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Report

Geotechnical Investigation report
Proposed Planning Proposal
School Road, Forbes NSW

Prepared for:

Sydney Environmental Group Pty Ltd
Unit 63/45 Huntley Street
Alexandria NSW 2015

Prepared by:

Core Geotech Pty Ltd

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Appendices

1 Introduction

As requested, Core Geotech Pty Ltd (CG) has carried out a geotechnical investigation of a site located at Lot 375, 376, 386-389, 830, 831, 1272 and 1273 in DP750158 School Road Forbes NSW which is being considered for a future residential subdivision development.

The land capability assessment comprised site inspections, non-intrusive and intrusive site investigations followed by laboratory testing of selected samples, engineering analysis and reporting.

Details of the work undertaken, and the results obtained are presented in this report, together with comments relating to engineering design and construction practice. Comments are also provided on the need for further geotechnical investigations that are required when the project progresses to the development application stage.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter QU23-0235 Rev 1 dated 18 June 2023.

2 Scope of Works

As detailed in our proposal letter, the instructed scope of work to be conducted by CG was defined as follows:

- Desktop study of available information relevant to the proposed development;
- Arrange and execute a geotechnical Site Investigation (SI);
- Review of all the data relevant to existing subsurface information and the proposed project;
- Details and descriptions of the existing subsoil strata with laboratory test results;
- Preliminary Site Classification as per AS2870 2011 Residential Slabs and Footings;
- Development of the geotechnical ground model and provide appropriate soil design parameters;
- Provide suitable foundation options as appropriate (e.g. shallow footings / bored piers etc.) and applicable design parameters;
- Provide permanent and temporary retention options for further consideration;
- Comment on the proposed construction methodology;
- Stability criteria for open excavations and advice regarding excavation staging including bench heights and the like. Advice on earthworks, rate of excavation, and on site trafficability after disturbance of the site at excavated levels;
- Geotechnical advice regarding site ground water conditions;
- Advice on ground construction difficulties likely to be encountered;
- Geotechnical design parameters provided for the foundation design;
- Risk of slope instability;
- Recommendations in terms of site preparation;

3 Proposed Development

Based on the supplied information, it is understood that under the Forbes Local Environmental Plan 2013, the land is currently zoned RU1 – Primary Production, R5 - Large Lot Residential, and RE1 - Public Recreation. A Planning Proposal is required to rezone the Site to facilitate future residential development. The Site has been identified by Forbes Shire Council for future residential development and is included within Council’s Draft Local Housing Strategy (LHS)

2021 – 2024. The Draft LHS indicates that the Site could facilitate the development of upwards of 600 dwellings (including R5 Large Lot Residential portion). The Site is identified as Stage 4 and Stage 4a of Precinct 5 within the Draft LHS and identified for release in 2036.

4 Site Description

The proposed site is an irregular shaped rectangle which cover an area of approximately 92ha. The site is bounded to the north by School Road, to the south by rural residential dwelling and Morton Street, to the east by Farnell Street and to the west by Edward Street. No detailed contour survey plan was available for CG to review at the time of preparing this report. However, by visual observation site has a gently to moderately sloping land towards the east, west and south boundary.

At the time of the investigation, the site generally comprised a rural residential dwelling near the north west side and well maintained grassed agricultural land with individual paddocks separated by a series of farm fences. The area near the rural dwelling contained medium to large size trees and remainder of the site was generally vacant and covered with native grass and bushland. Some farm dams were observed at isolated locations during the investigation.

The surface soils generally comprise silty clay topsoil. Site photography is shown in Appendix E.

5 Fieldwork

Fieldwork was carried out on 29 and 30 June 2023 which included excavation of twenty-five (25) test pits (TP01 to TP25) to a termination/refusal depth ranging from 0.9m to 2.0m using a track mounted excavator fitted with 450mm wide bucket attachment. Dynamic Cone Penetration and Pocket Penetrometer (PP) test was carried out to assess the relative density/consistency of in-situ soils. Disturbed samples were collected, labelled and sent to a NATA Accredited laboratories with Chain of Custody (COC) documentation.

The field investigation was carried out in the presence of one of Geotechnical Engineers from CG who selected test pit locations, carried out sampling and prepared test pit logs. Two site plans showing the test pit locations (Ref. CG23-0608-3 and CG23-0608-4) and test pit logs are attached in Appendix B and C respectively.

6 Laboratory Testing

Laboratory testing was carried out generally in accordance with Australian Standards. All testing was scheduled by CG and carried out by Eurofins Environmental Testing and Benchmark Geotechnical, NATA Accredited Testing Laboratories. The extent of testing carried out to provide the geotechnical parameters required for this study, are presented below:

- Four (4) samples for Particle Size Distribution (PSD) and California Bearing Ratio (CBR) test;
- Six (6) samples to test for Atterberg Limit and Linear Shrinkage test, Aggressivity Suite and Cation exchange Capacity (CEC) test;
- Twenty-five (25) samples for Field Moisture Content test;

7 Ground Model

7.1 Soil Landscape

The NSW Environment & Heritage eSPADE web application identifies the soil landscape for majority of the site is as Bald Hill (bh). A small portion of the site on the north east side comprise Parkes (pa) landscape. The Bald Hill soil landscape is characterised by:

Landscape – Narrow elongate crests, ridges and gently inclined side slopes at Forbes and south and west of Forbes on predominately sandstones.

Soils – Shallow (<30 cm), rapidly drained Lithosols are widespread. Shallow (<50 cm), well-drained Red Earths and occasional shallow (<50 cm), well-drained Red Podzolic Soils occur on side slopes.

Limitations –Water erosion hazard; rock outcrop; shallow, strongly acid, highly permeable soils with low fertility, low available water holding capacity and localised high organic matter.

7.2 Geology

Based on the review of Forbes 1:250,000 Geological Map Geological Series Sheet S155-7 Second Edition 2000 from Geological Survey of NSW, the site area on the west is underlain by Palaeozoic Silurian Devonian Calarie Sandstone which generally comprises cross bedded pebbly to planer bedded medium grained sandstone. The area to the east is underlain by Cainozoic Quaternary (Qr) which generally comprises colluvial sheetwash and scree slopes, minor aeolian climbing dunes.

7.3 Subsurface Conditions

The ground conditions encountered and inferred from the investigation were considered to be generally consistent with the published geology for the area and can be summarised according to the following subsurface sequence:

Table 1: Summary of subsurface profile encountered in TP01 to TP25

Layer	Description	Depth to the base of layer (m)
Topsoil Unit 1	Silty CLAY, fine to medium grained, brown, trace grass rootlets, moisture condition >plastic limit	
		0.2 – 0.3
Residual Unit 2a	CLAY, medium plasticity to high , red, trace fine to medium grained sand and gravel, moisture condition >plastic limit, firm to very stiff	
		0.5 - >2.0
Unit 2b	Gravelly CLAY/Sandy CLAY/Sandy Gravelly CLAY, medium plasticity, red orange, fine to medium grained gravel and sand, moisture condition <plastic limit, very stiff (only TP01, TP05, TP21, TP23 and TP24)	
		0.5 - >1.3
Rock Unit 3	SANDSTONE, extremely to distinctly weathered, fine to medium grained, grey, orange, medium strength, Class V (only TP05 to TP08, TP13, TP14, TP17 to TP24)	
		>0.7 - >2.0

It should be noted that the depths and layer thickness provided in Table 1 are based on the subsurface conditions as observed at the investigation locations and may not be a representative of the entire site.

7.4 Groundwater

Groundwater was not encountered at the time of investigation. However, it is pointed out that standing groundwater and seepages may fluctuate with variations in rainfall, temperature and other factors. No longer term groundwater monitoring has been carried out.

8 Laboratory Test Results

Field Moisture Content (FMC) of soil samples tested ranged from 9.9% to 22.4% and liquid limit was recorded 37% to 89% which indicating high plasticity soils and of similar reactivity. A summary of laboratory test results which include field moisture content and Atterberg Limit with Linear Shrinkage tests is presented in Table 2 below.

Table 2: Summary of FMC and Atterberg Limit with Linear Shrinkage Test Results

TP No.	Depth (m)	Material Description/Origin	FMC (%)	LL (%)	PI (%)	LS (%)
TP01	0.4 – 0.8	Clay/Residual	15.5			
TP02	0.6 – 0.8	Clay/Residual	13.7			
TP03	0.8 – 1.0	Clay/Residual	19.4	89	69	23.5
TP04	1.0 – 1.2	Clay/Residual	22.4			
TP05	1.2 – 1.5	Sandy Clay/Residual	17.4			
TP06	0.3 – 0.6	Clay/Residual	20.1	53	33	16.0
TP07	0.4 – 0.8	Clay/Residual	15.6			
TP08	0.6 – 0.8	Clay/Residual	15.0			
TP09	0.4 – 0.8	Clay/Residual	20.5			
TP10	0.8 – 1.0	Clay/Residual	20.1			
TP11	1.5 – 2.0	Clay/Residual	19.4			
TP12	1.0 – 1.5	Clay/Residual	19.0			
TP13	1.0 – 1.5	Clay/Residual	15.7			
TP14	0.4 – 0.8	Clay/Residual	19.8			
TP15	0.6 – 0.8	Clay/Residual	15.5			
TP16	1.5 – 0.8	Clay/Residual	21.7			
TP17	0.8 – 1.0	Clay/Residual	15.8	53	38	14.5
TP18	0.4 – 0.8	Clay/Residual	16.2			
TP19	0.6 – 0.8	Clay/Residual	15.4	37	21	10.5
TP20	0.4 – 0.6	Clay/Residual	18.8	51	32	13.5
TP21	1.0 – 1.2	Sandy Gravelly Clay/Residual	11.1			
TP22	0.4 – 0.8	Clay/Residual	14.1	42	25	11.0
TP23	0.6 – 1.0	Sandstone/Rock	9.7			
TP24	0.3 – 0.6	Sandy Gravelly Clay/Residual	9.9			
TP25	0.6 – 1.0	Clay/Residual	14.7			

Note: FMC – Field Moisture Content, LL – Liquid Limit, PI – Plasticity Index and LS – Linear Shrinkage

Four (4) bulk samples were collected from to aid in assessment of strength of subgrade material. The FMC and CBR test results are shown in Table 3.

Table 3: A summary of FMC and CBR test results

TP No.	Depth (m)	Material Description/Origin	FMC (%)	OMC (%)	Swell (%)	MDD (t/m³)	CBR (%)
TP01	0.4 – 0.8	Clay/Residual	15.5	21.5	0.5	1.61	5.0
TP07	0.4 – 0.8	Clay/Residual	15.6	18.0	1.5	1.69	3.5
TP09	0.4 – 0.8	Clay/Residual	20.5	18.5	3.0	1.70	2.0
TP14	0.4 – 0.8	Clay/Residual	19.8	20.0	3.5	1.66	3.0
TP18	0.4 – 0.8	Clay/Residual	16.2	18.0	2.0	1.74	7.0

Note: FMC – Field Moisture Content, OMC – Optimum Moisture Content, MDD – Maximum Dry Density, CBR – California Bearing Ratio

A summary of Particle Size Distribution (PSD) test results is presented in Table 4 below.

Table 4: A summary of PSD test results

Sieve size, mm	TP11		TP13		TP23		TP25	
	Passed %	Retained %	Passed %	Retained %	Passed %	Retained %	Passed %	Retained %
26.5			100	0				
19	100	0	84	16	100	0	100	0
13.2	99	1	76	8	94	6	100	0
9.5	97	2	69	7	91	3	100	0
6.7	96	1	59	9	88	3	100	0
4.75	95	1	52	7	85	3	100	0
2.36	94	1	43	9	82	3	66	0
1.18	93	1	38	5	73	2	66	1
0.6	92	1	36	2	77	3	67	1
0.425	91	1	35	1	73	4	95	2
0.3	90	1	34	1	67	7	91	4
0.15	85	5	32	2	57	10	82	9
0.075	77	9	28	4	52	5	74	8

Six (6) soil samples were selected from test pit TP01, TP06, TP11, TP14, TP20 and TP24 to test for aggressivity suite to assess the exposure classification of in situ soils to buried concrete and steel members. The results of the laboratory testing summarised in Table 5 below.

Table 5: Summary of Field Moisture Content and Aggressivity test

TP No.	Depth (m)	Material Description/Origin	FMC (%)	pH	Conductivity µS/cm	Resistivity Ohm.m	Chloride, Cl- (ppm)	Sulphate, SO4- (ppm)
TP01	0.4 – 0.8	Clay/Residual	14	8.7	410	25	470	140
TP06	0.3 – 0.6	Clay/Residual	15	7.9	27	380	<10	20
TP11	1.5 – 2.0	Clay/Residual	17	9.3	210	47	37	94
TP14	0.4 – 0.8	Clay/Residual	18	9.4	180	56	36	73
TP20	0.4 – 0.6	Clay/Residual	17	8.0	17	580	<10	13
TP24	0.3 – 0.6	Sandy Gravelly Clay/Residual	9.6	7.3	<10	1900	<10	<10
Note: FMC – Field Moisture Content								

Six (6) soil samples were selected from TP03, TP08 TP13, TP17, TP19 and TP23 to test for conductivity and Cation Exchange Capacity (CEC) of in situ soils. The results of the laboratory testing summarised in Table 6 below.

Table 6: A summary of conductivity and Cation Exchange Capacity (CEC) test results

TP No.	Depth (m)	Material Description/Origin	Conductivity µS/cm	Cation Exchange Capacity
TP03	0.8 – 1.0	Clay/Residual	560	39
TP08	0.6 – 0.8	Clay/Residual	200	20
TP13	1.0 – 1.5	Clay/Residual	320	32
TP17	0.8 – 1.0	Clay/Residual	170	35
TP19	0.6 – 0.8	Clay/Residual	76	13
TP23	0.6 – 1.0	Sandstone/Rock	200	14

The laboratory test results are attached in Appendix D.

9 Geotechnical Discussion and Recommendations

9.1 General

The subsurface profile encountered in the test pits generally comprised firm to very stiff clay/sandy gravelly clay residual soils overlying sandstone rock.

9.2 Slope Stability

No evidence of slope instability (i.e. landslip, etc.) was observed within the site, which is consistent with the gently sloping landforms across most of the site. Therefore, it is considered that hillside instability does not impose significant constraints on the proposed site development. A stability hazard map has not been prepared, as no significant stability hazards were identified within the site.

9.3 Aggressivity

Based on the aggressivity test results, it is concluded that the soil conditions are non-aggressive for both steel and concrete piles as per AS2159:2009 Piling Design and Installation. It should be noted that for cast in-situ piles in soils under the water table (if encountered), concrete with a minimum compressive strength of 32MPa should be used.

9.4 Preliminary AS2870-2011 Site Classification

In accordance with AS2870-2011, “Residential Slabs and Footings - Construction” a class P site classification is appropriate for this site due to abnormal moisture conditions created by the presence of existing rural residential dwelling and small to large size trees.

The designing engineer should recognise that the majority of natural soil encountered on this site result in a Class M (moderately reactive) in areas of natural medium plasticity clays and shallow rock or Class H1 and H2 (highly reactive) in areas of deep high plasticity natural clays. It is anticipated that the characteristic surface movement under normal moisture condition may range from 40mm to 75mm.

It should be noted that in majority of samples the liquid limit ranging from 37% to 53% and linear shrinkage varying from 10.5% to 16.0%. However, in one sample the liquid limit and linear shrinkage was recorded higher as compared to the other samples. The liquid limit of this sample was recorded 89% and linear shrinkage was 23.5%. It is recommended that during the bulk cut/fill earthworks such high plasticity soils should be excavated and placed in deeper fill areas otherwise site classification in such soils could be worsen than Class H2 (highly reactive).

Placement of further reactive fill may increase the severity of classifications. Therefore, advice should be sought if fill earthworks exceeding about 0.4m depth is to be carried out on site to verify that the classification provided in this report remains valid.

The above recommendations are provided on the assumption that the performance expectations described in AS 2870 – 2011 are acceptable and future site maintenance accord CSIRO BTF -18 a copy of which is attached in Appendix F.

9.5 Removal of Dams

Three small to medium size dams were observed on site at the time of investigation. It is understood that this dam will be required to be decommissioned and desilted prior to earthworks operations commencing. The following methodology should be followed in the preparation process:

- Dewater all dams;
- Desilt and spread saturated and overly silty material in a designated stripped area separate to the dam (separating oversize and organic material) and allow sufficient time to dry;

- Once dry, assess the excavated material for suitability (geotechnical and environmental) for reuse in structural filling (to be undertaken by the geotechnical engineer);
- Remove all silt and sediment (and any excessively soft and compressible zones) from the dam base and surrounding dam batters, ensuring that excavation batters do not exceed the recommended values provided in *Section 9.8 Temporary Batter Slopes* of this report;
- Remove dam walls and associate uncontrolled filling and stockpile separately. This material will also need to be assessed by a geotechnical engineer for geotechnical and environmental suitability for reuse as structural filling;
- Follow site preparation procedures discussed in Section 9.7 Site Preparation and earthworks of this report. Ensure that a test roll is conducted in the presence of a geotechnical engineer in order to identify excessively weak subgrade or compressible zones; and
- Once approved, filling can be commenced with layer thickness, maximum particle size, compaction and moisture content to be in accordance with the requirements of Section 9.7 Site Preparation and earthworks of this report.

9.6 Groundwater Control During Excavation

Based on the investigation completed to date, it is anticipated that the groundwater may not be encountered during the excavation up to the termination/refusal depth of the test pits. However, if some seepage encountered during the excavation, then it may be controlled by conventional sump and pump dewatering system during construction.

It should be noted that groundwater levels are affected by climatic conditions, seasonal changes and soil permeability and will therefore vary with time.

9.7 Site Preparation and Earthworks

9.7.1 Excavation Characteristics

The depth of excavation to achieve the proposed design levels will vary across the site due to variations in existing surface levels.

Based on the subsurface profile encountered up to the termination/refusal depth of the test pits, the excavation below the existing surface grade is expected to be through firm to very stiff residual clay/sandy gravelly clay and then extremely to distinctly weathered sandstone rock. Excavation of such soils should be readily achieved using conventional earthmoving equipment, possibly with the assistance of light rock hammering or ripping in the upper weathered rock sequence (if rock encountered).

The excavation of medium to high strength rock (if encountered) would require moderate to heavy ripping with large bulldozers and the use of large hydraulic rock hammers for the bulk of the excavation. However, the use of such equipment should be limited due to the potential for excessive vibration transmitting across the site boundaries. Vertical rock excavation may require diamond-tipped rotary rock saws or milling heads along site boundaries to reduce vibrations and minimise over-break.

Excavation for footings and trenches in medium strength rock (if encountered) will also require the use of large hydraulic rock hammers together with rotary rock saws or milling heads.

It is recommended that a trial excavation with smaller equipment be carried out to assess vibration generated prior to bulk excavation. Vibration monitoring should be carried out by engaging an experienced consultant during the trial and in bulk excavation.

9.7.2 Subgrade Preparation

Following stripping and excavation to design levels, the subgrade should be proof rolled with at least eight passes of a static (non-vibratory) smooth drum roller of at least 12 tonnes deadweight. The final pass of proof rolling should be carried out under the direction of an experienced geotechnical engineer for the detection of unstable or soft areas.

Subgrade heaving during proof-rolling may occur in areas where the clays have become ‘wet' and should be expected in areas of poorly compacted fill. Heaving areas should be locally removed to a stable base and replaced with engineered fill, as outlined below in *Section 9.7.3 Engineered Fill* of this report.

If soil softening occurs after rainfall periods, then the clay subgrade should be over-excavated to below the depth of moisture softening and replaced with engineered fill. If the clay subgrade exhibits shrinkage cracking, then the surface should be watered and rolled until the shrinkage cracks are no longer evident.

Engineered fill must be used where site levels need to be raised.

9.7.3 Engineered Fill

From a geotechnical perspective, the excavated residual soils and sandstone rock encountered up to the termination/refusal depth of test pits should be suitable for re-use as engineered fill, given it is ‘clean’, free of organic matter, contain a maximum particle size of 75mm and is approved by an environmental consultant to use on a residential development site.

Engineered fill comprising the excavated above-mentioned material should be compacted in maximum 200mm thick loose layers using a minimum 12 tonne deadweight padfoot roller to the following density and moisture ratios:

- Below the proposed buildings: strictly between 98% and 102% of SMDD and at a moisture content within 2% of SOMC;
- Below landscaped areas: to a density ratio of at least 95% of SMDD and at a moisture content within 2% of SOMC;

Where subgrade preparation and engineered fill placement will be required within about 15m of any nearby buildings and retaining walls then it would need to be carried out at the commencement of works using vibration monitors affixed onto the building(s) to assess the exclusion zone width where static rolling would need to be completed.

9.7.4 Edge Compaction

In order to achieve adequate edge compaction where fill platforms are proposed, we recommend that the outer edge of each fill layer extend a horizontal distance of at least 1m beyond the design geometry. The roller must extend over the edge of each placed layer in order to seal the batter surface. On completion of filling, the excess under-compacted edge fill should be trimmed back to the design geometry.

9.7.5 Service Tranches

Backfilling of service trenches must be carried out using engineered fill in order to reduce post construction settlements. Due to the reduced energy output of the rollers that can be placed in trenches, backfilling should be carried out in maximum 150mm thick loose layers and compacted using a trench roller, a pad foot roller attachment fitted to an excavator, and/or a vertical rammer compactor (also known as a ‘Wacker Packer’). Due to the reduced loose layer thickness, the maximum particle size of the backfill material should also reduce to 100mm. The compaction specifications provided above are applicable. This is particularly important below any stormwater pipes where lack of compaction could lead to localised settlement and linear depressions over the trenches.

9.7.6 Earthworks Inspection and Testing

Density tests should be regularly carried out on the engineered fill to confirm the above specifications are achieved, as outlined below:

- The frequency of density testing for general engineered fill should be at least one test per layer per 1000m² or one test per 200m³ distributed reasonably evenly throughout the full depth and area, or 3 tests per visit, whichever requires the most tests (assumes maximum 300mm thick loose layers);
- The frequency of density testing for trench backfill should be at least one test per two layers per 40 linear metres (assumes maximum 150mm thick loose layers), with each test fully penetrating both layers.

Engineered fill to support any building loads must be placed under Level 1 inspection and testing. Level 2 testing of fill compaction is considered appropriate for pavement construction, including for the trench backfill.

9.8 Temporary Batter Slopes

The requirements for the excavation support will be governed by the geotechnical conditions and occupational health and safety requirements. The current NSW Work Cover code of practice for construction works/excavations requires that excavations in soil deeper than 1.5m must be stabilised by retaining structures. Also, if the excavations are to extend below the zone of influence of any nearby footings, then the proposed excavations are to be retained prior to excavation.

Based upon our past experiences, the following maximum batter slopes in Table 7 are recommended for the design of temporary and permanent cuts of up to 2.5m depends upon the surface level.

Table 7: Recommended Maximum Batter slopes for Exposed Material

Material	Temporary Batter Slope (H:V)	Permanent Batter Slope (H:V)
Unit 2a and 2b - Residual clay soils	1.5:1	3:1
Unit 3 - Sandstone rock	1.25:1	1.5:1
Notes: Any temporary cuts in soils should be covered to maintain the natural moisture		

The above safe batter is based on the assumption that all surcharge and footing loads are kept well clear of the excavation perimeter. As a guide, surcharge loadings should be no closer than 2.5H from the top of any batter or the face of any excavation (including footing excavation), where H is the vertical height in meters of the batter or depth of the excavation.

Steeper batter angles may be adopted following approval from a suitability experienced geotechnical engineer, and adoption of an inspection regime by a qualified geotechnical engineer. All vertical excavations to be avoided during periods of predicted heavy or prolonged rainfall. Inspections are to be completed by this office following any of the below events during construction:

- Following rainfall events in excess of 30mm over a 24-hour period.
- At any sign of instability including but not limited to:
  - Water seepage through the excavation face;
  - Loose/very soft material observed at the face of the excavation;
  - Tension cracks observed at the surface;

Excavations adjacent to existing structures, property boundaries or services (where batters cannot be achieved during horizontal distance constraints) are to be retained prior to excavation via use of an in-situ retaining wall system (e.g. non-contiguous pile wall).

9.9 Retention Design Parameters

It is suggested that design of permanent retaining structures be based on an average bulk unit weight for the retained material of 19kN/m³ and on a triangular distribution. In order to maximise rigidity of these walls, 'at rest' (K_o) earth pressure conditions may be considered. Earth pressure coefficients and geotechnical parameter for retaining wall design are presented in Table 8 below. Surcharge loads from the adjacent properties should be included in the wall design by multiplying vertical loads by the appropriate coefficient given in Table 8 below:

Table 8: Earth Pressure Coefficients (non-sloping crest surface)

Material	Unit Weight (kN/m³)	Ø' (in degrees)	E' (MPa)	Earth Pressure Coefficient		
				K_0	K_a	K_p
Residual Clay	18	26	20	0.5	0.39	2.56
Sandstone Class V	20	30	50	0.50	0.33	3.00

Note:

1. Ø' - angle of internal soil friction; E' – long term Young's modulus, N/A – No geotechnical parameters have been assigned to manmade fill layers due to the absence of records;
2. K_0 - coefficient of earth pressure at rest, K_a - coefficient of active earth pressure, K_p - coefficient of passive earth pressure.
3. The estimated values of K_0 are based on initial conditions before the construction of the perimeter retention system.
4. The retaining wall designer must adopt the above set of K_a and K_p parameters relevant to the actual construction method and structure type adopted.
5. The above parameters are based on the condition of a horizontal ground surface behind the retaining structure. Applicable surcharge loads behind the wall must also be considered in the design.
6. Inferred from AS 4678.

Retaining structures should be designed in accordance with AS 4678-2002 "Earth Retaining Structures" or an alternate approved factor of safety approach. Should any fill be placed against the permanent retaining wall after construction, it is expected that the compaction induced pressures will be much greater than the above active earth pressures. The compaction equipment used to compact backfill behind the wall must be carefully selected and preferably light-weight compaction equipment should be used. The load on the retaining wall due to compaction equipment may be estimated from Figure J5 in AS4678-2002 "Earth Retaining Structures".

It is noted that some ground movement will occur behind temporary or permanent retaining walls. By definition, movement of the wall must occur to fully mobilise the active and passive earth pressure coefficients provided in Table 8 above. The extent of this movement is dependent on the height of retaining, type of wall selected and construction methodology. This must be considered during the design and construction of the retaining walls to ensure adjacent facilities are not adversely affected.

Application of hydrostatic pressure should not be ignored unless a permanent drainage system of the ground behind the walls is installed. We advise all wall drainage to comprise a proper subsoil drainage designed by an experienced groundwater engineer.

9.10 Footings

For high level footings founded in engineered fill placed under Level 1 control to the specification in *Section 9.7 Site Preparation and Earthworks* above, which are not underlain by any uncontrolled fill, or natural clayey soils of at least very stiff strength, an allowable bearing pressure of 100kPa may be adopted for footings embedded at least 0.5m below the surrounding ground level, provided the movements associated with shrink swell reactivity of the underlying soils can be accommodated.

The proposed buildings must be designed to accommodate shrink swell movements as discussed above. We note that the effects of differential movements associated with the reactive soils would be reduced where pavements extend around the entire perimeter of the buildings. Planters, gardens or grassed areas immediately adjacent to the building should be avoided for buildings founded on high level footings as they allow for the ingress of moisture and exacerbate reactive movements.

We recommend that all high-level footings be excavated, cleaned, inspected and poured with minimum delay to avoid either wetting or drying of the foundation. If delays in pouring concrete are anticipated, we recommend that the base of the footings be protected with a blinding layer of concrete of at least 75mm thickness. Water should be prevented from ponding in the base of footing excavations as this will tend to soften the foundation material, resulting in further excavation and cleaning being required.

9.11 Pile Foundation

Pile foundations should be used to support any part of the proposed structure to transfer proposed loads to the more competent subsurface ground units at depth accommodating concentrated compression or tension loads below to mitigate any predicted differential foundation settlement issues.

A range of pile foundation options for this site are available, the suitability of which is dictated by site location, ground conditions, nature of the surrounding environment, local availability, programme, plant access and cost. Typical pile foundation options include:

- Continuous Flight Auger (CFA) concrete;
- Bored Piles;

Based on the ground conditions, location of the site with respect to the surrounding built up environment and local market availability, it is expected that bored piles may be a preferred option for this project. Recommended bearing pressures and modulus values for the range of possible foundation materials encountered in test pits at the site are presented in Table 9. These parameters apply to the design of socketed bored piers.

Table 9: Summary of Pile Design Parameters

Recommended Parameters for Foundation Design

Foundation Stratum	Rock Classification	Allowable bearing pressure (kPa)	Allowable compressive socket side shear (kPa)[1]	Design Young's modulus (MPa)
Sandstone	Class V	600	40	50

Notes:

1. End Bearing pressure to cause settlement of <1% of minimum footing dimension.
2. [1]Clean sockets of roughness category R2 or better (Walker and Pells, 1998); values must be reduced if smear is not removed.
3. Shaft adhesion applicable for the design of bored piers, uncased over rock socket length, where adequate sidewall cleanliness and roughness achieved.

The foundation design parameters given in the Table 9 assume that footings are socketed at least 0.6m into rock but it must be verified by the design engineer. It is recommended that the foundation excavations (piles) are clean and free of loose debris, with pile sockets free of smear and adequately rough immediately prior to concrete placement.

Bored piles should be cleaned and inspected and approved by a geotechnical consultant for the adequacy of the bearing and socket depths prior to concreting. If groundwater encountered during the drilling of bored piles, then temporary steel casing may require preventing hole collapse in clay.

Foundation proportioned on the basis of the above parameters would be expected to experience total settlements of less than 1% of the footing width (or pile diameter) under the applied Working (i.e Serviceability) Load, with differential settlements between adjacent columns expected to be less than half of this value.

9.12 Pavement Design Parameters

Five (5) CBR samples were collected for the assessment of strength of the subgrade. CBR value of residual clay samples collected from the test pits (TP01, TP07, TP09, TP14 and TP18) ranged from 2.0% to 7.0%. The CBR test result reports are attached in Appendix D.

Subgrade material at the tested locations comprises high plasticity residual clay. Subgrade material was assessed to be about 2% wet to 6% dry of Standard Optimum Moisture Content (SOMC) at the time of testing.

The natural subgrade material of three samples from TP09, TP14 and TP18 recorded a swell ranging from 2.0% to 3.5%. There is a possibility that during the boxing of roads the existing subgrade material at some isolated location may either need to be removed and replaced or stabilised to improve the subgrade properties to reduce shrinkage/swelling. CG recommends the subgrade should be inspected by a geotechnical consultant after preliminary boxing to identify stabilisation requirements.

For the proposed, provided the subgrade has been prepared in accordance with recommendations described in *Section 9.7.2 Subgrade Preparation* above, a CBR value of 3% can be adopted for design, or, a short term Young's Modulus of 30MPa.

We recommend that all base course materials for flexible pavements and sub-base materials for rigid pavements comprise DGB20 in accordance with RTA QA Specification 3051 unbound base. The DGB20 material should be compacted in maximum 200mm thick loose layers using a large smooth drum roller to at least 98% of Modified Maximum Dry Density (MMDD). Adequate moisture conditioning to within 2% of Modified Optimum Moisture Content (MOMC) should be provided during placement. For rigid pavements a recycled DGB20 product would be considered appropriate.

We further recommend that all sub-base materials for flexible pavements, rigid pavements, and floor slabs comprise DGS40, DGS20 or DGB20 in accordance with RTA QA Specification 3051. Recycled materials may be used provided they conform to the specification requirements of 3051. If the recycled materials contain brick or ceramic fragments, it is highly unlikely that they will conform to the specification requirements. If a recycled subbase is adopted, then it must be overlain by a minimum thickness of 150mm of quarried (non-recycled) base to limit the potential for reflective cracking of the asphaltic concrete which can occur when recycled materials recement. The subbase material should be compacted in maximum 200mm thick loose layers using a large smooth drum roller to at least 98% of MMDD. Again, adequate moisture conditioning to within 2% of MOMC should be provided during placement .

The final pavement material and compaction specification must be determined by the pavement designer once the traffic loading and location of the proposed roads are confirmed.

Density tests should be carried out on the granular pavement materials to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per 500m2; three tests per lot and three tests per visit, whichever requires the most tests. Level 2 testing of fill compaction in accordance with AS3798-2007 would be considered acceptable for the pavement layers. The geotechnical testing authority (GTA) should be directly engaged by Client.

Subsoil drains should be provided below the perimeter of the proposed pavements, including any internal planters etc. with invert levels at least 200mm below subgrade level. The drainage trenches should be excavated with a uniform longitudinal fall to appropriate discharge points so as to reduce the risk of water ponding. The subgrade should be graded to promote water flow towards the subsoil drains. Discharge from the subsoil drains should be piped to the stormwater system.

10 Further Inspection

It is recommended that the following review/inspections be undertaken during the construction stage:

- All the footings should be cleared of debris, softened materials and designed by a qualified professional Structural Engineer and should be inspected and approved by a Structural or Geotechnical Consultant prior to pouring of concrete.
- Temporary and permanent support design should be approved by an experienced consultant.
- Structural drawings for footings should be reviewed and approved by an experienced person.
- All footings must be inspected and approved by an experienced Geotechnical Engineer prior to pouring concrete.
- All earthworks including proof rolling inspections, density testing of all engineered fill should be carried out under the geotechnical supervision.
- In the event soil conditions encountered differ significantly from those described within this report.
- If project design is altered significantly from drawings reviewed and outlined or project described within this report.
- Any excavations exceeding 1.5m depth should be inspected by an experienced person to assess its stability.
- To confirm founding materials and allowable bearing pressures.

11 Reference

1. AS1726 - 2017, “Geotechnical Site Investigation”.
2. AS2870 - 2011, “Residential slabs and footings”.
3. AS2159-2009, “Piling – Design and installation”.
4. AS3798 – 2007, “Guidelines on earthworks for commercial and residential developments”.
5. AS4678 – 2002, “Earth-retaining structures”.
6. NSW Environment & Heritage eSPADE web application.
7. Forbes 1:250,000 Geological Map Geological Series Sheet S155-7 Second Edition 2000 from Geological Survey of NSW
8. HB 160 – 2006 Soils testing Reconfirmed 2016 Standards Australia.

12 Closure

This report has been prepared for Sydney Environmental Group Pty Ltd in accordance with CG's proposal dated 18 June 2023 (Ref. QU23-0235 Rev 1) under CG's Terms of Engagement.

The report is provided for the exclusive use of Sydney Environmental Group Pty Ltd for the specific development and purpose as described in the report. The report may not contain sufficient information for developments or purposes other than that described in the report.

The information in this report is considered accurate at the date of issue with regard to the current conditions of the site. The conclusions drawn in the report are based on interpolation between test pits. Conditions can vary between test locations that cannot be explicitly defined or inferred by investigation.

The report, or sections of the report, should not be used as part of a specification for a project, without review and agreement by CG, as the report has been written as advice and opinion rather than instructions for construction.

The report must be read in conjunction with the attached Information Sheets and any other explanatory notes and should be kept in its entirety without separation of individual pages or sections. CG cannot be held responsible for interpretations or conclusions from review by others of this report or test data, which are not otherwise supported by an expressed statement, interpretation, outcome or conclusion stated in this report. In preparing the report CG has necessarily relied upon information provided by the client and/or their agents.

This report has been prepared to advise on causes of distress and to suggest methods of remediation and should not be used for any litigation matters as the scope of work did not include such litigation objectives.

This report must be read in conjunction with the attached Information Sheets and any other explanatory notes.

We trust these comments are sufficient to meet your present requirements. Please do not hesitate to contact the undersigned should you have any queries.

For and on behalf of
Core Geotech Pty Ltd

Report prepared by:

Vishnu Inturi
Geotechnical Engineer
B.Tech (Civil) ME (Civil)

Reviewed and Authorised by:

Raj Singh
Principal Geotechnical Engineer
MIEAust CPEng NER
(Membership No. 3428360)

Appendix A
Information About this Report

Information About This Report

Limitations

Scope of Services: The report has been prepared in accordance with the scope of services set out in CG's Proposal under CG's Terms of Engagement, or as otherwise agreed with the client. The scope of services may have been limited and/or amended by a range of factors including time, budget, access and site constraints.

Specific Purpose: The report is provided for the specific development and purpose as described in the report. The report may not contain sufficient information for developments or purposes other than that described in the report.

Currency of Information: The information in this report is considered accurate at the date of issue with regard to the current conditions of the site.

Reliance on Information: In preparing the report CG has necessarily relied upon information provided by the Client and/or their Agents. Such data may include surveys, analyses, designs, maps and plans. CG has not verified the accuracy or completeness of the data except as stated in this report.

Copyright and Reproductions: The contents of this documents are and remain the intellectual property of CG. This document should only be used for the purpose for which it was commissioned and should not be used for other projects or by a third party. This report shall not be reproduced either totally or in part without the permission of CG. Where information from this report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimise the likelihood of misinterpretation.

Construction Specifications: Unless otherwise stated, the report, or sections of the report, should not be used as part of a specification for a project, without review and agreement by CG.

Report Should Not be Separated: The report must be read in conjunction with the attached information Sheets and any other explanatory notes and should be kept in its entirely without separation of individual pages or sections.

Review by Others: CG cannot be held responsible for interpretation or conclusions from review by others of this report or test data, which are not otherwise supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

GENERAL NOTES

Geotechnical Reporting: Geotechnical reporting relies on the interpretation of factual information based on judgment and opinion and is far less exact than other engineering or design disciplines. Geotechnical reports are for a specific purpose, development and site as described in the report and may not contain sufficient information for other purposes, developments or sites (including adjacent sites) other than that described in the report.

Subsurface Conditions: Subsurface conditions can change with time and can vary between test locations. For example, the actual interface between the materials may be far more gradual or abrupt than indicated and contaminant presence may be affected by spatial and temporal patterns. Therefore, actual conditions in areas not sampled may differ from those predicted since no subsurface investigation, no matter how comprehensive, can reveal all subsurface details and anomalies. Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations can also affect subsurface conditions and thus the continuing adequacy of a geotechnical report. CG should be kept informed of any such events and should be retained to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Groundwater: Groundwater levels indicated on borehole and test pit logs are recorded at specific times. Depending on ground permeability, measured levels may or may not reflect actual levels if measured over a longer time period. Also, groundwater levels and seepage inflows may fluctuate with seasonal and environmental variations and construction activities.

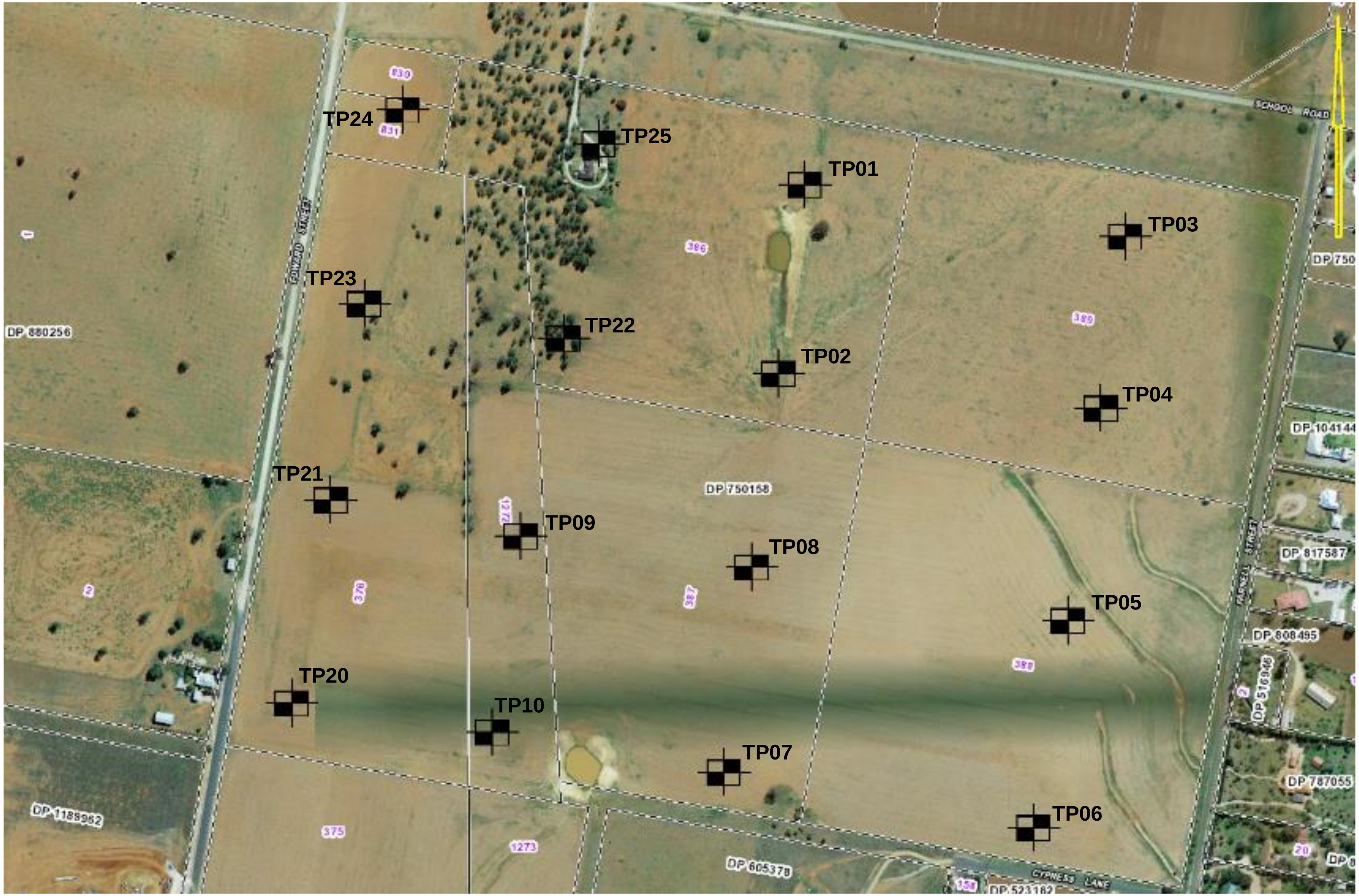
Interpretation of Data: Data obtained from nominated discrete locations, subsequent laboratory testing and empirical or external sources are interpreted by trained professionals in order to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions in accordance with any relevant industry standards, guidelines or procedures.

Soil and Rock Descriptions: Soil and rock descriptions are based on AS 1726 – 2017, using visual and tactile assessment except at discrete locations where field and / or laboratory tests have been carried out. Refer to the accompanying soil and rock terms sheet for further information.

Further Advice: CG would be pleased to further discuss how any of the above issues could affect a specific project. We would also be pleased to provide further advice or assistance including:

- Assessment of suitability of designs and construction techniques;
- Contract documentation and specification;
- Construction control testing (earthworks, pavement materials, concrete);
- Construction advice (foundation assessments, excavation support).

Appendix B
Test Pit Location Plan
Drawing No. CG23-0608-1



LEGEND:		Core Geotech	Scale: A4 - NOT TO SCALE	Client: SYDNEY ENVIRONMENTAL GROUP PTY LTD	
	APPROXIMATE TEST PIT LOCATION		Date: 10/08/2023	Project: PROPOSED RESIDENTIAL DEVELOPMENT	
		31 Lilburn Street, Tallawong NSW 2762 Tel: 0479 154 977 Email: rsingh@coregeotech.com.au	Drawing: RS	Location: SCHOOL ROAD, FORBES NSW	
			Drawing No: CG23/0608-3	Sheet: 1 of 1	**SITE PLAN**

LEGEND:	Core Geotech	Scale: A4 - NOT TO SCALE	Client: SYDNEY ENVIRONMENTAL GROUP PTY LTD
APPROXIMATE TEST PIT LOCATION		Date: 10/08/2023	Project: PROPOSED RESIDENTIAL DEVELOPMENT
	31 Lilburn Street, Tallawong NSW 2762 Tel: 0479 154 977 Email: rsingh@coregeotech.com.au	Drawing: RS	Location: SCHOOL ROAD, FORBES NSW
		Drawing No: CG23/0608-4	Sheet: 1 of 1 — **SITE PLAN**

Appendix C
Test Pit Logs

Core Geotech

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TEST PIT NUMBER TP01

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED		0.0		CI	Silty CLAY, low to medium plasticity, brown, trace grass rootlets, moisture condition >plastic limit	DCP = 2 2 4	TOPSOIL
			0.3		CH	CLAY, high plasticity, red, trace fine to medium grained sand and gravel, moisture condition >plastic limit, very stiff	7 7 9 14 17 17	RESIDUAL
			1.1		CI/CH	Gravelly CLAY, medium to high plasticity, red orange, fine to medium grained gravel and sand, moisture condition <plastic limit, very stiff		
			1.5			Borehole TP01 terminated at 1.5m		

TEST PIT NUMBER TP02

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23
R.L. SURFACE
DATUM
EXCAVATION CONTRACTOR
SLOPE ---
BEARING ---
EQUIPMENT Track Mounted Excavator
TEST PIT LOCATION Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm
LOGGED BY VI
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI	Silty CLAY, low to medium plasticity, brown, trace grass rootlets, moisture condition >plastic limit	DCP = 3 3 4	TOPSOIL
			0.5 1.0		CH	CLAY, high plasticity, red grey, trace fine to medium grained sand and gravel, moisture condition >plastic limit, very stiff	6 6 12 12 12 17	RESIDUAL
			1.5		CH	CLAY, high plasticity, red orange yellow,with fine to medium grained sand and gravel, moisture condition >plastic limit, very stiff		
			2.0			Borehole TP02 terminated at 1.8m		

TEST PIT NUMBER TP03

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CH	Silty CLAY, low to medium plasticity, brown, trace grass rootlets, moisture condition >plastic limit		TOPSOIL
			0.5, 1.0, 1.5		CH	CLAY, high plasticity, red, trace fine to medium grained sand and gravel, moisture condition >plastic limit, very stiff		RESIDUAL
			2.0		CH	CLAY, high plasticity, red orange, with fine to m grained sand and gravel, moisture condition >plastic limit, very stiff		
			2.5			Borehole TP03 terminated at 2m		

TEST PIT NUMBER TP04

Core Geotech

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23
R.L. SURFACE
DATUM
EXCAVATION CONTRACTOR
SLOPE ---
BEARING ---
EQUIPMENT Track Mounted Excavator
TEST PIT LOCATION Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm
LOGGED BY VI
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CH	Silty CLAY, low to medium plasticity, brown, trace grass rootlets, moisture condition >plastic limit	DCP = 2	TOPSOIL
							2	
					CH	CLAY, high plasticity, red, trace fine to medium grained sand and gravel, moisture condition >plastic limit, stiff to very stiff	3	RESIDUAL
							4	
			0.5				5	
							7	
							7	
							8	
							7	
			1.0				7	
							5	
							5	
							5	
							4	
			1.5				5	
							5	
							5	
							5	
					CI/CH	CLAY, medium to high plasticity, red orange, with fine to medium grained sand and gravel, moisture condition >plastic limit, very stiff	4	
			2.0				3	
							3	
							4	
						Borehole TP04 terminated at 2.2m	7	
							12	
			2.5				12	
							12	

TEST PIT NUMBER TP05

Core Geotech

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23
R.L. SURFACE
DATUM
EXCAVATION CONTRACTOR
SLOPE ---
BEARING ---
EQUIPMENT Track Mounted Excavator
TEST PIT LOCATION Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm
LOGGED BY VI
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Additional Observations
E	NONE ENCOUNTERED		0.0–0.2		CH	Silty CLAY, low to medium plasticity, brown, trace grass rootlets, moisture condition >plastic limit	TOPSOIL
			0.2–0.9		CH	CLAY, high plasticity, orange red, trace fine to medium grained sand, moisture condition >plastic limit, firm to very stiff	RESIDUAL
			0.9–1.2		CI	Sandy CLAY, medium plasticity, orange grey, with fine to medium grained sand and gravel, moisture condition >plastic limit, stiff to very stiff	
			1.2–1.5			SANDSTONE, extremely to distinctly weathered, fine to medium grained, grey orange, medium strength	ROCK
			1.5			Borehole TP05 terminated at 1.5m	

Samples / Tests / Remarks (DCP, per 0.1 m):

Depth (m)	DCP
0.0–0.1	DCP = 2
0.1–0.2	2
0.2–0.3	3
0.3–0.4	2
0.4–0.5	4
0.5–0.6	4
0.6–0.7	5
0.7–0.8	4
0.8–0.9	4
0.9–1.0	5
1.0–1.1	4
1.1–1.2	9
1.2–1.3	+12 Double bounce

Depth scale: 0.5, 1.0, 1.5, 2.0

TEST PIT NUMBER TP06

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 3	TOPSOIL
			0.5		CH	CLAY, high plasticity, red, trace fine to medium grained sand and gravel, moisture condition > plastic limit, firm to very stifff	2 4 6 9 17	RESIDUAL
						SANDSTONE, extremely to distinctly weathered, medium to coarse grained, green brown orange, medium to high strength	DB	ROCK
			1.0 1.5 2.0			Borehole TP06 terminated at 0.9m		

TEST PIT NUMBER TP07

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23
R.L. SURFACE
DATUM
EXCAVATION CONTRACTOR
SLOPE ---
BEARING ---
EQUIPMENT Track Mounted Excavator
TEST PIT LOCATION Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm
LOGGED BY VI
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 4	TOPSOIL
			0.5		CH	CLAY, high plasticity, red, trace fine to medium grained sand and gravel, moisture condition > plastic limit, stiff to very stifff	4 3 4 5 9 9 9	RESIDUAL
			1.0		CI/CH	CLAY, medium to high plasticity, red, with fine to medium grained sand and gravel, moisture condition = plastic limit, stiff to very stifff	12 12 16	
						SANDSTONE, extremely to distinctly weathered, medium to coarse grained, green brown orange, medium to high strength	+17	ROCK
			1.5 2.0			Borehole TP07 terminated at 1.4m		

TEST PIT NUMBER TP08

Core Geotech

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 4 3	TOPSOIL
			0.5		CH	CLAY, high plasticity, red, trace fine to medium grained sand and gravel, moisture condition > plastic limit, stiff to very stifff	3 4 5 9	RESIDUAL
					CI/CH	CLAY, medium to high plasticity, red, with fine to medium grained sand and gravel, moisture condition = plastic limit, stiff to very stifff	9 12 17	
			1.0			SANDSTONE, extremely to distinctly weathered, medium to coarse grained, green brown orange, medium to high strength	DB	ROCK
			1.5 2.0			Borehole TP08 terminated at 1.3m		

Core Geotech

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TEST PIT NUMBER TP09

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED		0.0–0.2		CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2, 2	TOPSOIL
			0.2–1.5		CH	CLAY, high plasticity, red, trace fine to medium grained sand and gravel, moisture condition > plastic limit, firm to very stifff	1, 1, 2, 2, 2, 2, 4, 3, 4, 5, 4, 5, 4	RESIDUAL
			1.5–2.0		CI	CLAY, medium plasticity, red, with fine to medium grained sand and gravel, moisture condition < plastic limit, stiff to very stifff	4, 6, 5, 6, 9	
			2.0			Borehole TP09 terminated at 2m	9, 12, 10, 10	

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5

TEST PIT NUMBER TP10

Core Geotech Pty Ltd
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Telephone: +61 0479 154 977

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 3	TOPSOIL
			0.5		CH	CLAY, high plasticity, red, trace fine to medium gravel, moisture condition > plastic limit, firm to stiff	2 2 3 4 5 4 3 4	RESIDUAL
			1.0 1.5 2.0		CI/CH	CLAY, medium to high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit, stiff to very stifff	5 6 7 9 9 10 9 9	
			2.5			Borehole TP10 terminated at 2m		

BOREHOLE / TEST PIT CG23-0608 TEST PIT LOGS.GPJ GINT STD AUSTRALIA.GDT 19/8/23

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TEST PIT NUMBER TP11

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 1	TOPSOIL
			0.5 1.0		CH	CLAY, high plasticity, red, trace fine to medium grained sand, moisture condition > plastic limit, firm to stiff	2 2 4 3 4 3 3 3 4 5	RESIDUAL
			1.5 2.0		CI/CH	CLAY, medium to high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit, stiff to very stifff	6 7 9 9 12 10 9 9	
			2.5			Borehole TP11 terminated at 2m	12 10	

TEST PIT NUMBER TP12

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 29/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED		0.0		CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2, 3	TOPSOIL
			0.2		CH	CLAY, high plasticity, red, trace fine to medium grained sand, moisture condition > plastic limit, firm to stiff	2, 2, 3, 2, 4, 5, 4, 3, 4, 5, 4, 6, 7	RESIDUAL
			1.5		CI/CH	CLAY, medium to high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit, very stiff to hard	9, 8, 9, 9	
			2.0			Borehole TP12 terminated at 2m		

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5

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TEST PIT NUMBER TP13

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 2 3	TOPSOIL
			0.5		CH	CLAY, high plasticity, red, trace fine to medium grained sand, moisture condition > plastic limit, firm to stiff	4 3 5 6 5 5 5	RESIDUAL
			1.0		CI/CH	CLAY, medium to high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit, very stiff to hard	9 9 12 12	
			1.5			SANDSTONE, extremely to distinctly weathered, medium to coarse grained, green brown orange, medium to high strength		ROCK
			2.0			Borehole TP13 terminated at 1.7m		

TEST PIT NUMBER TP14

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 3 2	TOPSOIL
			0.5 1.0		CH	CLAY, high plasticity, red, trace fine to medium grained sand, moisture condition > plastic limit, firm to stiff	2 2 4 5 4 4 4 4	RESIDUAL
			1.5		CI/CH	CLAY, medium to high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit, very stiff to hard	6 5 8 8 8 8 9	
			2.0			SANDSTONE, extremely to distinctly weathered, medium to coarse grained, green brown orange, medium to high strength	+12 Double bounce	ROCK
			2.5			Borehole TP14 terminated at 2m		

TEST PIT NUMBER TP15

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 4 2	TOPSOIL
			0.5 1.0 1.5 2.0		CH	CLAY, high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit, stiff to very stiff	4 4 3 4 3 4 5 7 8 7 7 7 8 9	RESIDUAL
			2.5			Borehole TP15 terminated at 2m		

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TEST PIT NUMBER TP16

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2	TOPSOIL
							2	
							1	
					CH	CLAY, high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit, stiff to very stiff	2	RESIDUAL
							4	
			0.5				4	
							5	
							4	
							5	
			1.0				4	
							4	
							7	
							8	
							8	
			1.5				8	
							8	
			2.0					
						Borehole TP16 terminated at 2m		
			2.5					

TEST PIT NUMBER TP17

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit		TOPSOIL
			0.5		CH	CLAY, high plasticity, red, trace fine to medium grained sand, moisture condition > plastic limit, stiff to very stiff		RESIDUAL
			1.0		CI/CH	CLAY, medium to high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit		
			1.5			SANDSTONE, extremely to distinctly weathered, medium to coarse grained, green brown orange, medium to high strength		ROCK
			2.0			Borehole TP17 terminated at 2m		
			2.5					

TEST PIT NUMBER TP18

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23
R.L. SURFACE
DATUM
EXCAVATION CONTRACTOR
SLOPE ---
BEARING ---
EQUIPMENT Track Mounted Excavator
TEST PIT LOCATION Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm
LOGGED BY VI
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 1 0 1	TOPSOIL
			0.5 1.0		CH	CLAY, high plasticity, red, trace fine to medium grained sand, moisture condition > plastic limit, firm to stiff	3 2 5 4 5 4 5 9 12	RESIDUAL
						SANDSTONE, extremely to distinctly weathered, medium to coarse grained, green brown orange, medium to high strength	DB	ROCK
			1.5			Borehole TP18 terminated at 1.4m		

TEST PIT NUMBER TP19

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CLIENT Sydney Environmental Group Pty Ltd

PROJECT NAME Proposed Planning Proposal

PROJECT NUMBER CG23-0608

PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23

R.L. SURFACE

DATUM

EXCAVATION CONTRACTOR

SLOPE ---

BEARING ---

EQUIPMENT Track Mounted Excavator

TEST PIT LOCATION Refer to Drawing No. CG23-0608-1

TEST PIT SIZE 400mm

LOGGED BY VI

CHECKED BY RS

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 1	TOPSOIL
			0.5		CH	CLAY, medium to high plasticity, red, trace fine to medium grained sand, moisture condition > plastic limit, firm to stiff	0 2 4 6 7 12	RESIDUAL
			1.0			SANDSTONE, extremely to distinctly weathered, medium to coarse grained, yellow brown orange, medium to high strength	DB	ROCK
			1.5			Borehole TP19 terminated at 1m		

TEST PIT NUMBER TP20

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 2	TOPSOIL
			0.5 1.0		CH	CLAY, high plasticity, red, trace fine to medium grained sand, moisture condition > plastic limit, firm to stiff	1 4 3 3 5 7 9 9	RESIDUAL
					CI/CH	CLAY, medium to high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit	12 12	
			1.5			SANDSTONE, extremely to distinctly weathered, medium to coarse grained, yellow brown orange, medium to high strength		ROCK
			2.0			Borehole TP20 terminated at 1.7m		

TEST PIT NUMBER TP21

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CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23
R.L. SURFACE
DATUM
EXCAVATION CONTRACTOR
SLOPE ---
BEARING ---
EQUIPMENT Track Mounted Excavator
TEST PIT LOCATION Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm
LOGGED BY VI
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition > plastic limit	DCP = 2 1 2	TOPSOIL
			0.5		CH	CLAY, high plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition = plastic limit	4 5 4 5 4 4	RESIDUAL
			1.0		CI	Sandy Gravelly CLAY, medium plasticity, yellow grey red, fine to medium grave and sand, moisture condition <plastic limit	5 5 12 18	
						SANDSTONE, extremely to distinctly weathered, medium to coarse grained, yellow brown orange, medium to high strength	DB	ROCK
			1.5 2.0			Borehole TP21 terminated at 1.4m		

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TEST PIT NUMBER TP22

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23
R.L. SURFACE
DATUM
EXCAVATION CONTRACTOR
SLOPE ---
BEARING ---
EQUIPMENT Track Mounted Excavator
TEST PIT LOCATION Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm
LOGGED BY VI
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition = plastic limit	DCP = 2 2	TOPSOIL
			0.5		CI	CLAY, medium plasticity, red, fine to medium grained sand, trace fine to medium gravel, moisture condition < plastic limit	10 12 14 18 19 22	RESIDUAL
			1.0			SANDSTONE, extremely to distinctly weathered, medium to coarse grained, yellow brown orange, medium to high strength		ROCK
			1.5			Borehole TP22 terminated at 1.1m		

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TEST PIT NUMBER TP23

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23
R.L. SURFACE
DATUM
EXCAVATION CONTRACTOR
SLOPE ---
BEARING ---
EQUIPMENT Track Mounted Excavator
TEST PIT LOCATION Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm
LOGGED BY VI
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI/CH	Silty CLAY, medium to high plasticity, red brown, trace grass rootlets, moisture condition = plastic limit	DCP = 2 6	TOPSOIL
			0.5		CI	Sandy CLAY, medium plasticity, red , fine to medium grained sand, moisture condition < plastic limit	5 5 9 12	RESIDUAL
			1.0			SANDSTONE, extremely to distinctly weathered, medium to coarse grained, yellow brown orange, medium to high strength	18	ROCK
			1.5			Borehole TP23 terminated at 1.1m		

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TEST PIT NUMBER TP24

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI	Silty CLAY, medium plasticity, red brown, trace grass rootlets, moisture condition = plastic limit	DCP = 2 6	TOPSOIL
			0.5		CL-CI	Sandy Gravelly CLAY, medium plasticity, orange grey, medium to coarse gravel, fine to medium grained sand, moisture condition< plastic limit	8 12 DB	RESIDUAL
						SANDSTONE, extremely to distinctly weathered, medium to coarse grained, yellow brown orange, medium to high strength		ROCK
			1.0 1.5			Borehole TP24 terminated at 0.7m		

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TEST PIT NUMBER TP25

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Planning Proposal
PROJECT NUMBER CG23-0608
PROJECT LOCATION School Road, Forbes NSW

DATE STARTED 29/6/23 **COMPLETED** 30/6/23 **R.L. SURFACE** **DATUM**
EXCAVATION CONTRACTOR **SLOPE** --- **BEARING** ---
EQUIPMENT Track Mounted Excavator **TEST PIT LOCATION** Refer to Drawing No. CG23-0608-1
TEST PIT SIZE 400mm **LOGGED BY** VI **CHECKED BY** RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
E	NONE ENCOUNTERED				CI	Silty CLAY, medium plasticity, red brown, trace grass rootlets, moisture condition = plastic limit	DCP = 2 4	TOPSOIL
			0.5 1.0		CI/CH	CLAY, medium to high plasticity, red orange grey, with fine to medium grained sand, moisture condition < plastic limit	2 4 3 5 6 7 8 9	RESIDUAL
			1.5		CI	CLAY, medium plasticity, red orange grey, with fine to medium grained sand and gravel, moisture condition < plastic limit	12 12	
			2.0			Borehole TP25 terminated at 1.7m		

Abbreviations, Notes & Symbols

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SUBSURFACE INVESTIGATION

METHOD

Borehole Logs		Excavation Logs	
AS#	Auger screwing (#-bit)	BH	Backhoe/excavator bucket
AD#	Auger drilling (#-bit)	NE	Natural exposure
B	Blank bit	HE	Hand excavation
V	V-bit	X	Existing excavation
T	TC-bit		
HA	Hand auger	**Cored Borehole Logs**	
R	Roller/tricone	NMLC	NMLC core drilling
W	Washbore	NQ/HQ	Wireline core drilling
AH	Air hammer		
AT	Air track		
LB	Light bore push tube		
MC	Macro core push tube		
DT	Dual core push tube		

SUPPORT

Borehole Logs		Excavation Logs	
C	Casing	S	Shoring
M	Mud	B	Benched

SAMPLING

B	Bulk sample
D	Disturbed sample
U#	Thin-walled tube sample (#mm diameter)
ES	Environmental sample
EW	Environmental water sample

FIELD TESTING

PP	Pocket penetrometer (kPa)
DCP	Dynamic cone penetrometer
PSP	Perth sand penetrometer
SPT	Standard penetration test
PBT	Plate bearing test
s_U	Vane shear strength peak/residual (kPa) and vane size (mm)
N*	SPT (blows per 300mm)
Nc	SPT with solid cone
R	Refusal

**denotes sample taken*

BOUNDARIES

————	Known
— — — -	Probable
....	Possible

SOIL

MOISTURE CONDITION

D	Dry
M	Moist
W	Wet
Wp	Plastic Limit
Wl	Liquid Limit
MC	Moisture Content

CONSISTENCY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard
Fb	Friable

DENSITY INDEX

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

USCS SYMBOLS

GW	Well graded gravels and gravel-sand mixtures, little or no fines
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well graded sands and gravelly sands, little or no fines
SP	Poorly graded sands and gravelly sands, little or no fines
SM	Silty sand, sand-silt mixtures
SC	Clayey sand, sand-clay mixtures
ML	Inorganic silts of low plasticity, very fine sands, rock flour, silty or clayey fine sands
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays
OL	Organic silts and organic silty clays of low plasticity
MH	Inorganic silts of high plasticity
CH	Inorganic clays of high plasticity
OH	Organic clays of medium to high plasticity
PT	Peat muck and other highly organic soils

ROCK

WEATHERING		STRENGTH	
RS	Residual Soil	EL	Extremely Low
XW	Extremely Weathered	VL	Very Low
HW	Highly Weathered	L	Low
MW	Moderately Weathered	M	Medium
DW*	Distinctly Weathered	H	High
SW	Slightly Weathered	VH	Very High
FR	Fresh	EH	Extremely High

**covers both HW & MW*

ROCK QUALITY DESIGNATION (%)

$$= \frac{\text{sum of intact core pieces} > 100\text{mm}}{\text{total length of section being evaluated}} \times 100$$

CORE RECOVERY (%)

$$= \frac{\text{core recovered}}{\text{core lift}} \times 100$$

NATURAL FRACTURES

Type

JT	Joint
BP	Bedding plane
SM	Seam
FZ	Fractured zone
SZ	Shear zone
VN	Vein

Infill or Coating

Cn	Clean
St	Stained
Vn	Veneer
Co	Coating
Cl	Clay
Ca	Calcite
Fe	Iron oxide
Mi	Micaceous
Qz	Quartz

Shape

pl	Planar
cu	Curved
un	Undulose
st	Stepped
ir	Irregular

Roughness

pol	Polished
slk	Slickensided
smo	Smooth
rou	Rough

Soil and Rock Terms

SOIL

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through the hand.
Moist	Feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist, but with free water forming on hands when handled.

For cohesive soils, moisture content may also be described in relation to plastic limit (W_P) or liquid limit (W_L). [>> much greater than, > greater than, < less than, << much less than].

CONSISTENCY

Term	c_u (kPa)	Term	c_u (kPa)
Very Soft	< 12	Very Stiff	100 - 200
Soft	12 - 25	Hard	> 200
Firm	25 - 50	Friable	-
Stiff	50 - 100		

DENSITY INDEX

Term	I_D (%)	Term	I_D (%)
Very Loose	< 15	Dense	65 – 85
Loose	15 – 35	Very Dense	> 85
Medium Dense	35 – 65		

PARTICLE SIZE

Name	Subdivision	Size (mm)
Boulders		> 200
Cobbles		63 - 200
Gravel	coarse	20 - 63
	medium	6 - 20
	fine	2.36 - 6
Sand	coarse	0.6 - 2.36
	medium	0.2 - 0.6
	fine	0.075 - 0.2
Silt & Clay		< 0.075

MINOR COMPONENTS

Term	Proportion by Mass coarse grained	fine grained
Trace	≤ 5%	≤ 15%
Some	5 - 2%	15 - 30%

SOIL ZONING

Layers	Continuous exposures
Lenses	Discontinuous layers of lenticular shape
Pockets	Irregular inclusions of different material

SOIL CEMENTING

Weakly	Easily broken up by hand
Moderately	Effort is required to break up the soil by hand

SOIL STRUCTURE

Massive	Coherent, with any partings both vertically and horizontally spaced at greater than 100mm
Weak	Peds indistinct and barely observable on pit face. When disturbed approx. 30% consist of peds smaller than 100mm
Strong	Peds are quite distinct in undisturbed soil. When disturbed >60% consists of peds smaller than 100mm

ROCK

SEDIMENTARY ROCK TYPE DEFINITIONS

Rock Type	**Definition** (more than 50% of rock consists of….)
Conglomerate	… gravel sized (> 2mm) fragments
Sandstone	… sand sized (0.06 to 2mm) grains
Siltstone	… silt sized (<0.06mm) particles, rock is not laminated
Claystone	… clay, rock is not laminated
Shale	… silt or clay sized particles, rock is laminated

STRENGTH

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	< 0.03	High	1 – 3
Very Low	0.03 – 0.1	Very High	3 – 10
Low	0.1 – 0.3	Extremely High	> 10
Medium	0.3 – 1		

WEATHERING

Term	Description
Residual Soil	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident
Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded, in water. Fabric of original rock is still visible
Highly Weathered	Rock strength usually highly changed by weathering; rock may be highly discoloured
Moderately Weathered	Rock strength usually moderately changed by weathering; rock may be moderately discoloured
Distinctly Weathered	See 'Highly Weathered' or 'Moderately Weathered'
Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh	Rock shows no signs of decomposition or staining

NATURAL FRACTURES

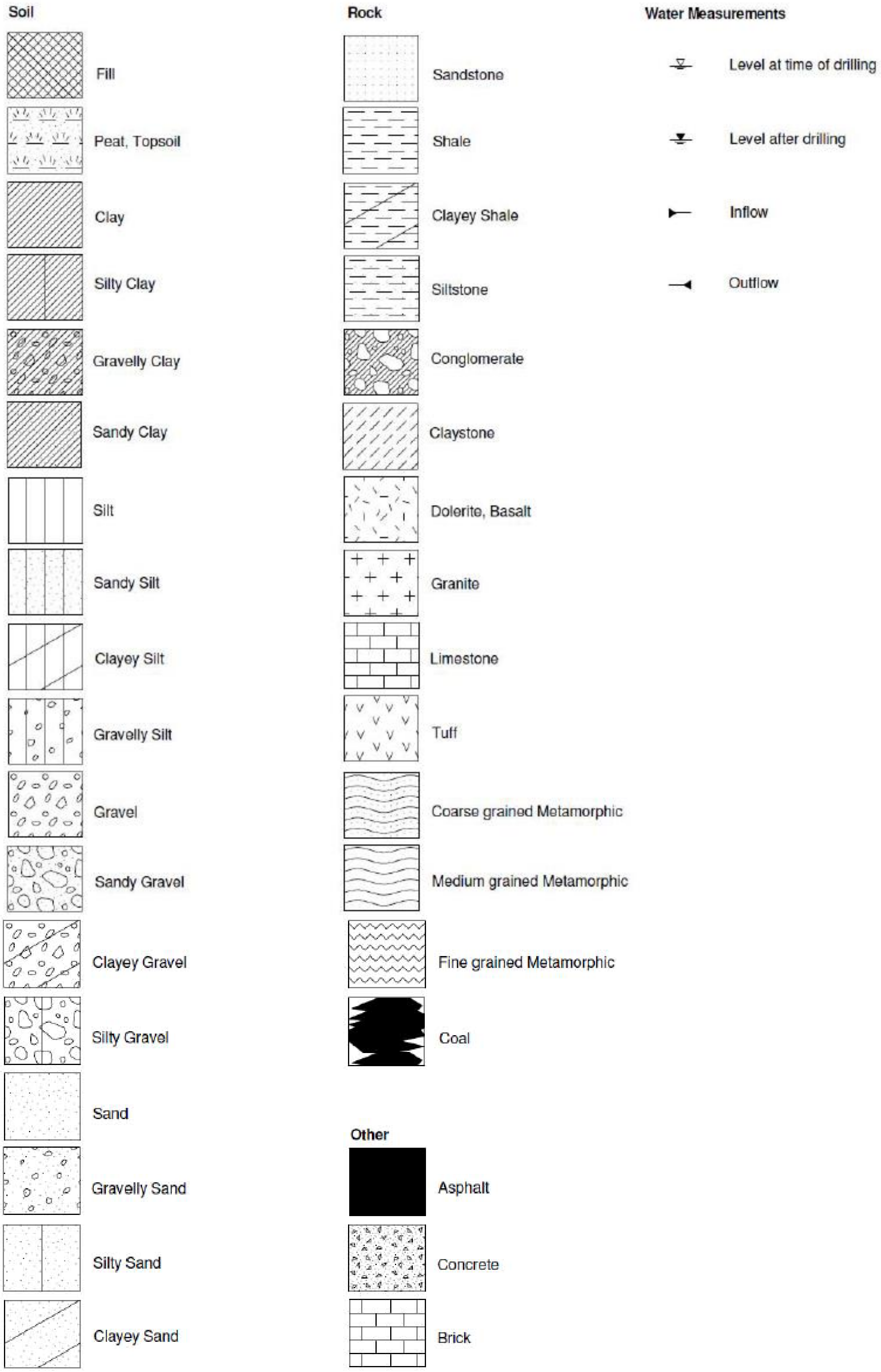
Type	Description
Joint	A discontinuity or crack across which the rock has little or no tensile strength. May be open or closed
Bedding plane	Arrangement in layers of mineral grains of similar sizes or composition
Seam	Seam with deposited soil (infill), extremely weathered insitu rock (XW), or disoriented usually angular fragments of the host rock (crushed)
Shear zone	Zone with roughly parallel planar boundaries, of rock material intersected by closely spaced (generally < 50mm) joints and /or microscopic fracture (cleavage) planes
Vein	Intrusion of any shape dissimilar to the adjoining rock mass. Usually igneous

Shape	Description
Planar	Consistent orientation
Curved	Gradual change in orientation
Undulose	Wavy surface
Stepped	One or more well defined steps
Irregular	Many sharp changes in orientation

Infill or Coating	Description
Clean	No visible coating or discolouring
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	Visible coating ≤ 1mm thick. Ticker soil material described as seam

Roughness	Description
Polished	Shiny smooth surface
Slickensided	Grooved or striated surface, usually polished
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally < 1mm). Feels like fine to coarse sandpaper

Note: soil and rock descriptions are generally in accordance with AS1726-1993 Geotechnical Site Investigations



Soil
Fill
Peat, Topsoil
Clay
Silty Clay
Gravelly Clay
Sandy Clay
Silt
Sandy Silt
Clayey Silt
Gravelly Silt
Gravel
Sandy Gravel
Clayey Gravel
Silty Gravel
Sand
Gravelly Sand
Silty Sand
Clayey Sand
Rock
Sandstone
Shale
Clayey Shale
Siltstone
Conglomerate
Claystone
Dolerite, Basalt
Granite
Limestone
Tuff
Coarse grained Metamorphic
Medium grained Metamorphic
Fine grained Metamorphic
Coal
Other
Asphalt
Concrete
Brick
Water Measurements
Level at time of drilling
Level after drilling
Inflow
Outflow

Appendix D
Laboratory Test Results

Material Test Report

Benchmark Geotechnical Pty Ltd
Unit 3, 39 Eddie Road Minchinbury NSW 2770
Phone: 1300 919 000
Email: matt@bmgeo.com.au

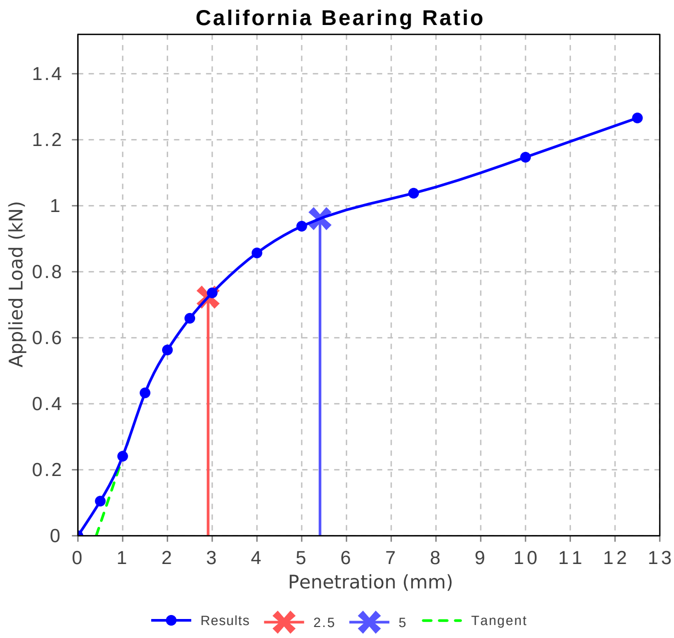
Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Hamish Barsing
Laboratory Supervisor

NATA Accredited Laboratory Number: 20634

Report Number:	**P230463-1**
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech 31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126A
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 31/07/2023
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Site Selection:	Selected by Client
Sample Location:	**TP01, Depth: 0.4 - 0.8 m**
Material:	Ruddy Brown Silty Clay trace Sand
Material Source:	In-Situ

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Tactile		
Additive Type	None		
Additive Percent (%)	0		
Maximum Dry Density (t/m^3)	1.61		
Optimum Moisture Content (%)	21.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.5		
Dry Density after Soaking (t/m^3)	1.60		
Field Moisture Content (%)	15.6		
Moisture Content at Placement (%)	21.7		
Moisture Content Top 30mm (%)	28.4		
Moisture Content Rest of Sample (%)	23.4		
Mass Surcharge (kg)	6.75kg		
Soaking Period (days)	4		
Curing Hours	91.5		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	69		
Plastic Limit (%)	20		
Plasticity Index (%)	**49**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**19.0**		
Cracking Crumbling Curling	Curling		

Material Test Report

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Date Issued:	07/08/2023
Client:	Core Geotech
	31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126C
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 28/07/2023
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Site Selection:	Selected by Client
Sample Location:	**TP03, Depth: 0.8 - 1.0 m**
Material:	Brown Silty Clay
Material Source:	In-Situ

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Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	89		
Plastic Limit (%)	20		
Plasticity Index (%)	**69**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**23.5**		
Cracking Crumbling Curling	Cracking & Curling		

Material Test Report

Report Number:	**P230463-1**
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Date Issued:	07/08/2023
Client:	Core Geotech
	31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126F
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 24/07/2023
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Site Selection:	Selected by Client
Sample Location:	**TP06, Depth: 0.3 - 0.6 m**
Material:	Dark Brown Silty Clay
Material Source:	In-Situ

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Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	53		
Plastic Limit (%)	20		
Plasticity Index (%)	**33**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**16.0**		
Cracking Crumbling Curling	Cracking		

Material Test Report

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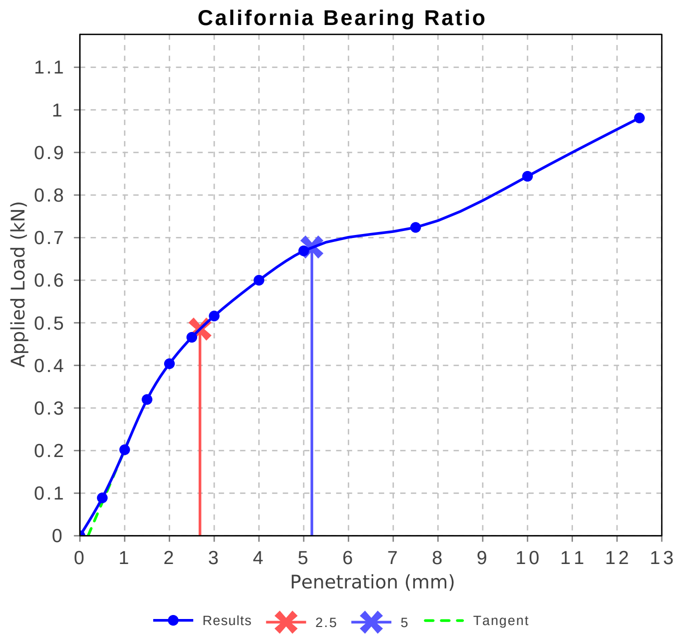
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech 31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126G
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 24/07/2023
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Site Selection:	Selected by Client
Sample Location:	**TP07, Depth: 0.4 - 0.8 m**
Material:	Brown Silty Clay
Material Source:	In-Situ

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**3.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Tactile		
Additive Type	None		
Additive Percent (%)	0		
Maximum Dry Density (t/m^3)	1.69		
Optimum Moisture Content (%)	18.0		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	102.0		
Dry Density after Soaking (t/m^3)	1.66		
Field Moisture Content (%)	15.5		
Moisture Content at Placement (%)	18.5		
Moisture Content Top 30mm (%)	24.4		
Moisture Content Rest of Sample (%)	19.0		
Mass Surcharge (kg)	6.75kg		
Soaking Period (days)	4		
Curing Hours	96.1		
Swell (%)	1.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

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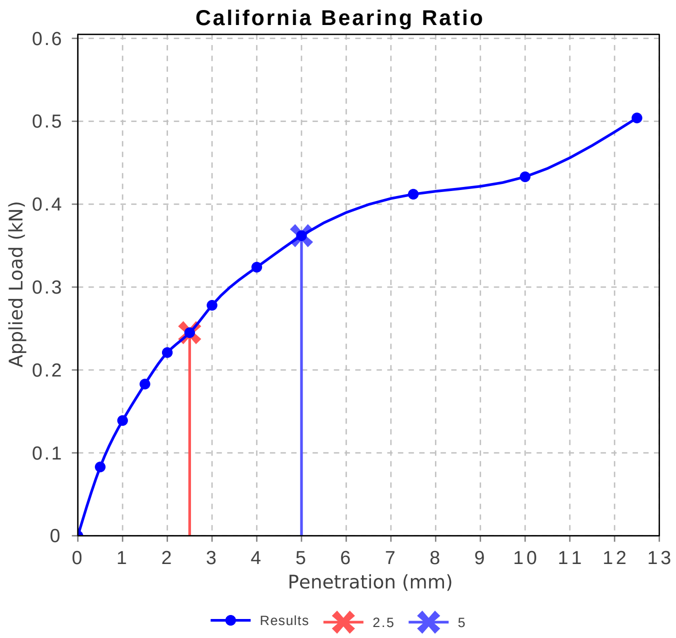
Report Number: **P230463-1**
Issue Number: 1
Date Issued: 07/08/2023
Client: Core Geotech
31 Lilburn Street, Tallawong NSW 2762
Contact: Raj Singh, 0479 154 977
Project Number: P230463
Project Name: Forbes Planning Proposal - Geotechnical
Project Location: School Road, Forbes
Client Reference: CG23-0608
Work Request: 2126
Sample Number: 23-2126I
Date Sampled: 30/06/2023
Dates Tested: 03/07/2023 - 24/07/2023
Sampling Method: Sampled by Client
The results apply to the sample as received
Site Selection: Selected by Client
Sample Location: **TP09, Depth: 0.4 - 0.8 m**
Material: Ruddy Brown Silty Clay
Material Source: In-Situ

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**2.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Tactile		
Additive Type	None		
Additive Percent (%)	0		
Maximum Dry Density (t/m^3)	1.70		
Optimum Moisture Content (%)	18.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.5		
Dry Density after Soaking (t/m^3)	1.65		
Field Moisture Content (%)	20.4		
Moisture Content at Placement (%)	18.4		
Moisture Content Top 30mm (%)	29.3		
Moisture Content Rest of Sample (%)	20.2		
Mass Surcharge (kg)	6.75kg		
Soaking Period (days)	4		
Curing Hours	92.3		
Swell (%)	3.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



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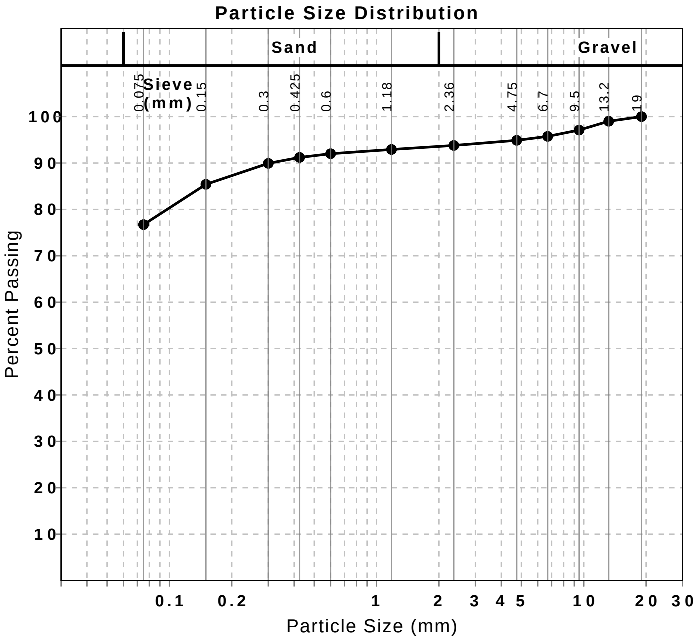
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech 31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126K
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 28/07/2023
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Site Selection:	Selected by Client
Sample Location:	**TP11, Depth: 1.5 - 2.0 m**
Material:	Ruddy Brown Silty Clay
Material Source:	In-Situ

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	**97**			2		
6.7 mm	**96**			1		
4.75 mm	**95**			1		
2.36 mm	**94**			1		
1.18 mm	**93**			1		
0.6 mm	**92**			1		
0.425 mm	**91**			1		
0.3 mm	**90**			1		
0.15 mm	**85**			5		
0.075 mm	**77**			9		



Moisture Content (AS1289.2.1.1)		Min	Max
Moisture Content (%)	19.4		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	48		
Plastic Limit (%)	16		
Plasticity Index (%)	**32**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**13.0**		
Cracking Crumbling Curling	Curling		

Material Test Report

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NATA Accredited Laboratory Number: 20634

Report Number:	**P230463-1**
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech
	31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126M
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 28/07/2023
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Site Selection:	Selected by Client
Sample Location:	**TP13, Depth: 1.0 - 1.5 m**
Material:	Ruddy Brown Silty Clay with Shale
Material Source:	In-Situ

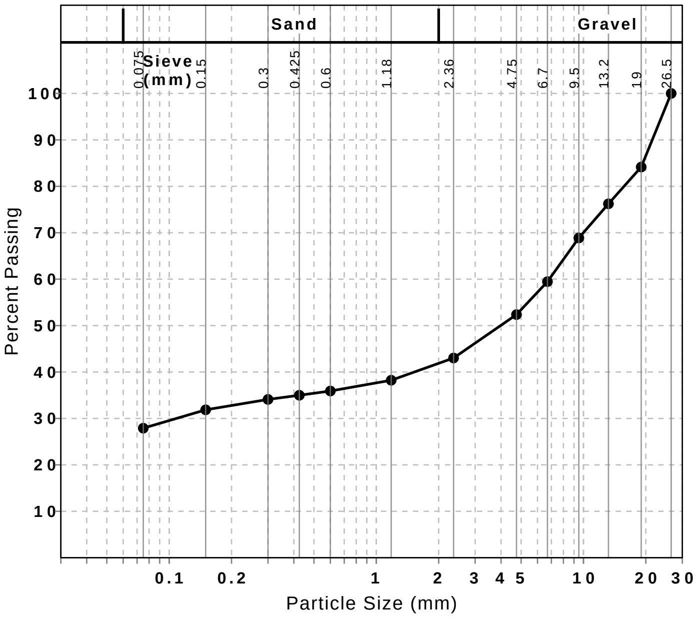
Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
26.5 mm	**100**			0		
19 mm	**84**			16		
13.2 mm	**76**			8		
9.5 mm	**69**			7		
6.7 mm	**59**			9		
4.75 mm	**52**			7		
2.36 mm	**43**			9		
1.18 mm	**38**			5		
0.6 mm	**36**			2		
0.425 mm	**35**			1		
0.3 mm	**34**			1		
0.15 mm	**32**			2		
0.075 mm	**28**			4		

Moisture Content (AS1289.2.1.1)		Min	Max
Moisture Content (%)	15.7		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	65		
Plastic Limit (%)	18		
Plasticity Index (%)	**47**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**16.0**		
Cracking Crumbling Curling	Curling		

Particle Size Distribution



Material Test Report

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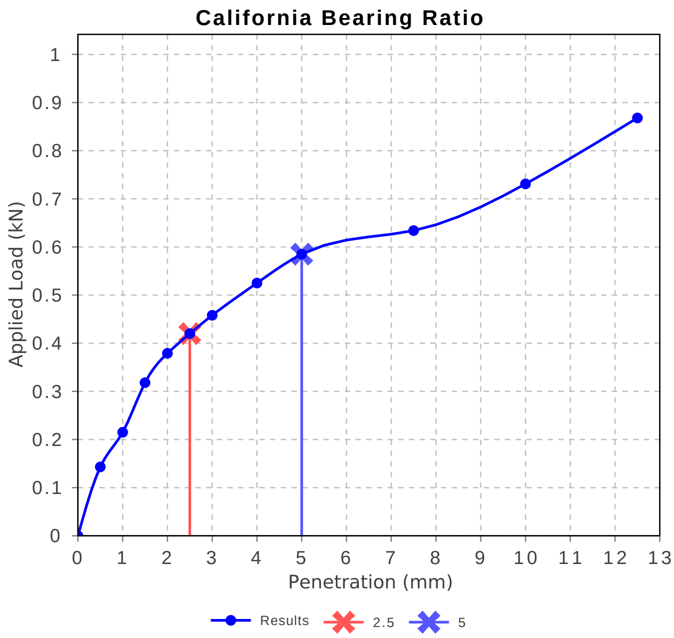
Date Issued:	07/08/2023
Client:	Core Geotech 31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126N
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 24/07/2023
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Site Selection:	Selected by Client
Sample Location:	**TP14, Depth: 0.4 - 0.8 m**
Material:	Ruddy Brown Silty Clay
Material Source:	In-Situ

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**3.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Tactile		
Additive Type	None		
Additive Percent (%)	0		
Maximum Dry Density (t/m^3)	1.66		
Optimum Moisture Content (%)	20.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.60		
Field Moisture Content (%)	20.8		
Moisture Content at Placement (%)	20.0		
Moisture Content Top 30mm (%)	29.6		
Moisture Content Rest of Sample (%)	21.2		
Mass Surcharge (kg)	6.75kg		
Soaking Period (days)	4		
Curing Hours	93.8		
Swell (%)	3.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Report Number:	**P230463-1**
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech 31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126Q
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 31/07/2023
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Site Selection:	Selected by Client
Sample Location:	**TP17 , Depth: 0.8 - 1.0 m**
Material:	Ruddy Brown Silty Clay with Shale
Material Source:	In-Situ

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Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	53		
Plastic Limit (%)	15		
Plasticity Index (%)	**38**		

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

Material Test Report

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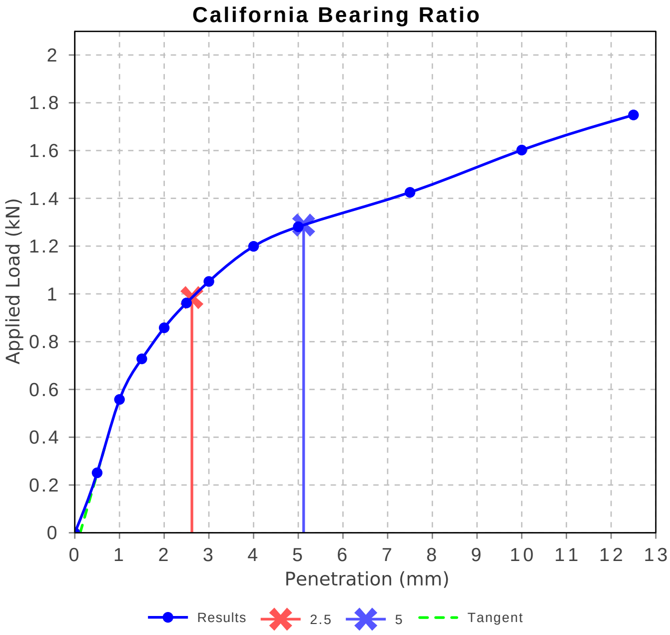
Client:	Core Geotech
	31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126R
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 24/07/2023
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Site Selection:	Selected by Client
Sample Location:	**TP18, Depth: 0.4 - 0.8 m**
Material:	Ruddy Brown Silty Clay
Material Source:	In-Situ

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**7**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Tactile		
Additive Type	None		
Additive Percent (%)	0		
Maximum Dry Density (t/m^3)	1.74		
Optimum Moisture Content (%)	18.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.70		
Field Moisture Content (%)	18.1		
Moisture Content at Placement (%)	18.1		
Moisture Content Top 30mm (%)	20.4		
Moisture Content Rest of Sample (%)	18.3		
Mass Surcharge (kg)	6.75kg		
Soaking Period (days)	4		
Curing Hours	27.0		
Swell (%)	2.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Report Number:	**P230463-1**
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech
	31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126S
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 04/08/2023
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Site Selection:	Selected by Client
Sample Location:	**TP19, Depth: 0.6 - 0.8 m**
Material:	Ruddy Brown Silty Clay
Material Source:	In-Situ

BENCHMARK GEOTECHNICAL
Benchmark Geotechnical Pty Ltd
Unit 3, 39 Eddie Road Minchinbury NSW 2770
Phone: 1300 919 000
Email: matt@bmgeo.com.au

NATA WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Hamish Barsing
Laboratory Supervisor

NATA Accredited Laboratory Number: 20634

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	37		
Plastic Limit (%)	16		
Plasticity Index (%)	**21**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**10.5**		
Cracking Crumbling Curling	Curling		

Material Test Report

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Hamish Barsing
Laboratory Supervisor

NATA Accredited Laboratory Number: 20634

Report Number: **P230463-1**
Issue Number: 1
Date Issued: 07/08/2023
Client: Core Geotech
31 Lilburn Street, Tallawong NSW 2762
Contact: Raj Singh, 0479 154 977
Project Number: P230463
Project Name: Forbes Planning Proposal - Geotechnical
Project Location: School Road, Forbes
Client Reference: CG23-0608
Work Request: 2126
Sample Number: 23-2126T
Date Sampled: 30/06/2023
Dates Tested: 03/07/2023 - 04/08/2023
Sampling Method: Sampled by Client
The results apply to the sample as received
Site Selection: Selected by Client
Sample Location: **TP20, Depth: 0.4 - 0.6 m**
Material: Ruddy Brown Silty Clay
Material Source: In-Situ

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	51		
Plastic Limit (%)	19		
Plasticity Index (%)	**32**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**13.5**		
Cracking Crumbling Curling	Curling		

Material Test Report

Report Number:	**P230463-1**
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech
	31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126V
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 04/08/2023
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Site Selection:	Selected by Client
Sample Location:	**TP22, Depth: 0.4 - 0.8 m**
Material:	Brown Silty Clay
Material Source:	In-Situ

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Hamish Barsing
Laboratory Supervisor
NATA Accredited Laboratory Number: 20634

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	42		
Plastic Limit (%)	17		
Plasticity Index (%)	**25**		

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

Material Test Report

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Accredited for compliance with ISO/IEC 17025 - Testing

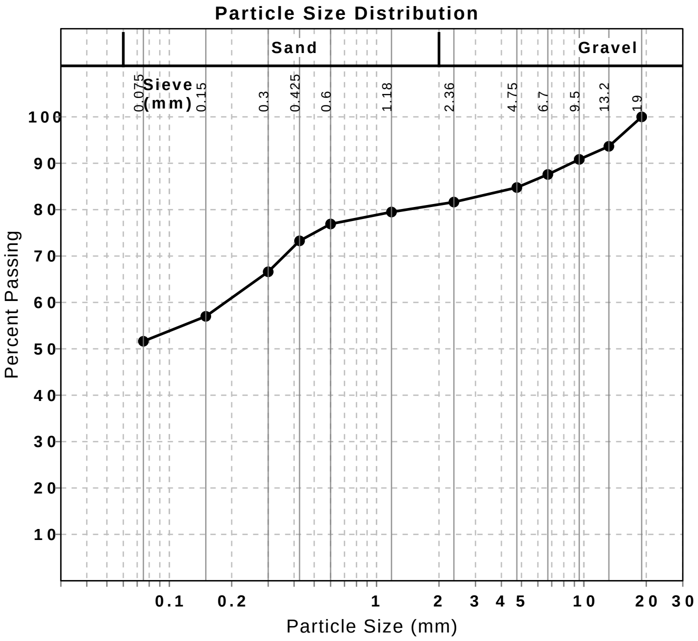
Approved Signatory: Hamish Barsing
Laboratory Supervisor

NATA Accredited Laboratory Number: 20634

Report Number:	**P230463-1**
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech 31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Sample Number:	23-2126W
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 24/07/2023
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Site Selection:	Selected by Client
Sample Location:	**TP23, Depth: 0.6 - 1.0 m**
Material:	Ruddy Brown Silty Clay with Shale
Material Source:	In-Situ

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
19 mm	**100**			0		
13.2 mm	**94**			6		
9.5 mm	**91**			3		
6.7 mm	**88**			3		
4.75 mm	**85**			3		
2.36 mm	**82**			3		
1.18 mm	**79**			2		
0.6 mm	**77**			3		
0.425 mm	**73**			4		
0.3 mm	**67**			7		
0.15 mm	**57**			10		
0.075 mm	**52**			5		

Moisture Content (AS1289.2.1.1)		Min	Max
Moisture Content (%)	9.7		



Material Test Report

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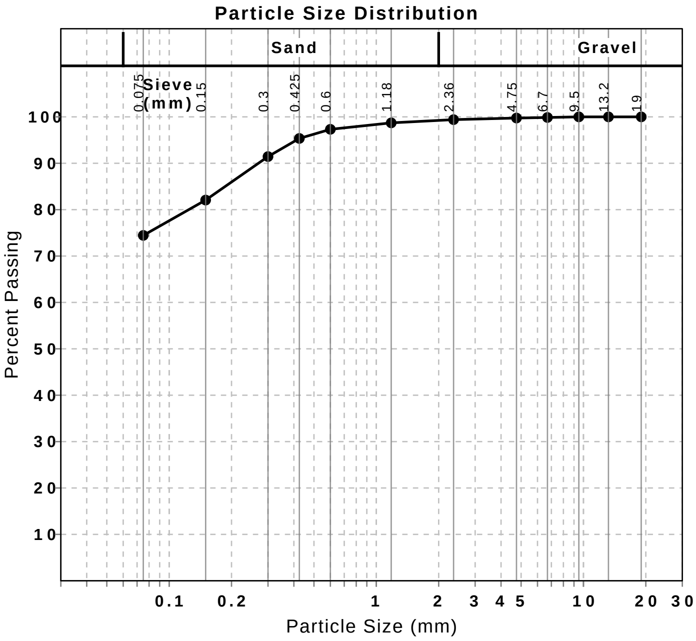
NATA WORLD RECOGNISED ACCREDITATION
Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Hamish Barsing
Laboratory Supervisor
NATA Accredited Laboratory Number: 20634

Report Number: **P230463-1**
Issue Number: 1
Date Issued: 07/08/2023
Client: Core Geotech
31 Lilburn Street, Tallawong NSW 2762
Contact: Raj Singh, 0479 154 977
Project Number: P230463
Project Name: Forbes Planning Proposal - Geotechnical
Project Location: School Road, Forbes
Client Reference: CG23-0608
Work Request: 2126
Sample Number: 23-2126Y
Date Sampled: 30/06/2023
Dates Tested: 03/07/2023 - 21/07/2023
Sampling Method: Sampled by Client
The results apply to the sample as received
Site Selection: Selected by Client
Sample Location: **TP25, Depth: 0.6 - 1.0 m**
Material: Ruddy Brown Silty Clay
Material Source: In-Situ

Particle Size Distribution (AS1289 3.6.1)						
Sieve	Passed %	Passing Limits		Retained %	Retained Limits	
19 mm	**100**			0		
13.2 mm	**100**			0		
9.5 mm	**100**			0		
6.7 mm	**100**			0		
4.75 mm	**100**			0		
2.36 mm	**99**			0		
1.18 mm	**99**			1		
0.6 mm	**97**			1		
0.425 mm	**95**			2		
0.3 mm	**91**			4		
0.15 mm	**82**			9		
0.075 mm	**74**			8		

Moisture Content (AS1289.2.1.1)		Min	Max
Moisture Content (%)	9.9		



Material Test Report

Report Number:	**P230463-1**
Issue Number:	1
Date Issued:	07/08/2023
Client:	Core Geotech
	31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P230463
Project Name:	Forbes Planning Proposal - Geotechnical
Project Location:	School Road, Forbes
Client Reference:	CG23-0608
Work Request:	2126
Date Sampled:	30/06/2023
Dates Tested:	03/07/2023 - 17/07/2023
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Site Selection:	Selected by Client
Location:	School Road, Forbes
Material:	CLAY
Material Source:	In-Situ

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Approved Signatory: Hamish Barsing
Laboratory Supervisor

NATA Accredited Laboratory Number: 20634

Moisture Content AS 1289 2.1.1

Sample Number	Sample Location	Moisture Content (%)	Min	Max	Material
23-2126A	TP01, Depth: 0.4 - 0.8 m	15.5 %	**	**	Ruddy Brown Silty Clay trace Sand
23-2126B	TP02, Depth: 0.6 - 0.8 m	13.7 %	**	**	Brown Silty Clay
23-2126C	TP03, Depth: 0.8 - 1.0 m	19.4 %	**	**	Brown Silty Clay
23-2126D	TP04, Depth: 1.0 - 1.2 m	22.4 %	**	**	Brown Silty Clay
23-2126E	TP05, Depth: 1.2 - 1.5 m	17.4 %	**	**	Light Brown Silty Clay
23-2126F	TP06, Depth: 0.3 - 0.6 m	20.1 %	**	**	Dark Brown Silty Clay
23-2126G	TP07, Depth: 0.4 - 0.8 m	15.6 %	**	**	Brown Silty Clay
23-2126H	TP08, Depth: 0.6 - 0.8 m	15.0 %	**	**	Light Brown Silty Clay with Shale
23-2126I	TP09, Depth: 0.4 - 0.8 m	20.5 %	**	**	Ruddy Brown Silty Clay
23-2126J	TP10, Depth: 0.8 - 1.0 m	20.1 %	**	**	Ruddy Brown Silty Clay with Shale
23-2126K	TP11, Depth: 1.5 - 2.0 m	19.4 %	**	**	Ruddy Brown Silty Clay
23-2126L	TP12, Depth: 1.0 - 1.5 m	19.0 %	**	**	Ruddy Brown Silty Clay
23-2126M	TP13, Depth: 1.0 - 1.5 m	15.7 %	**	**	Ruddy Brown Silty Clay with Shale
23-2126N	TP14, Depth: 0.4 - 0.8 m	19.8 %	**	**	Ruddy Brown Silty Clay
23-2126O	TP15, Depth: 0.6 - 0.8 m	15.5 %	**	**	Ruddy Brown Silty Clay
23-2126P	TP16, Depth: 1.5 - 2.0 m	21.7 %	**	**	Ruddy Brown Silty Clay
23-2126Q	TP17 , Depth: 0.8 - 1.0 m	15.8 %	**	**	Ruddy Brown Silty Clay with Shale
23-2126R	TP18, Depth: 0.4 - 0.8 m	16.2 %	**	**	Ruddy Brown Silty Clay
23-2126S	TP19, Depth: 0.6 - 0.8 m	15.4 %	**	**	Ruddy Brown Silty Clay

Sample Number	Sample Location	Moisture Content (%)	Min	Max	Material
23-2126T	TP20, Depth: 0.4 - 0.6 m	18.8 %	**	**	Ruddy Brown Silty Clay
23-2126U	TP21, Depth: 1.0 - 1.2 m	11.1 %	**	**	Brown Silty Clay
23-2126V	TP22, Depth: 0.4 - 0.8 m	14.1 %	**	**	Brown Silty Clay
23-2126W	TP23, Depth: 0.6 - 1.0 m	9.7 %	**	**	Ruddy Brown Silty Clay with Shale
23-2126X	TP24, Depth: 0.3 - 0.6 m	9.9 %	**	**	Brown Silty Clay
23-2126Y	TP25, Depth: 0.6 - 1.0 m	14.7 %	**	**	Ruddy Brown Silty Clay

Certificate of Analysis

Environment Testing

Benchmark Geotechnical Pty Ltd
146 Clifton Avenue
Kemps Creek
NSW 2178

NATA Accredited
Accreditation Number 1261
Site Number 18217

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates.

Attention:	**Hamish Barsing**
Report	**1011801-S**
Project name	PROPOSED PLANNING PROPOSAL
Project ID	P230463
Received Date	Jul 28, 2023

Client Sample ID			**TP01**	**TP03**	**TP06**	**TP08**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S23-Jl0063639**	**S23-Jl0063640**	**S23-Jl0063641**	**S23-Jl0063642**
Date Sampled			**Jun 30, 2023**	**Jun 30, 2023**	**Jun 30, 2023**	**Jun 30, 2023**
Test/Reference	LOR	Unit				
Chloride	10	mg/kg	470	-	< 10	-
Conductivity (1:5 aqueous extract at 25 °C as rec.)	10	uS/cm	410	560	27	200
pH (1:5 Aqueous extract at 25 °C as rec.)	0.1	pH Units	8.7	-	7.9	-
Resistivity*	0.5	ohm.m	25	-	380	-
Sulphate (as SO4)	10	mg/kg	140	-	20	-
Sample Properties						
% Moisture	1	%	14	16	15	14
Cation Exchange Capacity						
Cation Exchange Capacity*	0.5	meq/100g	-	39	-	20

Client Sample ID			**TP11**	**TP13**	**TP14**	**TP17**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**S23-Jl0063643**	**S23-Jl0063644**	**S23-Jl0063645**	**S23-Jl0063646**
Date Sampled			**Jun 30, 2023**	**Jun 30, 2023**	**Jun 30, 2023**	**Jun 30, 2023**
Test/Reference	LOR	Unit				
Chloride	10	mg/kg	37	-	36	-
Conductivity (1:5 aqueous extract at 25 °C as rec.)	10	uS/cm	210	320	180	170
pH (1:5 Aqueous extract at 25 °C as rec.)	0.1	pH Units	9.3	-	9.4	-
Resistivity*	0.5	ohm.m	47	-	56	-
Sulphate (as SO4)	10	mg/kg	94	-	73	-
Sample Properties						
% Moisture	1	%	17	14	18	13
Cation Exchange Capacity						
Cation Exchange Capacity*	0.5	meq/100g	-	32	-	35

Client Sample ID			TP19	TP20	TP23	TP24
Sample Matrix			Soil	Soil	Soil	Soil
Eurofins Sample No.			S23-Jl0063647	S23-Jl0063648	S23-Jl0063649	S23-Jl0063650
Date Sampled			Jun 30, 2023	Jun 30, 2023	Jun 30, 2023	Jun 30, 2023
Test/Reference	LOR	Unit				
Chloride	10	mg/kg	-	< 10	-	< 10
Conductivity (1:5 aqueous extract at 25 °C as rec.)	10	uS/cm	76	17	200	< 10
pH (1:5 Aqueous extract at 25 °C as rec.)	0.1	pH Units	-	8.0	-	7.3
Resistivity*	0.5	ohm.m	-	580	-	1900
Sulphate (as SO4)	10	mg/kg	-	13	-	< 10
Sample Properties						
% Moisture	1	%	12	17	9.0	9.6
Cation Exchange Capacity						
Cation Exchange Capacity*	0.5	meq/100g	13	-	14	-

eurofins | Environment Testing

Sample History

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

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

Description	Testing Site	Extracted	Holding Time
Chloride	Sydney	Aug 03, 2023	28 Days
- Method: LTM-INO-4270 Anions by Ion Chromatography			
pH (1:5 Aqueous extract at 25 °C as rec.)	Sydney	Aug 03, 2023	7 Days
- Method: LTM-GEN-7090 pH by ISE			
Sulphate (as SO4)	Sydney	Aug 03, 2023	28 Days
- Method: In-house method LTM-INO-4270 Sulphate by Ion Chromatograph			
Conductivity (1:5 aqueous extract at 25 °C as rec.)	Sydney	Aug 03, 2023	7 Days
- Method: LTM-INO-4030 Conductivity			
Cation Exchange Capacity	Melbourne	Aug 02, 2023	28 Days
- Method: LTM-MET-3060 Cation Exchange Capacity by bases & Exchangeable Sodium Percentage			
% Moisture	Sydney	Jul 28, 2023	14 Days
- Method: LTM-GEN-7080 Moisture			

Company Name: Benchmark Geotechnical Pty Ltd
Address: 146 Clifton Avenue
Kemps Creek
NSW 2178

Project Name: PROPOSED PLANNING PROPOSAL
Project ID: P230463

Order No.:
Report #: 1011801
Phone: 1300 919 000
Fax:

Received: Jul 28, 2023 10:02 AM
Due: Aug 4, 2023
Priority: 5 Day
Contact Name: Hamish Barsing

Eurofins Analytical Services Manager : Bonnie Pu

Sample Detail						Aggressivity Soil Set	Moisture Set	Moisture Set	Cation Exchange Capacity
Melbourne Laboratory - NATA # 1261 Site # 1254						X	X	X	X
Sydney Laboratory - NATA # 1261 Site # 18217						X	X	X	X
External Laboratory									
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**				
1	TP01	Jun 30, 2023		Soil	S23-Jl0063639	X		X	
2	TP03	Jun 30, 2023		Soil	S23-Jl0063640		X		X
3	TP06	Jun 30, 2023		Soil	S23-Jl0063641	X		X	
4	TP08	Jun 30, 2023		Soil	S23-Jl0063642		X		X
5	TP11	Jun 30, 2023		Soil	S23-Jl0063643	X		X	
6	TP13	Jun 30, 2023		Soil	S23-Jl0063644		X		X
7	TP14	Jun 30, 2023		Soil	S23-Jl0063645	X		X	
8	TP17	Jun 30, 2023		Soil	S23-Jl0063646		X		X
9	TP19	Jun 30, 2023		Soil	S23-Jl0063647		X		X
10	TP20	Jun 30, 2023		Soil	S23-Jl0063648	X		X	
11	TP23	Jun 30, 2023		Soil	S23-Jl0063649		X		X
12	TP24	Jun 30, 2023		Soil	S23-Jl0063650	X		X	

Company Name: Benchmark Geotechnical Pty Ltd
Address: 146 Clifton Avenue
Kemps Creek
NSW 2178

Project Name: PROPOSED PLANNING PROPOSAL
Project ID: P230463

Order No.:
Report #: 1011801
Phone: 1300 919 000
Fax:

Received: Jul 28, 2023 10:02 AM
Due: Aug 4, 2023
Priority: 5 Day
Contact Name: Hamish Barsing

Eurofins Analytical Services Manager : Bonnie Pu

Sample Detail	Aggressivity Soil Set	Moisture Set	Moisture Set	Cation Exchange Capacity
Melbourne Laboratory - NATA # 1261 Site # 1254	X	X	X	X
Sydney Laboratory - NATA # 1261 Site # 18217	X	X	X	X
Test Counts	6	12	12	6

Internal Quality Control Review and Glossary

General

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

Holding Times

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

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

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

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

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**µg/L:** micrograms per litre
ppm: parts per million	**ppb:** parts per billion	**%:** Percentage
org/100 mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100 mL:** Most Probable Number of organisms per 100 millilitres
CFU: Colony forming unit		

Terms

APHA	American Public Health Association
COC	Chain of Custody
CP	Client Parent - QC was performed on samples pertaining to this report
CRM	Certified Reference Material (ISO17034) - reported as percent recovery.
Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
LOR	Limit of Reporting.
LCS	Laboratory Control Sample - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
SRA	Sample Receipt Advice
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
TBTO	Tributyltin oxide (*bis*-tributyltin oxide) - individual tributyltin compounds cannot be identified separately in the environment however free tributyltin was measured and its values were converted stoichiometrically into tributyltin oxide for comparison with regulatory limits.
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	Toxic Equivalency Quotient or Total Equivalence
QSM	US Department of Defense Quality Systems Manual Version 5.4
US EPA	United States Environmental Protection Agency
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

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

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

Results <10 times the LOR: No Limit

Results between 10-20 times the LOR: RPD must lie between 0-50%

Results >20 times the LOR: RPD must lie between 0-30%

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

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

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.4 where no positive PFAS results have been reported have been reviewed and no data was affected.

QC Data General Comments

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

eurofins Environment Testing

Quality Control Results

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank									
Chloride			mg/kg	< 10			10	Pass	
Conductivity (1:5 aqueous extract at 25 °C as rec.)			uS/cm	< 10			10	Pass	
Sulphate (as SO4)			mg/kg	< 10			10	Pass	
Method Blank									
Cation Exchange Capacity									
Cation Exchange Capacity*			meq/100g	< 0.5			0.5	Pass	
LCS - % Recovery									
Chloride			%	108			70-130	Pass	
Conductivity (1:5 aqueous extract at 25 °C as rec.)			%	100			70-130	Pass	
Resistivity*			%	95			70-130	Pass	
Sulphate (as SO4)			%	105			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
				Result 1					
Chloride	S23-JI0063596	NCP	%	106			70-130	Pass	
Sulphate (as SO4)	S23-JI0063596	NCP	%	104			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
				Result 1	Result 2	RPD			
Chloride	S23-JI0063596	NCP	mg/kg	< 10	< 10	<1	30%	Pass	
Sulphate (as SO4)	S23-JI0063596	NCP	mg/kg	< 10	< 10	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25 °C as rec.)	S23-JI0063640	CP	uS/cm	560	630	12	30%	Pass	
pH (1:5 Aqueous extract at 25 °C as rec.)	S23-JI0063640	CP	pH Units	9.6	9.7	pass	30%	Pass	
Resistivity*	S23-JI0063640	CP	ohm.m	18	16	12	30%	Pass	
Duplicate									
Cation Exchange Capacity				Result 1	Result 2	RPD			
Cation Exchange Capacity*	S23-JI0062318	NCP	meq/100g	1.3	1.3	<1	30%	Pass	
Duplicate									
Sample Properties				Result 1	Result 2	RPD			
% Moisture	S23-JI0063647	CP	%	12	12	1.2	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Conductivity (1:5 aqueous extract at 25 °C as rec.)	S23-JI0063650	CP	uS/cm	< 10	< 10	<1	30%	Pass	
Resistivity*	S23-JI0063650	CP	ohm.m	1900	1500	18	30%	Pass	

Comments

Sample Integrity

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

Authorised by:

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Glenn Jackson
Managing Director

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

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

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

Appendix E
Site Photography

Photo 1: A view showing the site conditions

Photo 2: Another view showing the site conditions

Photo 3: A photo showing the material excavated from one of the test pits

Photo 4: A view showing the subsurface profile in the test pit

Photo 5: Site view looking towards north direction

Photo 6: Site view looking towards west direction from the eastern boundary

Appendix F
Foundation Maintenance Homeowner’s Guide

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO

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.

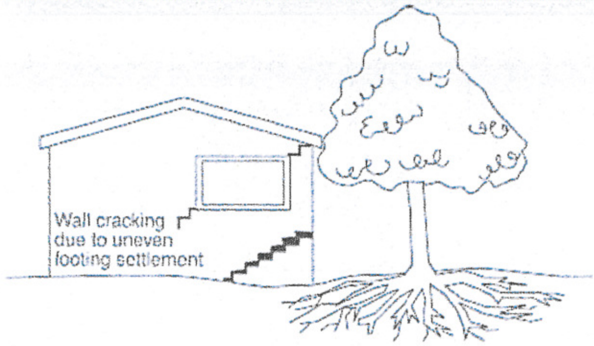
Seasonal swelling/shrinkage in clay

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

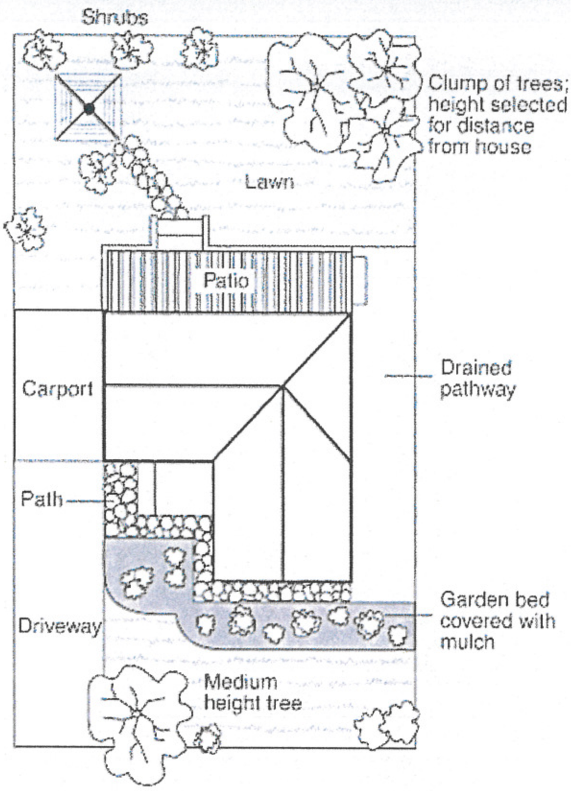
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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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