.0-1.5	Dry	0.19	0.26	Low Strength
DA1-TP15	Sandstone	1.0-1.5	Dry	0.22	0.27	Low Strength
DA1-TP15	Sandstone	1.0-1.5	Dry	0.09	0.12	Low Strength
DA1-TP15	Sandstone	1.0-1.5	Dry	0.24	0.33	Medium Strength
DA1-TP15	Sandstone	1.0-1.5	Dry	0.16	0.2	Low Strength
DA1-TP15	Sandstone	1.0-1.5	Dry	0.17	0.22	Low Strength

5 Pavement Design

5.1 Design Traffic Loadings

Design traffic loadings have been selected, and pavement thickness design calculations have been undertaken by EP Risk in accordance with *Maitland City Council - Manual of Engineering Standards*.

The design traffic data has been determined based on the following assumptions in Table 8.

Table 8 - Recommended Road Type and Design ESA's

Road Type	Roads Identification	Design ESA's
Local - Secondary	TBC	2×10^5
Local - Primary	TBC	5×10^5
Collector - Secondary	TBC	1×10^6
Collector - Primary	TBC	1.5×10^6
Distributor– Secondary (Bus Route)	TBC	2×10^6

Where traffic data varies from the above assumptions a review of pavement design will be required particularly considering connectivity with adjacent developments.

5.2 In-Situ Testing

The DCP test can be used to provide a correlation with in-situ (field) CBR in accordance with Austroads Guidelines. The in-situ CBR values for substrata for the pavement test pits are presented in Figure 5 and the correspondent field CBR versus laboratory CBR values are presented in Table 9.

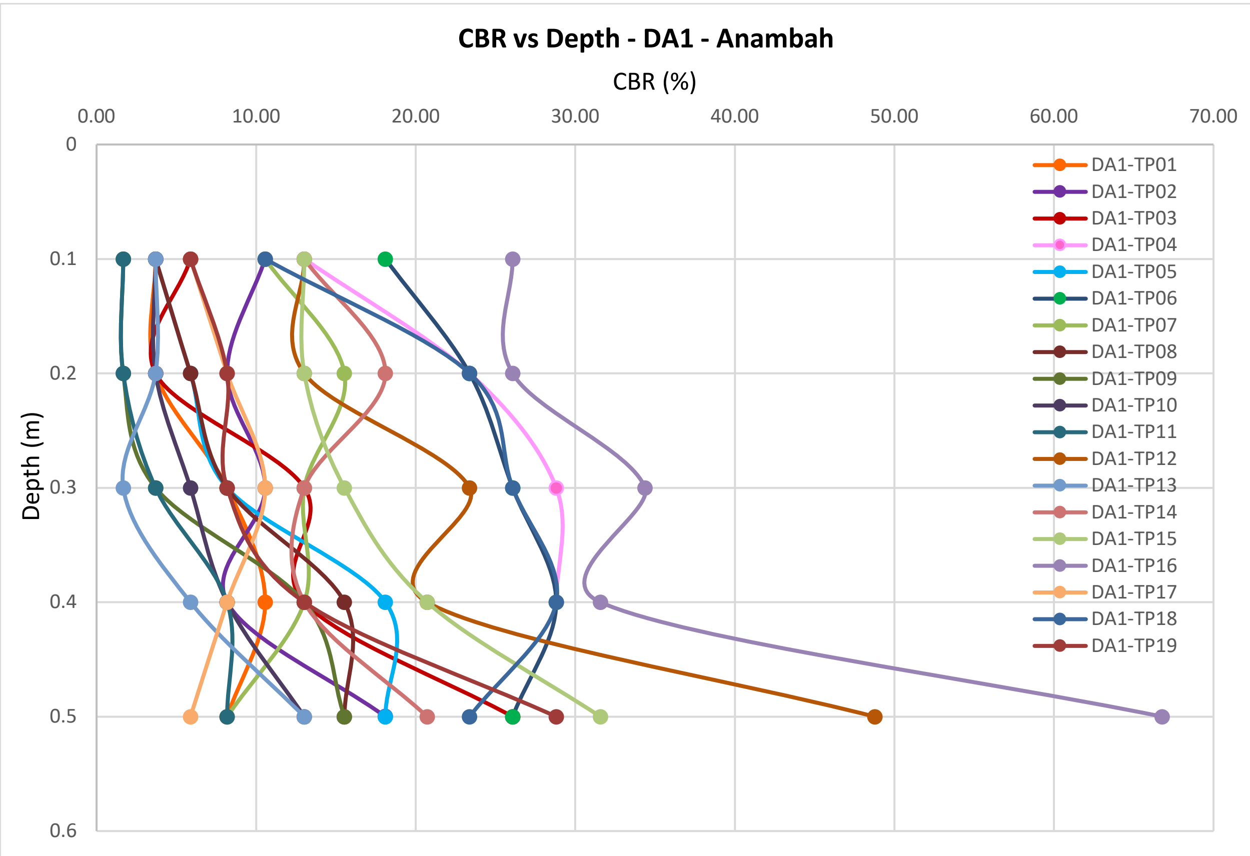


Figure 5 - In-situ CBR Values

Table 9 - Inferred field CBR (%) Values Versus Laboratory Results

Test Pit ID	XW	Depth (m BGL)		Average Field CBR (%) *	Laboratory CBR (%)
		Top	Bottom		
DA1-TP01	XW SANDSTONE	1.0	1.5	>40	50
DA1-TP02	RESIDUAL SOIL: Silty CLAY	0.1	0.6	11	**
DA1-TP03	RESIDUAL SOIL: Sandy CLAY	0.1	0.6	12	**
DA1-TP04	RESIDUAL SOIL: Sandy CLAY	0.1	0.6	23	**
DA1-TP05	RESIDUAL SOIL: Silty CLAY	0.1	0.6	10	**
DA1-TP06	RESIDUAL SOIL: Silty CLAY	0.1	0.6	24	**
DA1-TP07	RESIDUAL SOIL: Silty CLAY	0.1	0.6	12	**
DA1-TP08	RESIDUAL SOIL: Silty CLAY	0.1	0.6	9	**
DA1-TP09	RESIDUAL SOIL: Silty CLAY	0.1	0.6	7	**
DA1-TP10	RESIDUAL SOIL: Silty CLAY	0.1	0.6	6	**
DA1-TP11	RESIDUAL SOIL: Silty CLAY	0.1	0.6	5	**
DA1-TP12	RESIDUAL SOIL: Silty CLAY	0.1	0.6	23	**
DA1-TP13	XW SANDSTONE	0.1	0.6	31	30
DA1-TP14	RESIDUAL SOIL: Sandy CLAY	0.1	0.6	15	**
DA1-TP15	RESIDUAL SOIL: Sandy CLAY	0.1	0.6	18	**
DA1-TP16	SLOPE WASH: Sandy CLAY	0.1	0.6	37	**
DA1-TP17	XW SANDSTONE	1.4	1.8	15	17
DA1-TP18	RESIDUAL SOIL: Sandy CLAY	0.1	0.6	22	**
DA1-TP19	RESIDUAL SOIL: Sandy CLAY	0.1	0.6	12	**

* In-situ estimated CBR at anticipated design subgrade level (DSL) with minimum cut profile
**not tested

The CBR values at estimated subgrade level (0.1-0.6m) shown in Figure 6 are ranging between 2% to >20%. In general, there appear to be a good correlation between the in-situ values and the laboratory tested samples.

5.3 Design Parameters

It is noted the development layout is yet to be finalised and the pavement design is based on anticipated shallow cut/fill. Pavement thickness has been undertaken in accordance with Austroads AGPT02-17 Guide to Pavement Technology, Part 2: Pavement Structural Design based on the following parameters:

- Design subgrade CBR of 3.0% for Sandy/Silty CLAY (not expected).
- Design CBR of 6% for extremely weathered Siltstone/Sandstone. The CBR 6% subgrade would be expected to be the predominate subgrade material.
- CBR of 10% for distinctly/slightly weathered Siltstone/Sandstone.
- Design traffic as per Table 8.

The design subgrade has been determined in accordance with Section 5 of Austroads 2017 based on laboratory testing results and field interpretation. The CBR Swell results when compared to Table 5.2 in Austroads Guide to pavement Technology Part 2: Pavement Structural Design indicate that the soils tested have generally a low expansive nature and specific strategies are unlikely to be required for addressing potential volume change due to moisture variation in the subgrade. This will largely be dependent on the vertical alignment of roads and the material present within 0.5 m of design subgrade level (DSL).

Where filling is undertaken within the road alignments, the CBR of the fill material should be considered specifically regarding the final pavement design subgrade CBR. All fill materials should generally be a minimum of CBR 6% based on 4-day soak when compacted to 100% standard relative density and SOMC except where the final pavement design is based on a subgrade design CBR of 10%. Subgrade replacement with suitable site won materials is recommended for isolated areas of lower strength subgrade, potentially in the northern section of the site.

5.4 Pavement Design – Flexible Unbound Pavement

The option of pavement construction utilising flexible unbound pavement materials for Silty CLAY, XW Siltstone/ Sandstone and slightly weathered/fresh Siltstone are detailed in Table 10, Table 11 and Table 12.

From previous experience with Maitland City Council (Council) the bus route will be required to have a minimum 300mm select layer. The select layer could be sourced from the areas of cut across the site subject to laboratory testing and Council approval. It is noted the *Maitland City Council - Manual of Engineering Standards (MoES)* requires 100 mm minimum base thickness and 125 mm minimum sub-base thickness.

Table 10 - Recommended Flexible Pavement Composition – CBR 3%

Road Type	Collector Primary - Bus Route	Collector Primary	Collector Secondary	Local – Primary	Local – Secondary
Wearing Course (mm)	45 AC14 HD*	45 AC14 HD*	45 AC14 HD*	30 AC10*	30 AC10*
Basecourse (mm)	150	150	150	160**	160**
Subbase (mm)	360	345	320	290	240
Total Thickness (mm)	555	540	515	480	430
Subgrade CBR	min 3%	min 3%	min 3%	min 3%	min 3%
Select (mm)***	(300)	(300)	(300)	(300)	(300)
Design ESA	2.0×10^6	1.5×10^6	1.0×10^6	5.0×10^5	2.0×10^5

AC14/AC10 with 10mm primer seal placed under the asphaltic concrete wearing surface
** Basecourse layer will be 160mm to suit standard kerb & gutter (modified SA) or roll kerb for design traffic of 5×10^5 ESAs.
*** Minimum 300mm CBR 15% is required for the CBR 3% option where the CBR swell is ≥2.5%

Table 11 - Recommended Flexible Pavement Composition – CBR 6%

Road Type	Collector Primary - Bus Route	Collector - Primary	Collector - Secondary	Local - Primary	Local - Secondary
Wearing Course (mm)*	45 AC14 HD	45 AC14 HD	45 AC14 HD	30 AC10	30 AC10
Basecourse (mm)	150	150	150	160	160
Subbase (mm)	185	175	165	140	140
Total Thickness (mm)	380	370	360	330	330
Subgrade CBR	min 6%	min 6%	min 6%	min 6%	min 6%
Select (mm)***	TBC	TBC	TBC	TBC	TBC
Design ESA	2.0×10^6	1.5×10^6	1.0×10^6	5.0×10^5	2.0×10^5

AC14/AC10 with 10mm primer seal placed under the asphaltic concrete wearing surface
** Basecourse layer will be 160mm to suit standard kerb & gutter (modified SA) or roll kerb.
***A select may be required where unsatisfactory proof roll is obtained, or 300mm select where CBR swell is ≥2,5% (not anticipated)

Table 12 – Recommended Flexible Pavement Composition CBR – 10%

Road Type	Collector Primary - Bus Route	Collector Primary	Collector Secondary	Local - Primary	Local - Secondary
Wearing Course (mm)	45 AC14*	45AC14*	45 AC14 HD*	30 AC10*	30 AC10*
Basecourse (mm)	150	150	150	160**	160**
Subbase (mm)	150	150	150	140	140
Total Thickness (mm)	345	345	345	330	330
Subgrade CBR	min 10%	min 10%	min 10%	min 10%	min 10%
Select (mm)	-	-	-	-	-
Design ESA	2.0×10^6	1.5×10^6	1.0×10^6	5.0×10^5	2.0×10^5

AC14/AC10 with 10mm primer seal placed under the asphaltic concrete wearing surface
** Basecourse layer will be 160mm to suit standard kerb & gutter (modified SA) or roll kerb.

A minimum of fourteen days duration shall apply prior to application of asphalt layer. That period may be extended or shortened subject to approval by Council. It is noted Maitland City Council requires minimum 40mm AC (14) "Heavy Duty" for Classified Roads a 45mm AC14 has been specified to comply with 3-time nominal size of aggregate.

For areas where the clay subgrade has a CBR swell ≥2.5%, it is recommended that the pavement design incorporate a 300mm select layer with minimum CBR of 15% or other measures detailed in Austroads Guidelines for managing soils with a swell potential. Subgrade of 3% is not anticipated. The design CBR needs to be confirmed on road alignment following the regrade activities on site. Where subgrade is at elevated moisture content at the time of construction a select layer will be required and should be provisioned for particularly in lower lying areas in the northern section of the site.

5.4.1 Cycleway/Footpath & Threshold Pavement Design

A cycleway/footpath design has been considered for the proposed residential subdivision development and the details are included in Table 13 and Table 14.

Table 13 – Recommended Asphalt Surfaced Cycleway/Footpath Design

Pavement Layers	Cycleway/Footpath
Wearing Course (mm)	30mm AC10
Basecourse* (mm)	200
Subbase** (mm)	-
Total Thickness (mm)	230

* Basecourse in accordance with MoES Appendix D for Traffic Category 2D

Table 14 – Recommended Rigid Cycleway/Footpath Design & Thresholds

Pavement Layers	Cycleway/Footpath	Local Street Concrete Threshold No buses	Local Street Concrete Threshold With buses
Basecourse (mm)	125*	160**	180**
Subbase (mm)	50	100	100
Total Thickness (mm)	175	260	280
Subgrade CBR (%)	Min 5%	Min 5%	Min 5%

* 125mm Concrete Basecourse layer 32 MPa concrete with continuous lapped F72 mesh centrally placed. Detailing as per MCC Standard Drawing SD012.
** Concrete Basecourse 4.25 Flexural strength with no shoulder will vary according to the road category and should be with Table 9.2 in Cement and Concrete Association Australia Guide to residential streets and paths with reinforcement and jointing by an experienced structural engineer.

5.5 Subgrade Preparation

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

- Remove topsoil.
- Excavation of slopewash/residual soil/ weathered bedrock to design subgrade level.
- Ripping the encountered weathered Siltstone/Sandstone to 300-350mm below DSL and recompact to a minimum 100% of SMDD. Moisture contents should be within 70% to 90% of SOMC for weathered bedrock and closer to SOMC where highly expansive subgrade materials are encountered or used as fill. Over compaction dry of SOMC should be avoided in reactive materials.
- 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 material of similar consistency to the subgrade.
- Confirmation of design subgrade parameters by geotechnical consultant.
- Where filling or subgrade replacement is required, the materials employed should be free of organics or other deleterious material. The material should also have a maximum particle size of 100mm or one third of the layer thickness, with a minimum soaked CBR >3%.

Following satisfactory preparation of the subgrade, the pavement should be constructed in accordance with the recommendations of this report and *Maitland City Council – Manual of Engineering Standards Construction*. In case of discrepancy clarification should be sort from Council.

5.6 Drainage

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

It is recommended that subsoil drainage be installed along both sides of all roads within the development in accordance with Council requirements. CBR swell results from the preliminary investigation are low. Design measures and subsurface drainage measures to control subgrade swell are provided in Austroads Pavement Guide to Pavement Technology and the relevant Transport for New South Wales Supplement(s). Preferred measures shall also be discussed with Council's Representative prior to adoption in any pavement construction.

The pavement thickness designs presented above assume drained pavement conditions. The selection, construction and maintenance of appropriate drainage infrastructure would be required for adequate performance. The selection of appropriate construction materials that are relatively insensitive to moisture change is also essential in area subject to periodic inundation, even if for a relatively short period of time.

5.7 Materials

5.7.1 Specifications and Compaction Requirements

Pavement materials and compaction requirements for new pavement construction should conform to Council requirements outlined in MoES and the following requirements outlined in Table 15.

Table 15 - Material Specification and Compaction Requirements

Pavement Course	Material Specification	Compaction Requirements
Base Course DGB20 (Class 1* &2) & NGB20**	Material complying with Council MoES Appendix D Pavement Material Properties***	Min 98% Modified (AS 1289 5.2.1)
Subbase Subbase quality crushed rock (DGS20, DGS40, GMS40, NGS20, NGS40)	Material complying with Council MoES Appendix D Pavement Material Properties	Min 95% Modified (AS 1289 5.2.1)
Select Granular material	Minimum CBR 15%, (min 30% for Design CBR of3%) and PI ≤15% conforming to Council MoES	Min 100% Standard (AS 1289 5.1.1)
Subgrade or replacement	Minimum CBR ≥ 6% or 10% as appropriate for the design option.	Min 100% Standard (AS 1289 5.1.1)

*) - Class 1 material should be used on sub-arterial category roads
**) - NGB and NGS material cannot be used on collector category road or higher due to higher design traffic
***) - Material should comply with Council MoES Appendix D – Pavement Material Properties for the appropriate traffic category

Minimum testing on all potential imported pavement materials should be in accordance with TfNSW 3051 Ed 7. Pre-treatment of material prior to testing would be advisable for materials subject to breakdown.

5.7.2 Wearing Course

Wearing courses should be in accordance with Council's specifications with reference to TfNSW QA Specifications R116 for Dense Graded Asphalt. It is noted that a minimum of 40mm AC14 (Heavy Duty) wearing course is utilised for classified roads in accordance with Council Specifications. 45mm of AC14 heavy duty has been specified to meet the minimum 3 time the nominal size of aggregate. Recent trials have also shown that 48mm of AC14 is the optimal thickness for durability.

The design and construction of wearing courses should be in in consultation with the preferred supplier considering traffic volume and type. All pavement surfaces should be primer sealed prior to the application of the AC wearing course. A minimum delay of 14 days is required after the primer seal before placement of the AC wearing course.

5.7.3 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 or remedial treatment prior to construction.

6 Preliminary Site Classification

Australian Standard AS 2870-2011 establishes performance requirements and specific designs for common foundation conditions as well as providing guidance on the design of footing systems using engineering principles. Site classes as defined on Table 2.1 and 2.3 of AS 2870 are presented in Table 16.

Table 16 - General Definition of Site Classes

Site Class	Foundation	Characteristic Surface Movement
A	Most sand and rock sites with little or no ground movement from moisture changes	-
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes	20 – 40 mm
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes	40 – 60 mm
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes	> 75 mm
A to P	Filled sites (refer to clause 2.4.6 of AS 2870)	-
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.	

Reactive sites are sites consisting of clay soils that swell on wetting and shrink on drying, resulting in ground movements that can damage lightly loaded structures. The amount of ground movement is related to the physical properties of the clay and environmental factors such as climate, vegetation, and watering. A higher probability of damage can occur on reactive sites where abnormal moisture conditions occur, as defined in AS 2870, due to factors such as:

- Presence of trees on the building site or adjacent site, removal of trees prior to or after construction, and the growth of trees too close to a footing. The proximity of mature trees and their effect on foundations should be considered when determining building areas within each allotment (refer to AS 2870).
- Failure to provide adequate site drainage or lack of maintenance of site drainage, failure to repair plumbing leaks and excessive or irregular watering of gardens.
- Unusual moisture conditions caused by removal of structures, ground covers (such as pavements), drains, dams, swimming pools, tanks etc.

Regarding the performance of footings systems, AS 2870 states “footing systems designed and constructed in accordance with this Standard on a normal site (see Clause 1.3.2) that is:

a) not subject to abnormal moisture conditions; and

b) maintained, such that the original site classification remains valid and abnormal moisture conditions do not develop, are expected to usually experience no damage, a low incidence of damage category 1 and an occasional incidence of damage category 2.”

Damage categories are defined in Appendix C of AS 2870, which is reproduced in CSIRO Information Sheet BTF 18, Foundation Maintenance and Footing Performance: A Homeowner's Guide attached as **Appendix F – Foundation Maintenance and Footing Performance**.

The laboratory Shrink Swell test results summarised in Table 5 indicate that the tested Silty CLAY soil returned an I_{ss} value of 4.0% (DA1-TP01 0.5-1.0m). Correlation of *Iss* with Atterberg limits indicated moderate reactivity of 2.6% (DA1-TP01 2.5-3.0m) and 2.0% (DA1-TP17 0.7-1.2m), which indicate the soil across the Site of moderately to Highly reactive.

The classification of sites with controlled fill of depths greater than 0.4m (deep fill) comprising of material other than sand would be Class P. An alternative classification may however be given to sites with controlled fill if filling is undertaken under Level 1 supervision as provided for under AS2870-2011 and when placed in accordance with AS3798-2007 and where consideration is made to the potential for movement of the fill and underlying soil based on the moisture conditions at the time of construction and the long-term equilibrium moisture conditions.

Based on the subsurface profiles encountered during the Site inspection and in accordance with the AS 2870-2011; the Site in its existing condition and in the absence of abnormal moisture conditions would likely be classified as detailed in Table 17.

Table 17 - Anticipated Site Classifications

Anambah DA1	Site Classification
In Existing Condition prior to regrade	**Class M,** moderately reactive to **Class H2**, highly reactive
Following regrade activities	**Class M,** moderately reactive to **Class E,** extremely reactive

A characteristic surface movement (y_s) of 33mm to 63mm has been calculated for the site dependent on the soil profile in its existing state prior to regrade, using a depth of design suction (Hs) change of 2.3m. Following regrade characteristic surface movement (ys) in the order of 100mm has been calculated using worst case scenarios as the depth of the cracked zone is considered zero as per AS2870-2011 Clause 2.3.2. Actual site classifications will be dependent on regrade activities including depth to rock and filling depth along with the materials utilised as fill.

NB: Careful material management will be required to avoid Class E classifications and ensure best outcomes for site classifications and pavements design especially in the northern part of the site. Reactive fill material should be placed below 1.2m of finished design levels.

The above site classifications and footing recommendations are for the site conditions present at the time of fieldwork and consequently the site classification may need to be reviewed with consideration of any site works that may be undertaken after the investigation and this report.

Site works may include:

- Changes to the existing soil profile by cutting and filling.
- Landscaping, including trees removed or planted in the general building area; and
- Drainage and watering systems.

Designs and design methods presented in AS 2870-2011 are based on the performance requirement that significant damage can be avoided if site conditions are properly maintained. Performance requirements and foundation maintenance are outlined in Appendix B of AS 2870. The above site classification assumes that the performance requirements as set out in Appendix B of AS 2870 are acceptable and that site foundation maintenance is undertaken to avoid extremes of wetting and drying.

Details on appropriate site and foundation maintenance practices are presented in Appendix B of AS 2870-2011 and in CSIRO Information Sheet BTF 18, Foundation Maintenance and Footing Performance: A Homeowner's

Guide. Adherence to the detailing requirement outlined in Section 5 of AS 2870-2011 is essential, Section 5.6. Additional requirements for Classes M, H1, H2 and E sites, including architectural restrictions, plumbing and drainage requirements.

It is noted the thickness of the residual soil decreases south from DA-TP01 with a shallow rock profile from 0.7m BGL across the site and as such the above comments apply only for the northern section of the site in the proximity of the ephemeral creek, or where deep filling is proposed using highly reactive materials.

7 General Construction Considerations

7.1 Excavatability Assessment

Practical machine refusal for the 24-tonne excavator was encountered on a combination of siltstone and sandstone in two (2) test pits out of the nineteen (19) excavated test pits. Refusal depths ranged from 1.8m BGL to 1.9m BGL. The strength of bedrock encountered in test pits assessed by point load testing ranges from low to medium strength. To assess the excavatability of the bedrock, the strength range is plotted on the graph in Figure 6 for excavatability as per the suggested method by Pettifer and Fookes. The area of the chart covered indicates that hard to very hard ripping by a D8 will be typically the excavation method for the type of rock encountered within DA1 area.

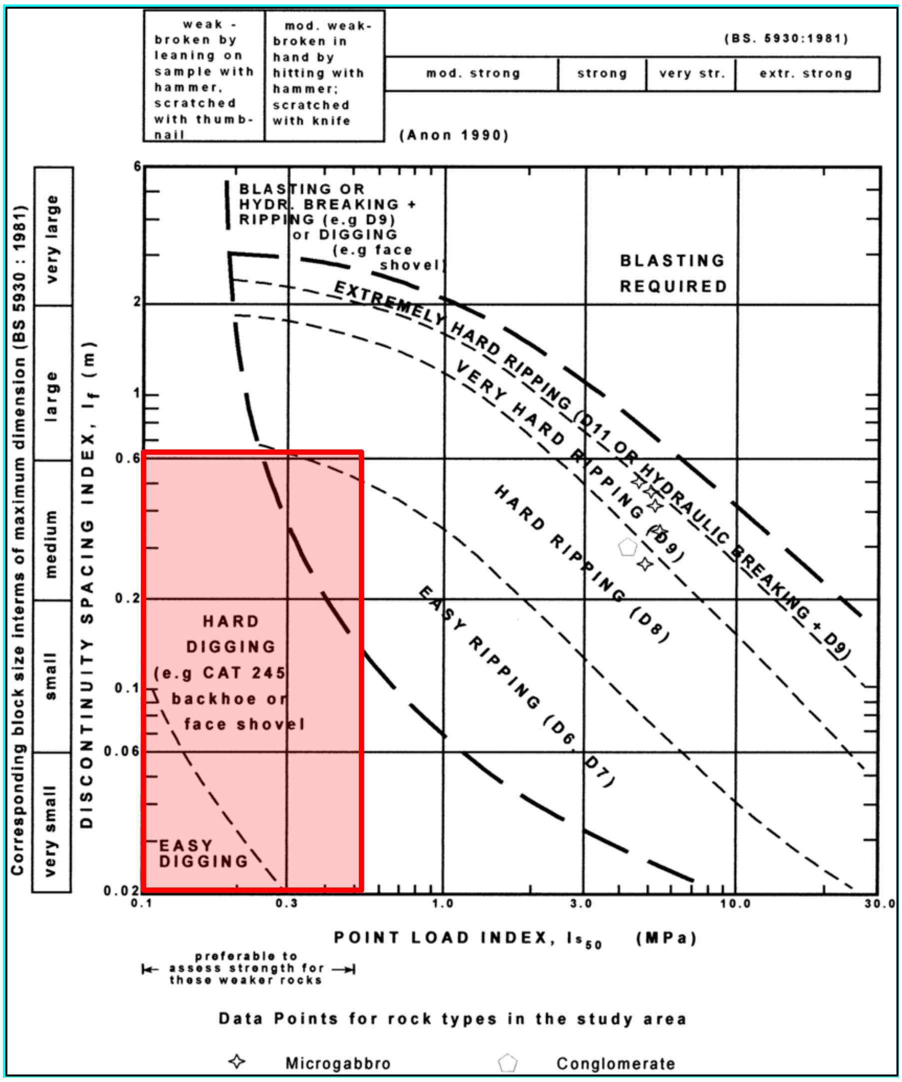


Figure 6 – Excavatability Assessment (Pettifer and Fookes)

Two of additional test pits outside of the DA1 footprint (BH17 and BH18) have been excavated to 3.0m BGL and one (BH19) to 1.8m BGL-refusal in slightly weathered/fresh bedrock. Excavations to depths of 1.5m-1.8 m BGL in weathered bedrock are expected to be readily achievable using larger (>25T) conventional earthmoving equipment. Excavations below 2m deep (especially in confined space like trenches) in slightly weathered/fresh bedrock may require excavators fitted with tiger teeth buckets or single ripper attachment.

Excavatability conditions have not been assessed beyond the depths to which the test pits were excavated; however, the following general comments regarding rock mass excavatability conditions can be made:

- Rock strength as well as rock mass defect (joint) spacing could be expected to control rock mass excavatability. Rock strength is likely to be variable, and layers of weaker rock can underlie stronger bedrock.
- Excavatability could be expected to be dependent on the plant used, the experience of the operator and the degree of confinement within the excavation.

It is recommended that long-term excavations are either battered at 2H:1V or flatter and protected against erosion or be supported by engineer designed and suitably constructed retaining walls. Excavations may be battered steeper than 2H:1V in rock materials, subject to specific geotechnical Investigation.

Excavations or trenches in the Silty/Sandy CLAY and extremely weathered material could be expected to stand close to vertical in the short-term. Where personnel are to enter excavations, options for short-term excavations stability include benching or battering back of the excavations to 1H:1V or the support of excavations within the residual soil and extremely weathered rock profile.

The excavation recommendations provided above should be considered with reference to the Safe Work Australia Code of Practice ‘Excavation Work’, dated January 2020.

7.2 Retaining Structures

All retaining structures should be designed by a civil engineer. Design of retaining walls should:

- Count surcharge loading from slopes and structures above the wall.
- Consider loading from any proposed compaction of fill behind the wall.
- Provide adequate surface and subsurface drainage behind all retaining walls, including a free draining granular backfill to prevent the build-up of hydrostatic pressures behind the wall.
- Utilise materials that are not susceptible to deterioration.
- Ensure walls are founded in materials appropriate for the loading conditions.

Footings for proposed retaining walls should be founded below any topsoil within stiff or better clay or weathered rock.

7.3 Filling and Material Management

7.3.1 Filling

Fill should be placed and compacted in accordance with AS 3798-2007. It is expected that construction of a suitable fill platform to support structural loads, such as pavements, ground slabs, footing and stiffened raft slabs, would include the following:

- Stripping of topsoil.
- Removal of any unsuitable soil/slopewash (if applicable).
- Wet material where encountered (along the northern boundary gully) will likely require treatment or moisture re-conditioning (drying and blending with dryer fill material) prior to placement and compaction.
- Proof rolling of the exposed subgrade to detect any weak or deforming areas of subgrade that should be excavated and replaced with compacted fill.

- Placement of fill in horizontal layers with compaction of each layer to a minimum dry density ratio of 95% Standard Relative Density (Australian Standard AS 1289 Clause 5.1.1) at moisture contents of 85-115% of SOMC and 98% Standard for fill in ≥1m depth. Fill within 0.5m of design subgrade in road alignments is to be compacted to 100% standard relative density at a 70-100% of SOMC. All fill materials should be supported by properly designed and constructed retaining walls or else battered at a slope of 2H:1V or flatter and protected against erosion by vegetation or similar and the provision of adequate drainage.

7.3.2 Material Management

The material management during regrade for this site will be important due to the presence of highly reactive cohesive soils (I_{ss} ≥4%) and depth to the rock 2.2m BGL in some areas of the site. Where highly reactive cohesive materials are used for filling more than 2.5m depth the characteristic surface movement can potentially be greater than 75mm and as such the lot classification would be Class E (extremely reactive).

Good material management should be employed for this site to avoid lot classification with Class E. Reactive / Expansive clay materials should be placed as close to SOMC as practical to minimise their swell potential and preferentially placed in lower layers of the deeper fill areas (≥1.2m BGSL). Over compaction of fill reactive fill materials dry of SOMC should be avoided.

Materials excavated on Site apart from topsoil are considered suitable for re-use as engineering fill. Some materials will likely require treatment such as blending and moisture re-conditioning to produce suitable structural fill, subject to further assessment and weather conditions prior to and during construction. Material should be managed during regrade to allow use of required design CBR and lower reactivity material in the top 500mm of filling and subgrade preparation to provide better outcome for pavement construction and site classification.

7.4 Geotechnical Design Parameters

The geotechnical parameters for the proposed development have been assessed based on results of the site and laboratory tests of the ground investigation. These are provided for the different geological units: soils in Table 18 and for bedrock in Table 19. The design parameters for bedrock have been assumed based on the observations during site investigation.

The low consistency topsoil layer has been considered unsuitable for shallow foundations and no design parameters have been calculated for these units.

Table 18 - Geotechnical Design Parameters-soil

Geotechnical Units	Bulk Unit Weight (kN/m3)	Undrained Cohesion Cu (kPa)	Drained Cohesion c' (kPa)	Drained friction angle ϕ' (°)	Poisson's Ratio (-)	Elastic Modulus E' (MPa)	Earth Pressure coefficient ka	Earth pressure coefficient kp
RESIDUAL SOIL Silty/Sandy CLAY (stiff or better)	19	50-75	3-5	26	0.3	10	0.39	2.56

The allowable bearing capacity for the stiff or better residual soil is estimated to 100kPa.

Table 19 - Geotechnical Design Parameters-Rock

Geotechnical Unit (strength)	Bulk Unit Weight (kN/m3)	Allowable Bearing Pressure (MPa)*	Ultimate shaft adhesion (kPa)**	Poisson's Ratio (-)	Elastic Modulus E' (MPa)
SILTSTONE very low strength (Class V)	20	0.7	50	0.3	50
SILTSTONE low strength (Class IV)	22	1	150	0.2	100
SILTSTONE medium strength (Class III)	21	2	350	0.2	200
SANDSTONE very low strength (Class V)	20	0.8	150	0.35	50
SANDSTONE low strength (Class IV)	21	2	250	0.3	100
SANDSTONE medium strength (Class III)	22	3.5	800	0.25	350

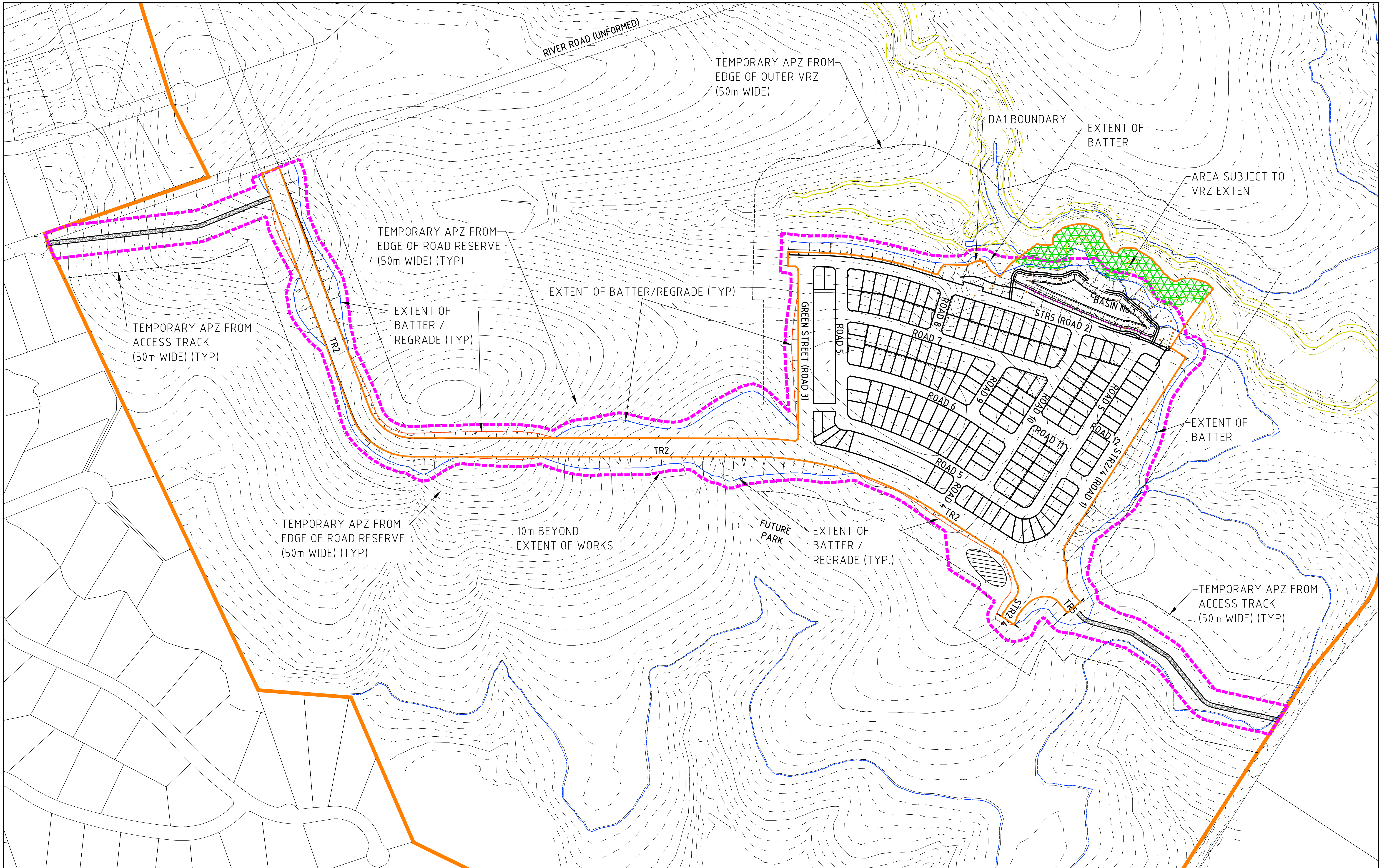
*) Bearing pressure to limit the settlement to <1% of minimum footing size
**) clean socket of roughness category R2 or better

8 References

- Austroads AGPT05-19, "Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design," Austroads Ltd, October 2019
- Austroads AGPT02-17, "Guide to Pavement Technology Part 2: Pavement Structural Design," Austroads Ltd, 2017.
- Austroads AGRD06A-17, "Guide to Road Design part 6A: Paths for Walking and Cycling", Austroads Ltd. 2021.
- Australian Standard AS2870-2011 "Residential slabs and footing"
- Australian Standard AS3798-2007 "Guideline on earthworks for commercial and residential developments".
- Australian Standard AS2159-2009, "Piling - Design & Installation," Standards Australia, 2009.
- Cement & Concrete Association of Australia C7CAA T51, "Guide to Residential Streets and Paths", TechMedia Publishing Pty Ltd February 2004.
- eSPADE, Online website of NSW Office of Environment and heritage (www.environment.nsw.gov.au)
- NSW Department of Planning and Environment, Resources and Geoscience (www.resourcesandgeoscience.nsw.gov.au)
- Maitland City Council – Manual of Engineering Standards April 2023.
- TfNSW QA Specification 3051 (Ed 7 Rev 0), "Granular Base and Subbase Materials for Surfaced Road Pavements," Roads and Maritime Services, April 2011
- TfNSW QA Specification 3051 (Ed 7 Rev 0), "Granular Base and Subbase Materials for Surfaced Road Pavements," Roads and Maritime Services, August 2018.

Appendix A

PROPOSED DEVELOPMENT DA1



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3	GENERAL AMENDMENTS	A.M	I.H	13.05.25
2	CLIENT COMMENTS	A.M	I.H	05.05.25
1	ORIGINAL ISSUE	AM	IH	01.05.25

North

Scale

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Designed: AM

Scale: 1:2500

Cad Reference: 22311C dE01 r4

Project Approval: IAN HILL (B.E) Consulting Civil Engineer

Client

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ANAMBAH URBAN RELEASE AREA
ANAMBAH ROAD
ANAMBAH - DA1

EXTENT OF WORKS PLAN

Project No: 22311C

Drawing No: E01

Revision: 4

A1 SHEET

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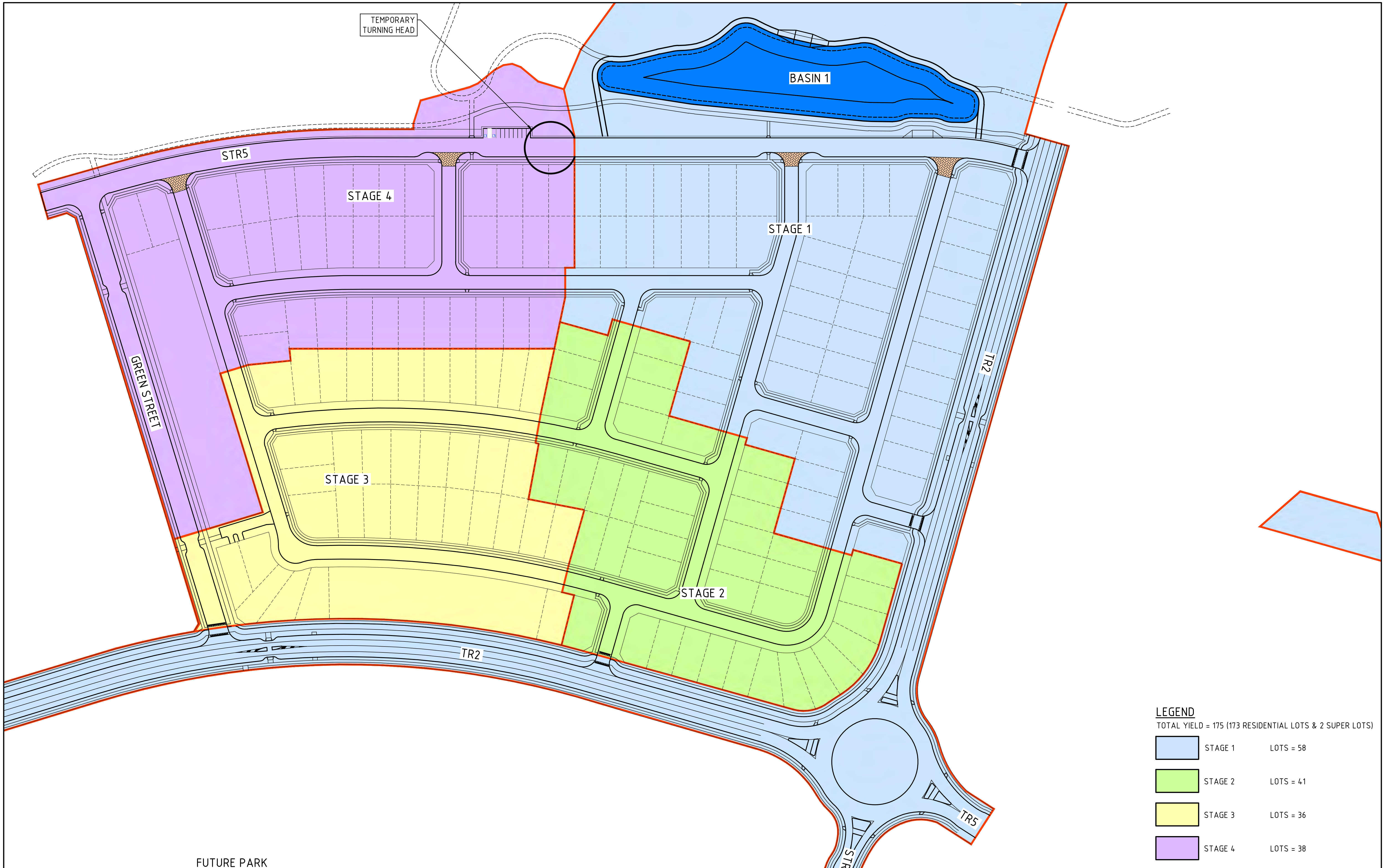

LEGEND

TOTAL YIELD = 175 (173 RESIDENTIAL LOTS & 2 SUPER LOTS)

	STAGE 1	LOTS = 58
	STAGE 2	LOTS = 41
	STAGE 3	LOTS = 36
	STAGE 4	LOTS = 38

REVISION	Description	Drawn	App'd	Date
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4	REVISED STAGING	DB	IH	12.05.25
3	GENERAL REVISION	DB	IH	17.04.25
2	REVISED STAGING	DB	IH	04.04.25
1	ORIGINAL ISSUE	DB	IH	25.03.25

North

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Designed: DB
Scale: 1:1000
Cad Reference: 22311LD LD1031 r5
Project Approval: IAN HILL (B.E) Consulting Civil Engineer

Client: ROCHE GROUP

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ANAMBAH URBAN RELEASE AREA
ANAMBAH ROAD
ANAMBAH
DA1 - STAGING PLAN

Project No: 22311LD
Drawing No: LD1031
Revision: 5
A1 SHEET

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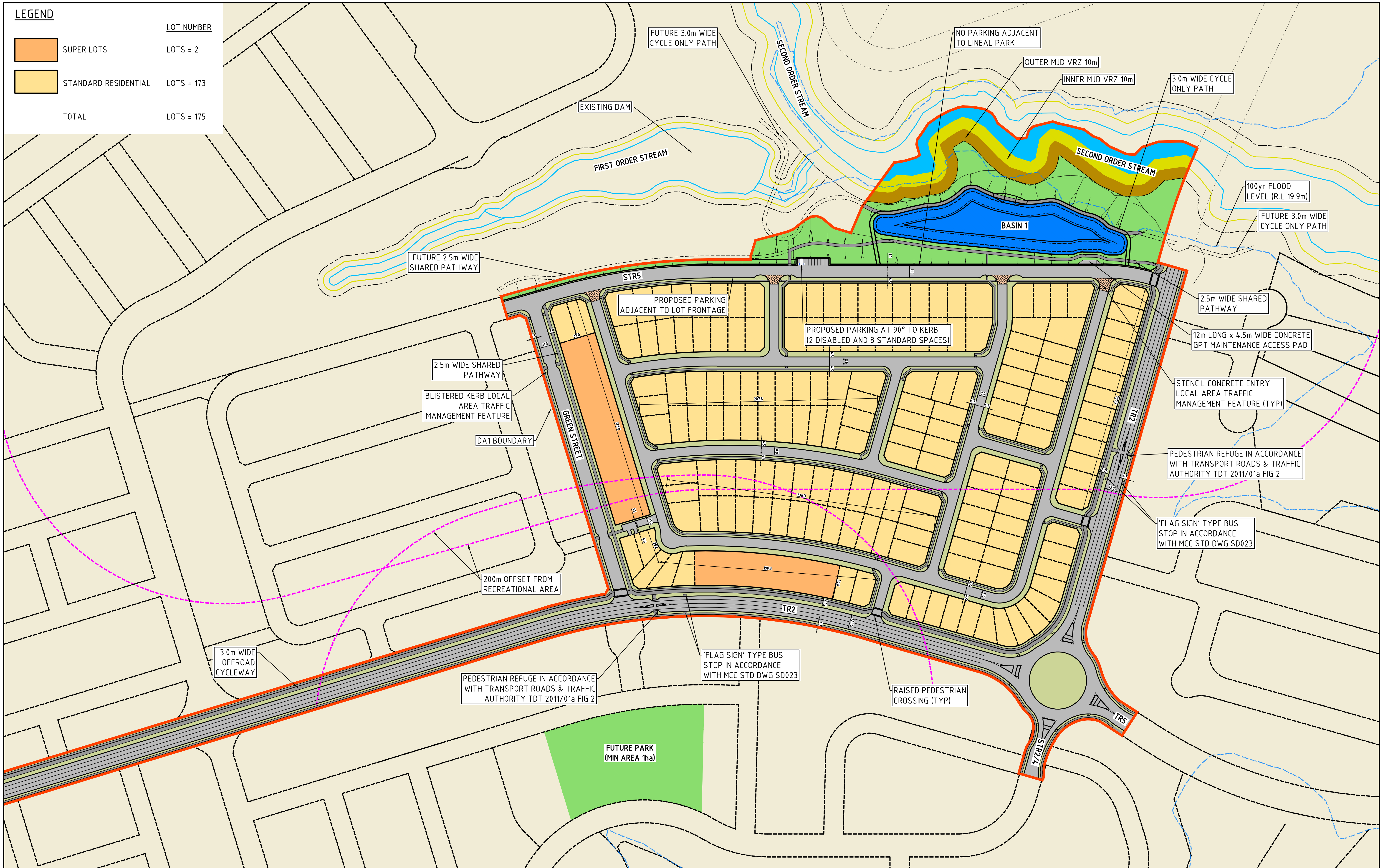

REVISION	Description	Drawn	App'd	Date
7	SECOND PRE DA MEETING AMENDMENTS	DB	IH	09.05.25
6	PRE DA MEETING AMENDMENTS	DB	IH	16.04.25
5	COUNCIL COMMENTS	DB	IH	04.04.25
4	COUNCIL COMMENTS	DB	IH	17.03.25
3	CLIENT COMMENTS	DB	IH	03.02.25
9	CLIENT COMMENTS	DB	IH	13.05.25
8	CLIENT COMMENTS	DB	IH	12.05.25

North

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Designed: DB
Scale: 1:1500
Cad Reference: 22311LD LD1010-1011 r9
Project Approval: IAN HILL (B.E) Consulting Civil Engineer

Client: ROCHE GROUP

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ANAMBAH URBAN RELEASE AREA
ANAMBAH ROAD
ANAMBAH
DA 1

Project No: 22311LD
Drawing No: LD1011
Revision: 9
A1 SHEET

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Appendix B

PHOTOLOG

	**Plate 1** **Description: Dam in the DA1 area** **Date: 24/01/2024**
	**Plate 2** **Description: looking NE towards Anambah** **Date: 24/01/2024**

	**Plate 3** **Description: Looking NW from DA1 area** Date: 24/01/2024
	**Plate 4** **Description: Looking north from DA1 area** **Date: 24/02/2024**

	**Plate 5** **Description: Second water dam in DA1 area** **Date: 24/01/2024**
	**Plate 6** **Description: Soil scarp in the DA1 area** **Date: 24/01/2024**

	**Plate 7** **Description: Looking north from DA1 area** **Date: 25/01/2024**
	**Plate 8** **Description: Rock outcrops in DA1 area** **Date: 25/01/2024**

	**Plate 9** **Description: Rock outcrops DA1 area** **Date: 25/01/2024**
	**Plate 10** **Description: Slightly weathered-fresh rock in DA1 area** **Date: 25/01/2024**

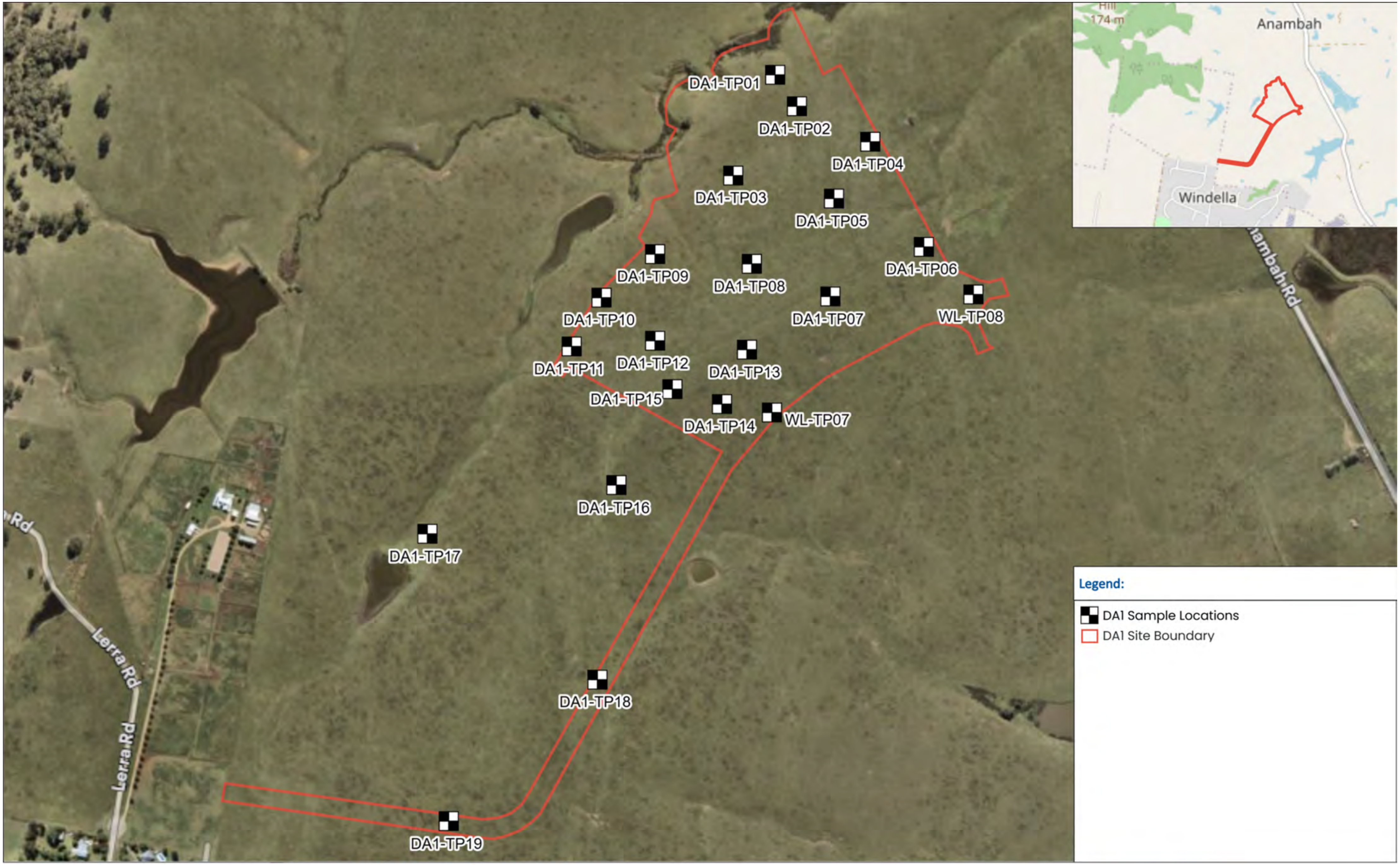
	**Plate 11** **Description: Looking towards the ephemeral creek** **Date: 25/01/2024**
	**Plate 12** **Description: Meander trajectory of the ephemeral creek** **Date: 25/01/2024**

	**Plate 13** **Description: Fence within DA1 area** **Date: 25/01/2024**
	**Plate 14** **Description: Bones close to DA1-TP19** **Date: 24/01/2024**

	**Plate 15** **Description: low lying area in the northern part of DA1** **Date: 24/01/2024**
	**Plate 16** **Description: Wide gully in the DA1 area** **Date: 24/01/2024**

Appendix C

GEOTECHNICAL INVESTIGATION LOCATIONS



EP RISK

www.eprisk.com.au

Geotechnical Investigation Report
Anambah Road, Anambah NSW, Australia

1 - Site & Sampling Locations

Job No: EP3487
Date: 15-05-2025
Version: v1

N

0 100 m 200 m
Approximate Scale Only

Coordinate System: WGS 84
Drawn By: JA Checked By: OP
Scale of regional map not shown
Source: © Department of Finance, Services & Innovation 2018

ISO 9001 ISO 45001 ISO 14001

Appendix D

TEST PIT LOGS

Soil Logging Symbols

CLAYS

CLAY

silty CLAY

sandy CLAY

gravelly CLAY

SILTS

SILT

clayey SILT

sandy SILT

gravelly SILT

SANDS

SAND

clayey SAND

silty SAND

gravelly SAND

GRAVELS

GRAVEL

clayey GRAVEL

silty GRAVEL

sandy GRAVEL

SEDIMENTARY ROCK

SANDSTONE

SILTSTONE

SHALE

CONGLOMERATE

FILL

FILL

CONCRETE

ASPHALT

GROUNDWATER WELL SYMBOLS

WELL SCREEN

CASING – filter pack

CASING – backfill

CASING – bentonite seal

CASING – grout seal

BACKFILL

OTHER

TOPSOIL – sandy SILT

TOPSOIL – highly organic

Rock Description Explanation Sheet (1 of 2)

Weathering Condition (Degree of Weathering):

The degree of weathering is a continuum from fresh rock to soil. Boundaries between weathering grades may be abrupt or gradational.

Rock Material Weathering Classification		
Weathering Grade	**Symbol**	**Definition**
Residual Soil	RS	Soil-like material developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume, but the material has not been significantly transported.
Extremely Weathered Rock	XW	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded in water, but substance fabric and rock structure still recognisable.
Highly Weathered Rock	HW	Strong discolouration is evident throughout the rock mass, often with significant change in the constituent minerals. The intact rock strength is generally much weaker than that of the fresh rock.
Moderately Weathered Rock	MW	Modest discolouration is evident throughout the rock fabric, often with some change in the constituent minerals. The intact rock strength is usually noticeably weaker than that of the fresh rock.
Slightly Weathered Rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh Rock	FR	Rock shows no sign of decomposition or staining.

Notes:

1. Minor variations within broader weathering grade zones will be noted on the engineering borehole logs.
2. Extremely weathered rock is described in terms of soil engineering properties.
3. Weathering may be pervasive throughout the rock mass or may penetrate inwards from discontinuities to some extent.
4. The 'Distinctly Weathered (DW)' class as defined in AS1726-2017 is divided to incorporate HW and MW in the above table. The symbol DW should not be used.

Strength Condition (Intact Rock Strength):

Strength of Rock Material (Based on Point Load Strength Index, corrected to 50mm diameter – $I_{s(50)}$. Field guide used if no tests available. Refer to AS 4133.4.1-2007.				
Term	**Symbol**	**Point Load Index (MPa) $I_{s(50)}$**		**Field Guide to Strength**
Very Low	VL	>0.03	≤0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 3cm thick can be broken by finger pressure.
Low	L	>0.1	≤0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	>0.3	≤1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	H	>1	≤3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	>3	≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High	EH	>10		Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Notes:

1. These terms refer to the strength of the rock material and not to the strength of the rock mass which may be considerably weaker due to the effect of rock defects.
2. Anisotropy of rock material samples may affect the field assessment of strength.
3. Extremely Low Strength ('EL') is now not considered a description of rock strength in line with the updated AS1726-2017 as by definition EL rock should be described in terms of soil properties.

Rock Description Explanation Sheet (2 of 2)

Discontinuity Description: Refer to AS1726-2017, Table A10.

Anisotropic Fabric	
BED	Bedding
FOL	Foliation
LIN	Mineral lineation
Defect Type	
LP	Lamination Parting
Pt	Bedding Parting
FP	Cleavage / Foliation Parting
Jt	Joint
SZ	Sheared Zone
CZ	Crushed Zone
BZ	Broken Zone
HFZ	Highly Fractured Zone
AZ	Alteration Zone
VN	Vein

Roughness (e.g. Planar, Smooth is abbreviated Pln / Sm)		**Class**
Stepped (Stp)	Rough or irregular (R or Irr)	I
	Smooth (Sm)	II
	Slickensided (Sl)	III
Undulating (Un)	Rough (R)	IV
	Smooth (Sm)	V
	Slickensided (Sl)	VI
Planar (Pln)	Rough (R)	VII
	Smooth (Sm)	VIII
	Slickensided (Sl)	IX

Aperture		**Infilling**		
Closed	CD	No visible coating or infill	Clean	Cn
Open	OP	Surfaces discoloured by mineral/s	Stain	St
Filled	FL	Visible mineral or soil infill <1mm	Veneer	Vr
Tight	TI	Visible mineral or soil infill >1mm	Coating	Ct

Other	
Clay	Clay
Fe	Iron
Co	Coal
Carb	Carbonaceous
Sinf	Soil Infill Zone
Qz	Quartz
Ca	Calcite
Chl	Chlorite
Py	Pyrite
Int	Intersecting
Inc	Incipient
DI	Drilling Induced
H	Horizontal
V	Vertical

Note: Describe 'Zones' and 'Coatings' in terms of composition and thickness (mm).

Discontinuity Spacing: On the geotechnical borehole log, a graphical representation of defect spacing vs depth is shown. This representation takes into account all the natural rock defects occurring within a given depth interval, excluding breaks induced by the drilling / handling of core. Refer to AS1726-2017, BS5930-1999.

Defect Spacing			**Bedding Thickness (Sedimentary Rock Stratification)**	
Spacing/Width (mm)	Descriptor	Symbol	Descriptor	Spacing/Width (mm)
			Thinly Laminated	< 6
<20	Extremely Close	EC	Thickly Laminated	6 – 20
20 – 60	Very Close	VC	Very Thinly Bedded	20 – 60
60 – 200	Close	C	Thinly Bedded	60 – 200
200 – 600	Medium	M	Medium Bedded	200 – 600
600 – 2000	Wide	W	Thickly Bedded	600 – 2000
2000 – 6000	Very Wide	VW	Very Thickly Bedded	> 2000
>6000	Extremely Wide	EW		

Defect Spacing in 3D	
Term	**Description**
Blocky	Equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greater than cross section

Defect Persistence (areal extent)
Trace length of defect given in metres

Symbols: The list below provides an explanation of terms and symbols used on the geotechnical borehole, test pit and penetrometer logs.

Test Results			
PI	Plasticity Index	c'	Effective Cohesion
LL	Liquid Limit	c_u	Undrained Cohesion
LI	Liquidity Index	c'_R	Residual Cohesion
DD	Dry Density	ϕ'	Effective Angle of Internal Friction
WD	Wet Density	ϕ_u	Undrained Angle of Internal Friction
LS	Linear Shrinkage	ϕ'_R	Residual Angle of Internal Friction
MC	Moisture Content	c_v	Coefficient of Consolidation
OC	Organic Content	m_v	Coefficient of Volume Compressibility
WPI	Weighted Plasticity Index	$c_{\alpha\varepsilon}$	Coefficient of Secondary Compression
WLS	Weighted Linear Shrinkage	e	Voids Ratio
DoS	Degree of Saturation	ϕ'_{cv}	Constant Volume Friction Angle
APD	Apparent Particle Density	q_t / q_c	Piezocone Tip Resistance (corrected / uncorrected)
s_u	Undrained Shear Strength	q_d	PANDA Cone Resistance
q_u	Unconfined Compressive Strength	$I_{s(50)}$	Point Load Strength Index
TCR	Total Core Recovery	*RQD*	Rock Quality Designation

Test Symbols	
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetration Test
CPTu	Cone Penetrometer (Piezocone) Test
PANDA	Variable Energy DCP
PP	Pocket Penetrometer Test
U50	Undisturbed Sample 50 mm (nominal diameter)
U100	Undisturbed Sample 100mm (nominal diameter)
UCS	Uniaxial Compressive Strength
Pm	Pressuremeter
FSV	Field Shear Vane
DST	Direct Shear Test
PR	Penetration Rate
PLI	Point Load Index Test (axial)
D	Point Load Test (diametral)
L	Point Load Test (irregular lump)

Groundwater level	Water Inflow	Water Outflow

Test Pit No: DA1-TP01

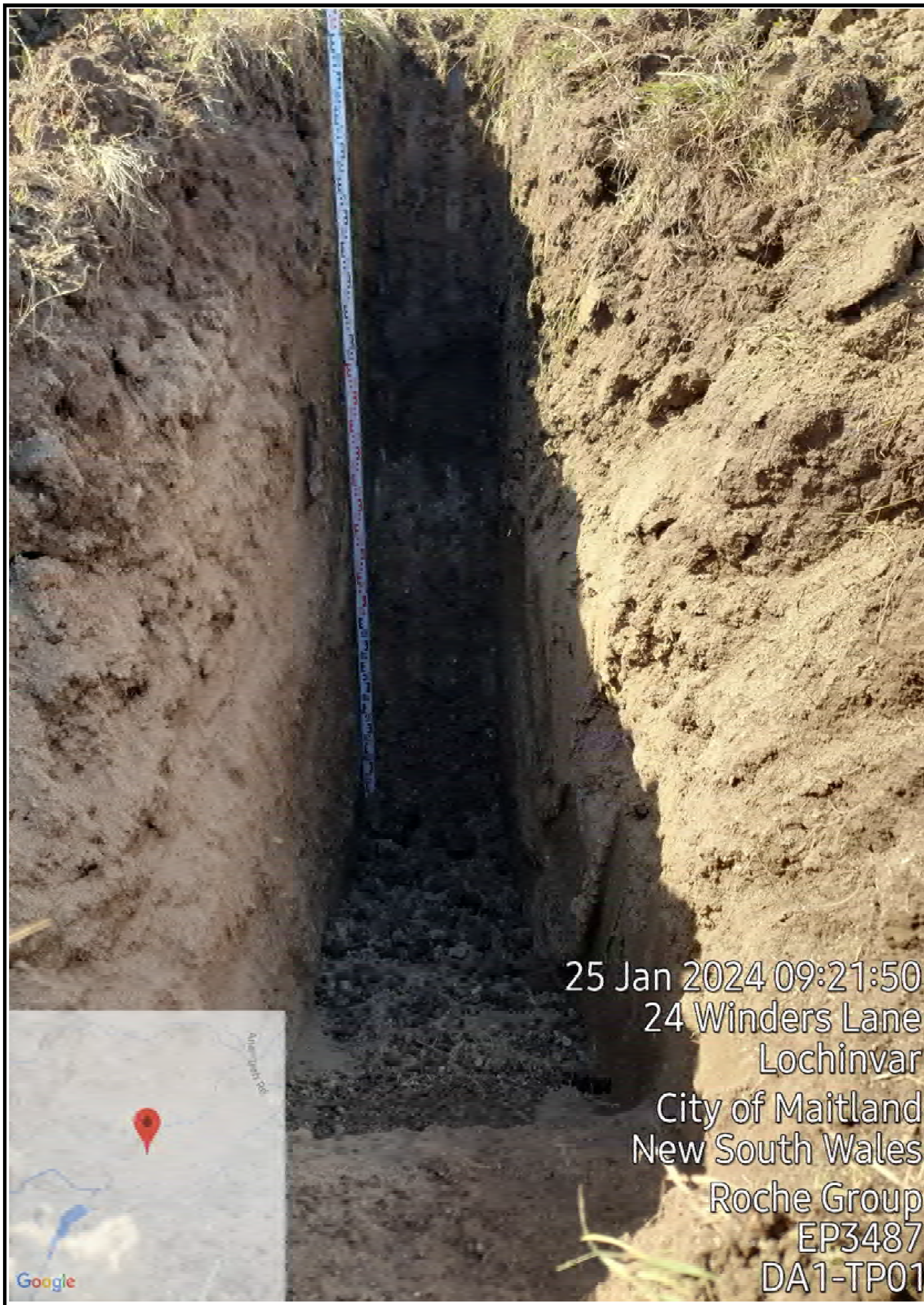
Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6383096.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358523.00	Bearing	---	Ground Level	20 AHD

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	20	0.0		CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	F	2, 2	U50	TOPSOIL
			0.2		CL-CI	Silty CLAY: low to medium plasticity, brown, with chips of lime	~PL	F	2		RESIDUAL SOIL
		19	1					St to VSt	4, 5, 4, 3, 4, 4, 3, 2, 3, 3, 3, 4, 4, 4		
			1.7		CI-CH	Extremely weathered Siltstone/Sandstone recovered as Sandy CLAY, medium to high plasticity, white and brown, with fine to coarse grained, sub-angular to angular gravel	~PL / <PL	VSt to H	10, 6	U50 / B	EXTREMELY WEATHERED ROCK DCP:-/20mm HB
		17	3			Test Pit DA1-TP01 Terminated at 3.00 m					Target depth

Remarks:



EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation
TP01	

Test Pit No: DA1-TP02

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6383054.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358553.00	Bearing	---	Ground Level	23 AHD

Method	Water	RL (m)	Depth (m)	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	23	0.00	CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, grey, fine to coarse grained sand	<PL	St to VSt	4, 5		TOPSOIL
				CL-CI	Sandy CLAY: low to medium plasticity, brown, fine to coarse grained sand	<PL		4, 5, 4, 8, 9		RESIDUAL SOIL
				CI-CH	Extremely weathered Sandstone and Siltstone recovered as Sandy Silty CLAY, medium to high plasticity, brown with lime	<<PL	H	25		EXTREMELY WEATHERED ROCK DCP:-HB
		21	2		Siltstone and Sandstone: thinly to medium bedded, stained and coated, block of 100-200mm					BEDROCK
					Test Pit DA1-TP02 Terminated at 2.80 m					Target depth

Remarks:

EP RISK

EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
TP02	

Test Pit No: DA1-TP03

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382954.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358463.00	Bearing	---	Ground Level	38 AHD

EXCAVATION				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	38	0		CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, grey, fine to coarse grained sand	<PL	F to St	3, 3		TOPSOIL
					CL-CI	Sandy CLAY: low to medium plasticity, brown, fine to coarse grained sand	<PL	F to St / VSt	2, 6, 6, 11		RESIDUAL SOIL
		37	1		CI-CH	Extremely weathered Sandstone and Siltstone recovered as Sandy CLAY, medium to high plasticity, brown, fine to coarse grained sand, with lime	<<PL	H	25		EXTREMELY WEATHERED ROCK DCP:-HB
		36	2								
		35	3			Test Pit DA1-TP03 Terminated at 3.10 m					Target depth
		34	4								

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation
	TP03

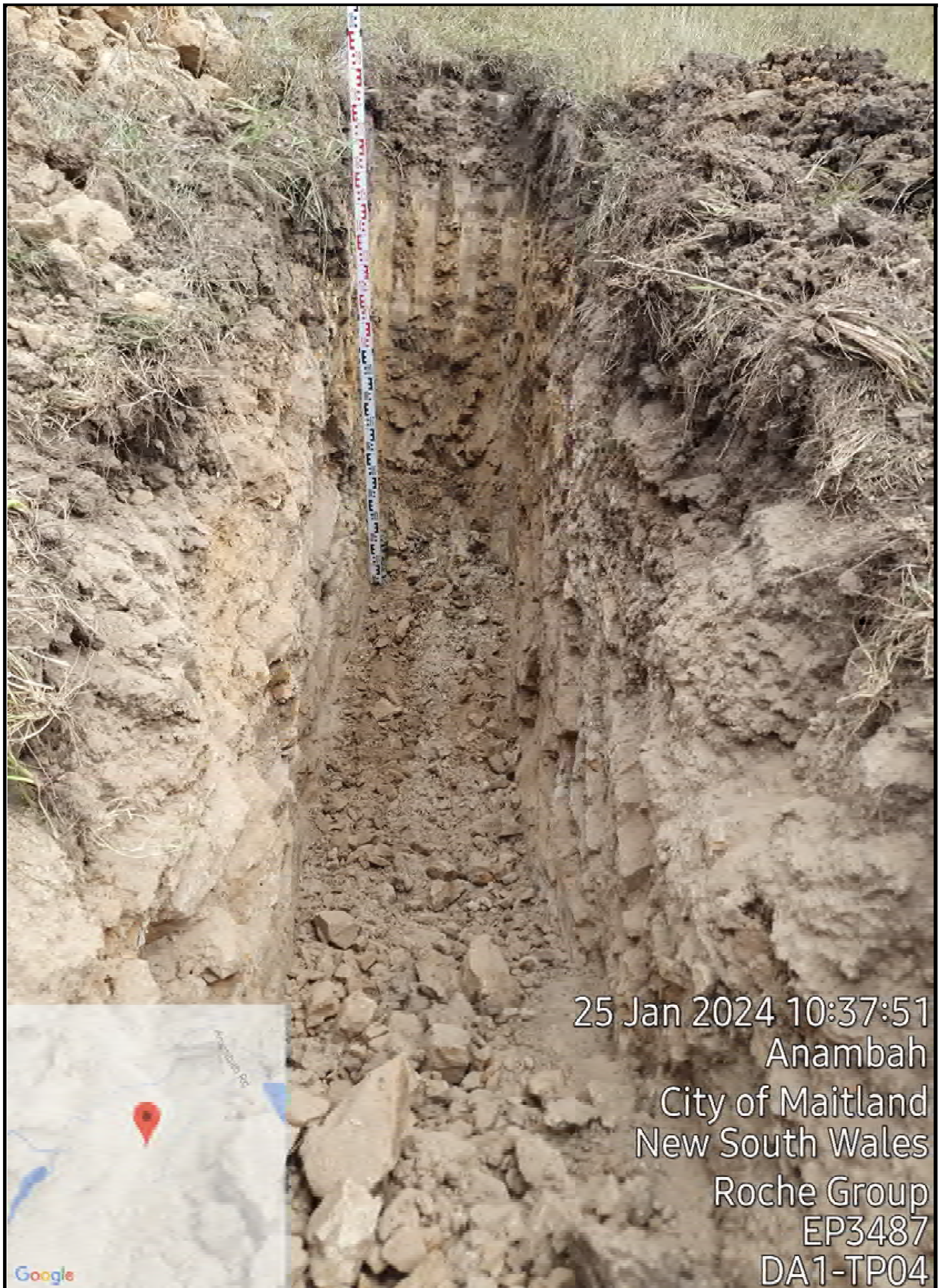
Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6383001.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358657.00	Bearing	---	Ground Level	27.3 AHD

EXCAVATION				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered				CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, grey, fine to coarse grained sand	<PL	VSt	5, 6		TOPSOIL
		27			CL-CI	Sandy CLAY: low to medium plasticity, brown, grey, fine to coarse grained sand			10, 12		RESIDUAL SOIL
		26	1		CI-CH	Extremely weathered Siltstone and Sandstone recovered as Sandy Clay, medium to high plasticity, brown, fine to coarse grained sand	<<PL	H	12	B	EXTREMELY WEATHERED ROCK DCP:-HB
						Siltstone and Sandstone: medium-thickly bedded, 150-250mm cementations 1.50m: 400 mm Blocks					BEDROCK
		25	2			Test Pit DA1-TP04 Terminated at 1.90 m					Refusal
		24	3								
			4								

Remarks:



EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation
	TP04

Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382922.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358612.00	Bearing	---	Ground Level	32.3 AHD

Method	Water	Depth (m)	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	0.0–0.2	CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	F	1, 2		TOPSOIL
E		0.2–0.6	CL-CI	Silty CLAY: low to medium plasticity, grey	<PL	St to VSt	3, 4, 8, 8		RESIDUAL SOIL
E		0.6–2.4	CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, low to medium plasticity, brow, fine to coarse grained sand	<<PL	VSt to H	12, 15, 18		EXTREMELY WEATHERED ROCK DCP:-HB
E		2.4–3.0		Sandstone: fine to coarse grained, brown, medium bedded with cementations 200-250mm					BEDROCK
		3.0		Test Pit DA1-TP05 Terminated at 3.00 m					Target depth

RL (m): 32, 31, 30, 29; Depth (m): 1, 2, 3, 4

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation
	TP05

Test Pit No: DA1-TP06

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382856.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358738.00	Bearing	---	Ground Level	37 AHD

EXCAVATION | MATERIAL DESCRIPTION | TESTING, SAMPLING & OTHER INFORMATION

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered				CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	St	3, 8		TOPSOIL
					CL-CI	Silty CLAY: low to medium plasticity, grey	<PL		10, 11, 12		RESIDUAL SOIL
		36, 35	1, 2		CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, fine to coarse grained. brown, with cementations 100-150mm	<<PL	H	11, 10, 17, 17, 20		EXTREMELY WEATHERED ROCK DCP:-HB
		34, 33	3, 4			Test Pit DA1-TP06 Terminated at 2.10 m					Target depth

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP06	

Test Pit No: DA1-TP07

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382780.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358609.00	Bearing	---	Ground Level	37.4 AHD

EXCAVATION | MATERIAL DESCRIPTION | TESTING, SAMPLING & OTHER INFORMATION

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered				CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	St to VSt	3		TOPSOIL
		37			CL-CI	Silty CLAY: low to medium plasticity, brown	<PL		5, 7, 6, 6, 4, 7, 15		RESIDUAL SOIL DCP:-HB
		36	1		CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, low to medium plasticity, brown, fine to coarse grained sand	<<PL	H			EXTREMELY WEATHERED ROCK
		35, 34	2, 3, 4			Test Pit DA1-TP07 Terminated at 2.00 m					Target depth

Remarks:

EP RISK

EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1
Geotechnical Investigation

TP07

Test Pit No: DA1-TP08

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382827.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358490.00	Bearing	---	Ground Level	37.8 AHD

EXCAVATION | MATERIAL DESCRIPTION | TESTING, SAMPLING & OTHER INFORMATION

Method	Water	RL (m)	Depth (m)	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered			CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	F to St	2, 2		TOPSOIL
				CL-CI	Silty CLAY: low to medium plasticity, brown			3, 4, 7, 7		RESIDUAL SOIL
		37, 36, 35	1, 2	CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, low to medium plasticity, brown, fine to coarse grained sand, with liestone chips	<<PL	VSt to H	11, 20		EXTREMELY WEATHERED ROCK DCP:-HB
		34	3, 4		Test Pit DA1-TP08 Terminated at 3.00 m					Target depth

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP08	

Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382840.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358352.00	Bearing	---	Ground Level	30 AHD

EXCAVATION				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	30	0		CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	F	1, 1		TOPSOIL
					CL-CI	Silty CLAY: low to medium plasticity, grey and brown			1, 2, 6		RESIDUAL SOIL
		29	1		CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, low to medium plasticity, fine to coarse grained sand, white and grey, with ferruginous cementaions (150mm-250mm), with limestone chips	<<PL	VSt and H	7, 11, 12, 15, 13, 8		EXTREMELY WEATHERED ROCK
		28	2					H	10, 10, 18		DCP:-HB
		27	3			Test Pit DA1-TP09 Terminated at 3.00 m					Target depth
		26	4								

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation
	TP09

Test Pit No: DA1-TP10

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382804.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358261.00	Bearing	---	Ground Level	28 AHD

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	28	0		CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	F	2		TOPSOIL
					CL-CI	Silty CLAY: low to medium plasticity, black, brown	<PL	F / St to VSt	2, 2, 3, 4, 6	B	RESIDUAL SOIL
		27	1		SC	Extremely weathered Sandstone recovered as ClayeySAND, fine to coarse grained, brown, with ferruginous cementation 50-100mm and chips of lime	D	D	10, 15, 10		EXTREMELY WEATHERED ROCK DCP:-/50mm HB
		26	2								
		25	3			Test Pit DA1-TP10 Terminated at 2.70 m					Target depth
		24	4								

EXCAVATION | MATERIAL DESCRIPTION | TESTING, SAMPLING & OTHER INFORMATION

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP10	

Test Pit No: DA1-TP11

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382707.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358228.00	Bearing	---	Ground Level	30.1 AHD

EXCAVATION | MATERIAL DESCRIPTION | TESTING, SAMPLING & OTHER INFORMATION

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	30			CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	F	1		TOPSOIL
					CL-CI	Silty CLAY: low to medium plasticity, grey and brown			1, 1, 2		RESIDUAL SOIL
								St	4, 4, 9		
		29, 28	1, 2		CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, medium to high plasticity, brown, fine to coarse grained sand, with cementations 50-100mm and chips of limestone	<<PL	VSt to H	20		EXTREMELY WEATHERED ROCK DCP:-HB
		27	3, 4			Test Pit DA1-TP11 Terminated at 2.50 m					Target depth

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP11	

Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382713.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358358.00	Bearing	---	Ground Level	38.3 AHD

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered		0.0		CL-CI	TOPSOIL: Silty CLAY: low to medium plasticity, grey	<PL	F	2		TOPSOIL
		38			CL-CI	Silty CLAY: low to medium plasticity, grey and brown	<PL	VSt	6, 6, 10		RESIDUAL SOIL
		37	1		CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, medium to high plasticity, brown and white, fine to coarse grained sand	<<PL	VSt / H	9, 19	D	EXTREMELY WEATHERED ROCK DCP:-HB
		36	2			Test Pit DA1-TP12 Terminated at 2.00 m					Target depth
		35	3								
			4								

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP12	

Test Pit No: DA1-TP13

Engineering Log - Test Pit

SHEET 1 OF 1

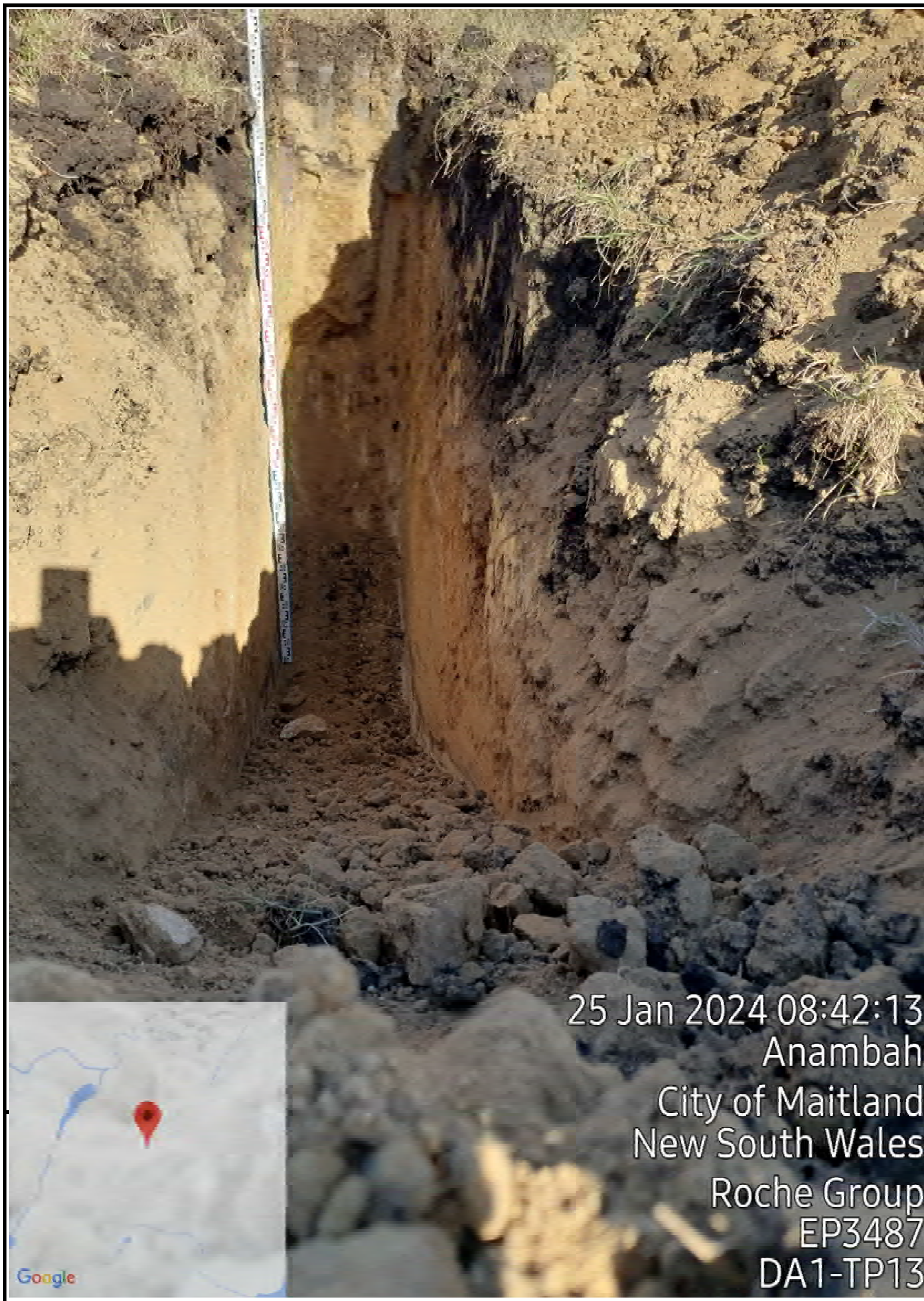
Client: Roche Group
Project: Anambah Western Link Road (DA1)
Location: Anambah NSW 2320

Project No. EP3487
Logged By: AN
Checked By: OP

Started Excavation 25.1.24 | Northing 6382705.00 | Slope 90° | Equipment 23T Excavator
Completed Excavation 25.1.24 | Easting 358486.00 | Bearing --- | Ground Level 41 AHD

EXCAVATION				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	41	0.0		CL-CI	TOPSOIL: Sandy CLAY: fine to coarse grained, low to medium plasticity, grey	<PL	F	2, 2		TOPSOIL
E					CL-CI	Sandy CLAY: fine to coarse grained, low to medium plasticity, grey and brown	<PL	F; St to VSt	2, 1, 3, 6, 12		RESIDUAL SOIL
E		40	1		CL-CI	Extremely weathered Sandstone recovered as sandy CLAY, medium to high plasticity, brown, fine to coarse sand	<<PL	H	14	B	EXTREMELY WEATHERED ROCK DCP:-HB
E		39	2			Sandstone: thinly bedded, brown, fine to coarse grained	D	VD			BEDROCK
		38	3			Test Pit DA1-TP13 Terminated at 2.50 m					Target depth
		37	4								

Remarks:



EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP13	

Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382630.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358452.00	Bearing	---	Ground Level	37.7 AHD

EXCAVATION				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered				CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, grey, fine to coarse grained sand	<PL	VSt	6, 6		TOPSOIL
					CI-CH	Sandy CLAY: medium to high plasticity, grey and brown, fine to coarse grained sand			8, 6, 6, 9		RESIDUAL SOIL
		37	1		CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, medmum to high plasticity, brown, with ferrugious cementations 50-100mm	<<PL	H	11, 16		EXTREMELY WEATHERED ROCK DCP:-HB
		36, 35	2, 3			Test Pit DA1-TP14 Terminated at 3.00 m					Target depth
		34	4								

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP14	

Test Pit No: DA1-TP15

Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382508.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358289.00	Bearing	---	Ground Level	37 AHD

EXCAVATION: Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	MATERIAL DESCRIPTION: Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	TESTING, SAMPLING & OTHER INFORMATION: Tests DCP Results (blows/100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	37	0.00		CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, grey, fine to coarse grained sand	<PL	VSt to H	10		TOPSOIL
					CL-CI	Sandy CLAY: low to medium plasticity, grey, fine to coarse grained sand	<PL		11, 11, 14, 13		RESIDUAL SOIL
		36	1		CI-CH	Extremely weathered Sandstone recovered as Sandy CLAY, medium to high plasticity, brown, fine to coarse grained sand	<<PL		25	B, B	EXTREMELY WEATHERED ROCK DCP:-HB
		35	2								
		34	3			Test Pit DA1-TP15 Terminated at 3.10 m					Target depth
		33	4								

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP15	

Test Pit No: DA1-TP16

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	24.1.24	Northing	6382436.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	24.1.24	Easting	358037.00	Bearing	---	Ground Level	30.7 AHD

EXCAVATION | MATERIAL DESCRIPTION | TESTING, SAMPLING & OTHER INFORMATION

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered				CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, grey, fine to medium grained sand	<PL	F and St	3, 3		TOPSOIL
		30			CL-CI	Sandy CLAY: low to medium plasticity, grey, fine to coarse grained sand			4, 5, 4, 3, 3		SLOPE WASH
		29	1, 2		CL-CI	Clayey SAND: fine to coarse grained, brown	D	MD to D	3, 3, 2, 3, 2, 4, 4, 4, 5, 5, 5, 7, 5, 5, 6, 10, 6, 7	B	RESIDUAL SOIL
		28	3		SC	Extremely weathered Sandstone recovered as Clayey SAND, fine to coarse grained, brown and yellow	D	VD	19		EXTREMELY WEATHERED ROCK DCP:-HB
		27	4			Test Pit DA1-TP16 Terminated at 3.10 m					Target depth

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation	
	TP16	

Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	24.1.24	Northing	6382265.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	24.1.24	Easting	358242.00	Bearing	---	Ground Level	46.7 AHD

EXCAVATION | MATERIAL DESCRIPTION | TESTING, SAMPLING & OTHER INFORMATION

Method	Water	RL (m)	Depth (m)	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered			CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, grey, fine to medium grained sand	<PL	St to VSt	3, 5		TOPSOIL
				CL-CI	Sandy CLAY: low to medium plasticity, brown, fine to coarse grained sand			10, 11	B	RESIDUAL SOIL
		46, 45	1, 2	CI-CH	Extremely weathered Sandstone recovered as Sandy CLAY, medium to high plasticity, brown and white, fine to coarse grained	<<PL	VSt to H	12, 10, 8, 15, 11		EXTREMELY WEATHERED ROCK DCP:-HB
		44			Sandstone: medium bedded, brown and white, fine to coarse grained	D	VD			BEDROCK
		43	3, 4		Test Pit DA1-TP17 Terminated at 3.00 m					Target depth

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation
	TP17

Test Pit No: DA1-TP18

Engineering Log - Test Pit

SHEET 1 OF 1

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	24.1.24	Northing	6382067.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	24.1.24	Easting	358085.00	Bearing	---	Ground Level	50 AHD

EXCAVATION | MATERIAL DESCRIPTION | TESTING, SAMPLING & OTHER INFORMATION

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/ 100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	50	0		CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, dark grey, fine to coarse grained sand	<<PL	St to VSt	3, 3		TOPSOIL
					CL-CI	Sandy CLAY: low to medium plasticity, grey and brown, fine to coarse grained sand	<PL		4, 4, 6		RESIDUAL SOIL
		49	1		SC	Extremely weathered Sandstone recovered as Claye SAND fine to coarse grained, brown, with cementations 150-200mm	D	VD	12, 12, 15, 19		EXTREMELY WEATHERED ROCK DCP:-HB
		48	2								
		47	3			Test Pit DA1-TP18 Terminated at 3.00 m					Target depth
		46	4								

Remarks:

EP LIB 05.GLB Log CW NON-CORED BOREHOLE LOG EP3487 ANAMBAH DA1 0.1 AN.GPJ <<DrawingFile>> 28/02/2024 10:24 10.03.00.09 Developed by Datgel

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation
	TP18

Test Pit No: DA1-TP19

Engineering Log - Test Pit

Client	Roche Group	Project No.	EP3487
Project	Anambah Western Link Road (DA1)	Logged By	AN
Location	Anambah NSW 2320	Checked By	OP

Started Excavation	25.1.24	Northing	6382647.00	Slope	90°	Equipment	23T Excavator
Completed Excavation	25.1.24	Easting	358380.00	Bearing	---	Ground Level	40 AHD

EXCAVATION				MATERIAL DESCRIPTION					TESTING, SAMPLING & OTHER INFORMATION		
Method	Water	RL (m)	Depth (m)	Graphic Log	Classification	Description of Soil (soil type: plasticity/grainsize, colour and other components)	Moisture Condition	Consistency	Tests DCP Results (blows/100mm)	Samples	Additional Comments (material origin, pocket penetrometer values, investigation observations)
E	Not Encountered	40	0		CL-CI	TOPSOIL: Sandy CLAY: low to medium plasticity, grey, fine to coarse grained sand	<PL	VSt	5		TOPSOIL
					CL-CI	Sandy CLAY: low to medium plasticity, grey and brown, fine to coarse grained sand			6, 6, 7, 9		RESIDUAL SOIL
					CL-CI	Extremely weathered Sandstone recovered as Sandy CLAY, medium to high plasticity, brown, fine to coarse grained sand		H	13, 16, 13		EXTREMELY WEATHERED ROCK DCP:-HB
		39	1								
						Sandstone: fine to coarse graine, medium bedded, brown	D	VD		B	BEDROCK
						Test Pit DA1-TP19 Terminated at 1.80 m					Refusal
		38	2								
		37	3								
		36	4								

Remarks:

EP RISK	EP3487 - DB20 Pty Ltd (ROCHE Group) Anambah DA1 Geotechnical Investigation
	TP19

Appendix E

LABORATORY TEST RESULTS

Material Test Report

Report Number:	**NEWC24010-6**
Issue Number:	4 - *This version supersedes all previous issues*
Reissue Reason:	
Date Issued:	21/02/2024
Client:	EP Risk Management PO Box 57, Lochinvar NSW 2321
Contact:	Ovidiu Pruteanu
Project Number:	NEWC24010
Project Name:	EP3487 - Anambah Roche
Project Location:	Anambah
Client Reference:	EP3487
Work Request:	120
Sample Number:	NEWC120A
Date Sampled:	24/01/2024
Dates Tested:	30/01/2024 - 30/01/2024
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location:	**DA1 - TP01 - U50 (0.50 - 1.00)**
Material:	Existing Ground
Material Source:	On-site

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Newcastle Laboratory
16 Callistemon Close Warabrook NSW 2304
Phone: 0424 521 225
Email: Cameron.Bik@coffeytesting.com

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Raphael Kirby-Faust
Geotechnician
Laboratory Accreditation Number: 431

Shrink Swell Index (AS 1289 7.1.1 & 2.1.1)	
Iss (%)	**4.0**
Visual Description	Clay, medium to high plasticity, brown.
* Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.	

Core Shrinkage Test	
Shrinkage Strain - Oven Dried (%)	**4.0**
Estimated % by volume of significant inert inclusions	
Cracking	
Crumbling	Yes / No
Moisture Content (%)	19.5

Swell Test	
Initial Pocket Penetrometer (kPa)	+600
Final Pocket Penetrometer (kPa)	110
Initial Moisture Content (%)	20.0
Final Moisture Content (%)	29.6
Swell (%)	**6.2**
* NATA Accreditation does not cover the performance of pocket penetrometer readings.	

Material Test Report

Report Number: **NEWC24010-6**
Issue Number: 4 - *This version supersedes all previous issues*
Reissue Reason:
Date Issued: 21/02/2024
Client: EP Risk Management
PO Box 57, Lochinvar NSW 2321
Contact: Ovidiu Pruteanu
Project Number: NEWC24010
Project Name: EP3487 - Anambah Roche
Project Location: Anambah
Client Reference: EP3487
Work Request: 120
Sample Number: NEWC120B
Date Sampled: 24/01/2024
Dates Tested: 30/01/2024 - 05/02/2024
Sampling Method: Sampled by Client
The results apply to the sample as received
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **DA1 - TP01 , Depth: 2.50 - 3.00**
Material: Existing Ground
Material Source: On-site

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ilac-MRA NATA

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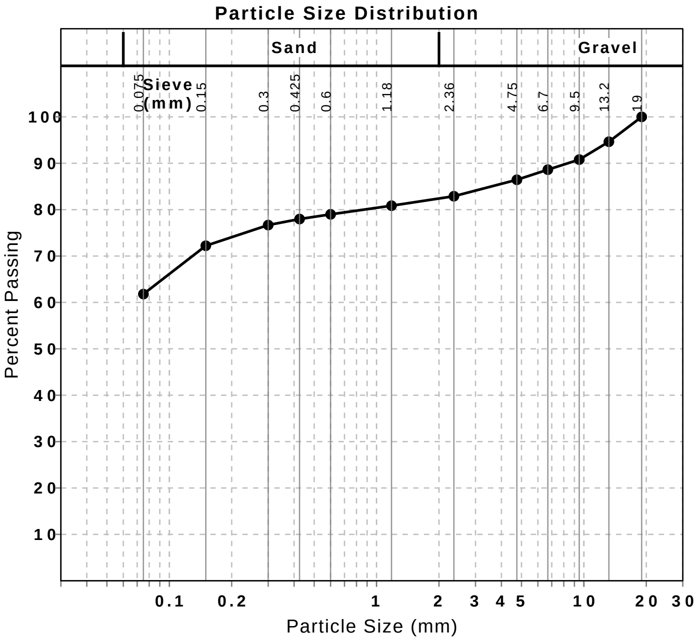
Approved Signatory: Raphael Kirby-Faust
Geotechnician
Laboratory Accreditation Number: 431

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
19 mm	**100**			0		
13.2 mm	**95**			5		
9.5 mm	**91**			4		
6.7 mm	**89**			2		
4.75 mm	**86**			2		
2.36 mm	**83**			4		
1.18 mm	**81**			2		
0.6 mm	**79**			2		
0.425 mm	**78**			1		
0.3 mm	**77**			1		
0.15 mm	**72**			4		
0.075 mm	**62**			10		

Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	53		
Plastic Limit (%)	17		
Plasticity Index (%)	**36**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	**14.5**		
Cracking Crumbling Curling			



Material Test Report

Newcastle Laboratory
16 Callistemon Close Warabrook NSW 2304
Phone: 0424 521 225
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Approved Signatory: Raphael Kirby-Faust
Geotechnician
Laboratory Accreditation Number: 431

Report Number:	**NEWC24010-6**
Issue Number:	4 - *This version supersedes all previous issues*
Reissue Reason:	
Date Issued:	21/02/2024
Client:	EP Risk Management PO Box 57, Lochinvar NSW 2321
Contact:	Ovidiu Pruteanu
Project Number:	NEWC24010
Project Name:	EP3487 - Anambah Roche
Project Location:	Anambah
Client Reference:	EP3487
Work Request:	120
Sample Number:	NEWC120C
Date Sampled:	24/01/2024
Dates Tested:	30/01/2024 - 17/02/2024
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location:	**DA1 - TP04 , Depth: 1.00 - 1.50**
Material:	Existing Ground
Material Source:	On-site

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**50**		
Method of Compactive Effort	Standard		
Method used to Determine MDD			
Method used to Determine Plasticity			
Maximum Dry Density (t/m^3)	1.68		
Optimum Moisture Content (%)	15.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	99.5		
Dry Density after Soaking (t/m^3)	1.67		
Field Moisture Content (%)	9.4		
Moisture Content at Placement (%)	14.8		
Moisture Content Top 30mm (%)	14.3		
Moisture Content Rest of Sample (%)	13.8		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)			
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			

Material Test Report

Report Number:	**NEWC24010-6**
Issue Number:	4 - *This version supersedes all previous issues*
Reissue Reason:	
Date Issued:	21/02/2024
Client:	EP Risk Management
	PO Box 57, Lochinvar NSW 2321
Contact:	Ovidiu Pruteanu
Project Number:	NEWC24010
Project Name:	EP3487 - Anambah Roche
Project Location:	Anambah
Client Reference:	EP3487
Work Request:	120
Sample Number:	NEWC120D
Date Sampled:	24/01/2024
Dates Tested:	30/01/2024 - 20/02/2024
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location:	**DA1 - TP13 , Depth: 1.00 - 1.40**
Material:	Existing Ground
Material Source:	On-site

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Geotechnician
Laboratory Accreditation Number: 431

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**30**		
Method of Compactive Effort	Standard		
Method used to Determine MDD			
Method used to Determine Plasticity			
Maximum Dry Density (t/m^3)	1.83		
Optimum Moisture Content (%)	16.5		
Laboratory Density Ratio (%)	98.0		
Laboratory Moisture Ratio (%)	102.0		
Dry Density after Soaking (t/m^3)	1.79		
Field Moisture Content (%)			
Moisture Content at Placement (%)	16.7		
Moisture Content Top 30mm (%)	17.7		
Moisture Content Rest of Sample (%)	18.0		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	0.4		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			

Material Test Report

Report Number:	**NEWC24010-6**
Issue Number:	4 - *This version supersedes all previous issues*
Reissue Reason:	
Date Issued:	21/02/2024
Client:	EP Risk Management PO Box 57, Lochinvar NSW 2321
Contact:	Ovidiu Pruteanu
Project Number:	NEWC24010
Project Name:	EP3487 - Anambah Roche
Project Location:	Anambah
Client Reference:	EP3487
Work Request:	120
Sample Number:	NEWC120E
Date Sampled:	24/01/2024
Dates Tested:	30/01/2024 - 20/02/2024
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location:	**DA1 - TP15 , Depth: 0.50 - 1.00**
Material:	Existing Ground
Material Source:	On-site

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California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**17**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual/Tactile		
Maximum Dry Density (t/m^3)	1.78		
Optimum Moisture Content (%)	16.0		
Laboratory Density Ratio (%)	98.5		
Laboratory Moisture Ratio (%)	100.5		
Dry Density after Soaking (t/m^3)	1.75		
Field Moisture Content (%)	10.1		
Moisture Content at Placement (%)	16.0		
Moisture Content Top 30mm (%)	19.1		
Moisture Content Rest of Sample (%)	19.1		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	96.0		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			

Material Test Report

Report Number:	**NEWC24010-6**
Issue Number:	4 - *This version supersedes all previous issues*
Reissue Reason:	
Date Issued:	21/02/2024
Client:	EP Risk Management PO Box 57, Lochinvar NSW 2321
Contact:	Ovidiu Pruteanu
Project Number:	NEWC24010
Project Name:	EP3487 - Anambah Roche
Project Location:	Anambah
Client Reference:	EP3487
Work Request:	120
Sample Number:	NEWC120G
Date Sampled:	24/01/2024
Dates Tested:	30/01/2024 - 14/02/2024
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location:	**DA1 - TP17 , Depth: 0.70 - 1.20**
Material:	Existing Ground
Material Source:	On-site

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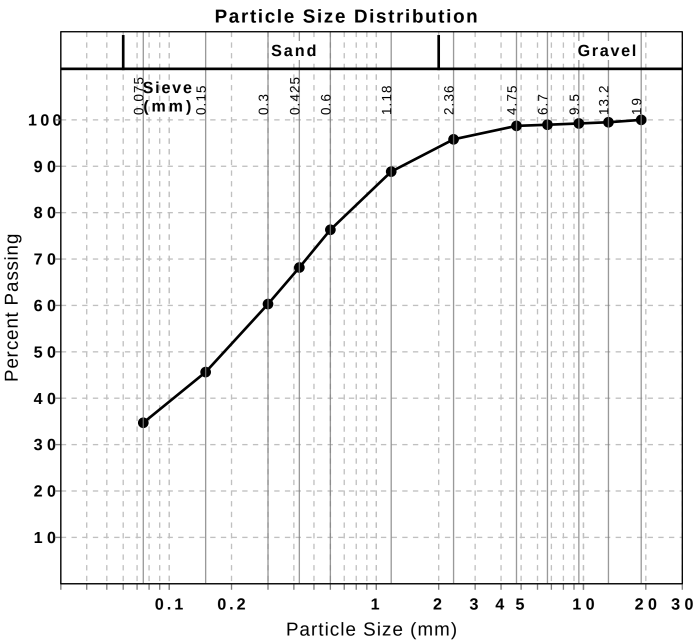
Approved Signatory: Raphael Kirby-Faust
Geotechnician
Laboratory Accreditation Number: 431

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
19 mm	**100**			0		
13.2 mm	**99**			1		
9.5 mm	**99**			0		
6.7 mm	**99**			0		
4.75 mm	**99**			0		
2.36 mm	**96**			3		
1.18 mm	**89**			7		
0.6 mm	**76**			13		
0.425 mm	**68**			8		
0.3 mm	**60**			8		
0.15 mm	**46**			15		
0.075 mm	**35**			11		



Atterberg Limit (AS1289 3.1.1 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Air Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	45		
Plastic Limit (%)	21		
Plasticity Index (%)	**24**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.1		
Linear Shrinkage (%)	**12.5**		
Cracking Crumbling Curling	Curling		

Material Test Report

Report Number: **NEWC24010-6**
Issue Number: 4 - *This version supersedes all previous issues*
Reissue Reason:
Date Issued: 21/02/2024
Client: EP Risk Management
PO Box 57, Lochinvar NSW 2321
Contact: Ovidiu Pruteanu
Project Number: NEWC24010
Project Name: EP3487 - Anambah Roche
Project Location: Anambah
Client Reference: EP3487
Work Request: 120
Date Sampled: 24/01/0024
Dates Tested: 30/01/2024 - 01/02/2024
Sampling Method: Sampled by Client
The results apply to the sample as received
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Site Selection: Selected by Client
Location: Anambah DA1

coffey TESTING

Newcastle Laboratory
16 Callistemon Close Warabrook NSW 2304
Phone: 0424 521 225
Email: Cameron.Bik@coffeytesting.com

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Raphael Kirby-Faust
Geotechnician
Laboratory Accreditation Number: 431

Moisture Content AS 1289 2.1.1

Sample Number	Sample Location	Moisture Content (%)	Min	Max	Material
NEWC120B	DA1 - TP01 , Depth: 2.50 - 3.00	20.2 %	**	**	Existing Ground
NEWC120C	DA1 - TP04 , Depth: 1.00 - 1.50	21.0 %	**	**	Existing Ground
NEWC120D	DA1 - TP13 , Depth: 1.00 - 1.40	9.8 %	**	**	Existing Ground
NEWC120E	DA1 - TP15 , Depth: 0.50 - 1.00	10.1 %	**	**	Existing Ground
NEWC120G	DA1 - TP17 , Depth: 0.70 - 1.20	20.9 %	**	**	Existing Ground

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Shrink Swell Index AS 1289 7.1.1 & 2.1.1					
Sample Number	NEWC120A				
Date Sampled	24/01/2024				
Date Tested	30/01/2024				
Material Source	on-site				
Sample Location	DA1 - TP01 - U50 (0.50 - 1.00)				
Inert Material Estimate (%)	**				
Pocket Penetrometer before (kPa)	+600				
Pocket Penetrometer after (kPa)	110				
Shrinkage Moisture Content (%)	19.5				
Shrinkage (%)	**4.0**				
Swell Moisture Content Before (%)	20.0				
Swell Moisture Content After (%)	29.6				
Swell (%)	**6.2**				
Shrink Swell Index Iss (%)	**4.0**				
Visual Description	Clay, medium to high plasticity, brown.				
Cracking	**				
Crumbling	**				
Remarks	**				

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

Appendix F

FOUNDATION MAINTENANCE AND FOOTING PERFORMANCE

Foundation Maintenance and Footing Performance: A Homeowner's Guide

BTF 18 replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

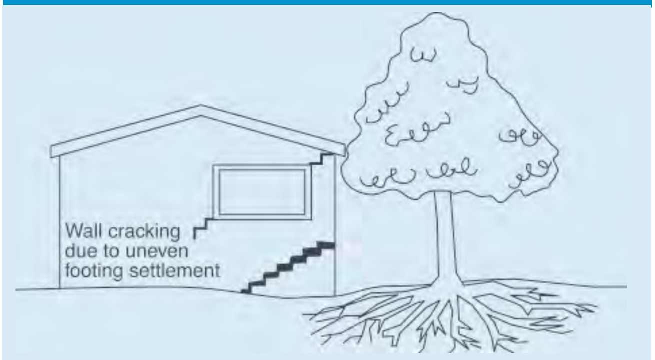
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

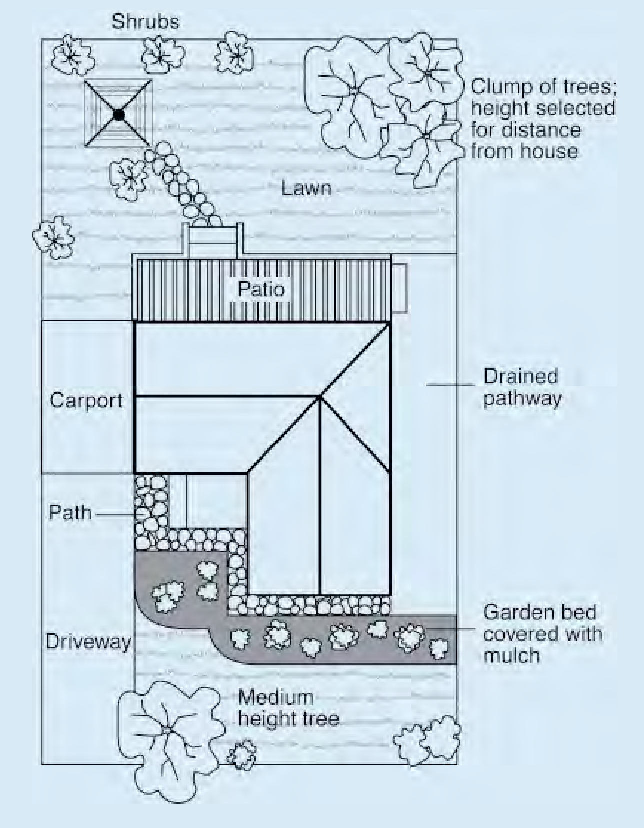
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation
In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden
The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees
Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs
State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation
Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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