Core Geotech

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Report

Geotechnical Assessment
Proposed Light Industries, and/or Warehouse and Distribution
323-327 Warringah Road, Frenchs Forest NSW

Prepared for:

Sydney Environmental Group Pty Ltd
PO Box A1420
Sydney South NSW

Prepared by:

Core Geotech Pty Ltd

14 October 2022

Ref: CG22-0774-A Rev 0

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Appendices

1 Introduction

1.1 Project Brief

Geotech Pty Ltd (CG) was engaged by Sydney Environmental Group Pty Ltd to carry out a geotechnical investigation of a site located at 323-327 Warringah Road, Frenchs Forest NSW, which is being considered for the proposed construction of a three (3) storey commercial building, car park and landscaping area.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal letter referenced QU22-0286 Rev 0 dated 11 August 2022.

1.2 Scope of Work

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;
- 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 / precast piles/tension piles etc.) and applicable design parameters;
- Provide permanent and temporary retention options for further consideration;
- Comment on the proposed construction methodology;
- Geotechnical advice regarding site ground water conditions;
- Advice on ground construction difficulties likely to be encountered;
- Geotechnical design parameters provided in both ultimate and allowable capacity formats (loads will be required from a structural designer);
- Recommendations in terms of site preparation;

2 Site Description

2.1 Site Location

The site comprises an area of approximately 8,657m² and is located at 323-327 Warringah Road, Frenchs Forest NSW as shown on Figure 1.

Figure 1: Site Location Plan (Reference ie. Google Maps)

2.2 Landform

The current general landform, together with associated features located within and adjacent to the site is presented on the attached Site Investigation Plan as Drawing CG22-0774-1.

The site is occupied by a commercial three storey building, an open carpark and landscaping area. A block retaining wall and crib walls were observed along the northern and western boundary respectively. By visual observations, the existing structures appears to be in a reasonably good condition.

The access to the site is through a carpark from Rodborough Road. No contour survey plan was available for CG to assess the slope of the site at the time of preparing this report. However, by visual observation site has gentle downward slope of approximately 2° to 3° towards the south boundary.

The site is bounded by Warringah Road to the north, commercial buildings with car park area to the south, west and east. The surface was sealed with asphalt. The site view is shown in Appendix E.

3 Proposed Development

The current development proposal, as shown on the on the architectural drawing prepared by WMK Architecture (Ref. 21143, Dwg No A-2500, Issue C) dated 29 May 2020, is to construct a three (3) storey residential commercial building, car park and landscaping area.

4 Aerial Imagery

A review of selected historical aerial imagery of the site was undertaken as a part of the geotechnical investigation. Based on the review of the historical aerial images, the following observations were made:

- In 1955 the site is observed to be cleared of vegetation and the topsoil appear to have been disturbed;
- In 1965 and 1970, it appears that significant earthworks was carried out on site in the south west side;
- In 1971 and 1975, the area on the south of the site appeared to be filled;

The historical aerial images of year 1955, 1965, 1970, 1971 and 1975 are attached in Appendix H.

5 Investigation Scope

Following a dial before you dig search, and onsite service location, the field investigation was carried out on 24 August 2022. All fieldwork was carried out under the direction of CG in general accordance with AS 1726 specifications and logged in accordance with AS 1726 (2017) guidance. The scope of fieldwork completed was as follows:

- Completed a walkover survey of the site to assess the general landform, site conditions and adjacent structures / infrastructure;
- An on-site services search was carried out by a specialist contractor to identify the presence of any underground obstructions or hazards, prior to the field investigation program commencing;
- Nine (9) machine boreholes, denoted BH01 to BH09 were drilled using tyre mounted drilling rig fitted 110mm diameter solid flight auger attachment to a termination/refusal depths ranging from 0.8m to 3.0m, to assess the ground model through the building development. Engineering logs of the boreholes are provided in Appendix C;
- Dynamic Cone Penetration (DCP) test was carried out inside the selected boreholes to assess the relative density/consistency of in-situ soils. The refusal depth of DCP tests can also provide an indicative depth to bedrock, though we note that refusal can also occur on obstructions in fill, ‘floaters’ and other hard layers;
- Samples were collected from the auger cuttings and delivered to laboratory for further testing;

The approximate locations of the respective investigation sites referred to above are shown on the Site Investigation Plan in Drawing CG22-0473-1.

6 Laboratory Testing

Laboratory testing was carried out generally in accordance with the Australian Standards. All testing was scheduled by CG and carried out by Benchmark Geotechnical and ALS, NATA registered Testing Laboratories.

The extent of testing carried out to provide the geotechnical parameters required for this study are presented in Table 1.

Table 1: Laboratory Testing Schedule		
Type of Test	**Test Method**	**Quantity**
Atterberg Limit	AS1289 3.1.2 & 3.2.1 & 3.3.1	1
Linear Shrinkage	AS 1289 3.1.2	1
Field Moisture Content	AS 1289 2.1.1	4
Aggressivity Suite	APHA	2

Certificates for the test results outlined above are presented in Appendix D.

7 Ground Model

7.1 Soil Landscape

The NSW Environment & Heritage eSPADE web application identifies the soil landscape at the site as Disturbed Terrain (xx). The soil landscape is characterised by:

Landscape – level plain to hummocky terrain, extensively disturbed by human activity, including complete disturbance, removal or burial of soil. Local relief <10 m, slopes <30%. Landfill includes soil, rock, building and waste materials. Original vegetation completely cleared, replaced with turf or grassland.

Soil – turfed fill areas commonly capped with up to 40 cm of sandy loam or up to 60 cm of compacted clay over fill or waste materials.

Limitations – dependent on nature of fill material. Mass movement hazard, unconsolidated low wet strength materials, impermeable soil, poor drainage, localised very low fertility and toxic materials.

7.2 Published Geology

Based on review of Sydney 1:100,000 Geological map Geological Series Sheet 9130 (Edition 1) 1983 indicates that site is underlain by Middle Triassic Aged Geology Wianamatta Group (Rhs) which generally comprises shale, laminate black to dark grey shale and laminite.

Figure 2: Geology of the site (Sydney 1:100,0000 Geology Map)

7.3 Stratigraphic Units

The ground conditions encountered and inferred from the investigation were considered to be consistent with the published geology for the area and can be generalised according to the following subsurface sequences.

Table 2: Summary of subsurface profile

Layer	Description	Top to base of layer (m)
PAVEMENT	Asphaltic Concrete	
		0.05
FILL	SAND/Gravelly SAND/Sandy GRAVEL, fine to medium grained, grey, moist	
		0.3 – 2.2
	CLAY/Sandy CLAY, low to medium plasticity, red mottled grey, some fine to medium grained sand and gravel, ≥plastic limit	
		0.9 – 1.7
PROBABLE ROCK	SANDSTONE, extremely to distinctly weathered, fine to medium grained, grey white, very low to low strength	
		>2.9 - >3.0

At the time of preparing the report, CG does not have any records of the fill. Therefore, fill is assessed to be uncontrolled in accordance with AS2870-2011.

8 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.

9 Laboratory Test Results

Field Moisture Content (FMC) of samples tested ranged from 7.3% to 21.2% indicating low to high plasticity soils and of similar reactivity. A summary of laboratory test results which include field moisture content, Atterberg limits and Linear Shrinkage tests test results are presented in Table 3.

Table 3: Atterberg limits and Linear shrinkage results

Borehole No.	Depth (m)	Material Description/Origin	FMC (%)	LL (%)	PL (%)	PI (%)	LS (%)
BH02	2.5 – 2.8	Sandstone/Rock	8.1				
BH06	1.5 – 1.7	Sandstone/Rock	11.0				
BH08	0.8 – 1.0	Clay/Fill	21.2	53	19	34	9.0
BH08	1.5 – 1.7	Sandstone/Rock	7.3				
BH09	1.2 – 1.5	Gravelly Sand/Fill	9.8				
BH09	2.8 – 3.0	Sandstone/Rock	11.3				

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

The soil samples from BH01 to BH09 were tested at an external laboratory to assess aggressivity to buried structural elements (chloride ion and sulphate content). The results of the laboratory testing are summarised in Table 4 below.

Table 4: Summary of Aggressivity test

Borehole No.	Depth (m)	Material Description/Origin	pH	EC (µS/cm)	Chloride, Cl- (ppm)	Sulphate, SO4- (ppm)
BH02	2.5 – 2.8	Sandstone/Rock	5.8	26	<10	20

Table 4: Summary of Aggressivity test

BH09	2.8 – 3.0	Sandstone/Rock	5.6	140	70	200

Note: EC – Electrical Conductivity

The results of the laboratory testing are included in Appendix D.

10 Geotechnical Discussion and Recommendations

10.1 General

In general, the subsurface profile encountered in the boreholes generally comprises sandy gravel/gravelly sand/sandy clay/clay fill overlying ‘probably’ sandstone bedrock. The reason we classified bedrock as ‘probably’ sandstone is because the historical aerial images of the site indicates that a part of this site appeared to be filled. At the time of preparing this report, CG does not have any information about the material used to fill the site and the depth of fill.

10.2 Dilapidation Survey

It is suggested that dilapidation (existing condition) surveys report be undertaken on the adjacent buildings and other structures. The condition survey should be undertaken prior to commencing work on the site to document any existing defects so that any claims for damage due to excavations or other constructions related activities are accurately assessed. The owner should be provided with copies of the relevant reports and asked to confirm that they represent a fair and accurate record of the existing condition of the building.

10.3 Existing Fill

The depth of fill encountered in the boreholes generally ranging from 0.9m to more than 2.9m below the existing surface grade. Based on the DCP test results, fill was assessed to be poorly compacted. There is a possibility that deeper fill may be due to the filling of an old excavation area which was observed on the historical aerial images. Due to the poor compaction, the existing fill is not suitable to support the proposed structure.

We recommend that Client make allowance for further investigation to confirm the depth and lateral extent of the deeper fill near BH01. This could comprise boreholes drilled prior to commencement of civil works for the proposed project.

Further, to reduce the potential for possible differential movements in the future, we recommend that below any proposed buildings, the existing fill should be fully stripped down to the underlying natural soil or bedrock profile. Engineered fill, as detailed in Section 10.4 below, should then be used to raise surface levels as required. Alternatively, it would likely be preferable to support the structure on piles founded within the bedrock.

10.4 Site Preparation and Earthworks

10.4.1 Excavation Conditions

From the architectural plans, it is assessed that the proposed project does not involve any basement. It is anticipated that some minor excavation works will be carried out to achieve the proposed design levels.

The excavation for the proposed project is expected to be through asphalt pavement/filling and then probably sandstone bedrock. The material encountered up to the termination depth of the boreholes should be readily achieved using conventional earthmoving equipment, possibly with the assistance of light rock hammering or ripping in the upper weathered rock sequence.

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.

10.4.2 Re-use of Excavated Material

Apart from the asphalt layer, the gravelly sand/sandy gravel/sandy clay/clay fill material encountered in the boreholes should be suitable for re-use as engineered filling from a geotechnical perspective, given that it will comprise a mixture of clay, sand, gravel, free or organic matter and contain a maximum particle size of 75mm.

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 and car park pavements: 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 existing buildings 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.

10.4.2.1 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.

10.4.2.2 Service Trenches

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 50mm. The compaction specifications provided above are applicable. This is particularly important below the proposed stormwater pipes where lack of compaction could lead to localised settlement and linear depressions over the trenches.

10.4.2.3 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.

Level 2 testing of fill compaction is considered appropriate for this project, including for the trench backfill. However, if engineered fill is to support any buildings, Level 1 inspection and testing must be completed over the footprint of the buildings.

10.5 Batter Slopes

Based upon previous experiences, the maximum batter slopes in Table 5 are recommended for the proposed project:

Table 5: Recommended Maximum Batter slopes for Exposed Material

Material [1]	Temporary Batter Slope (H:V)	Permanent Batter Slope (H:V)
Filling or natural soils	1.5:1	3.0:1

Surface erosion protection, for example, quick establishing grass or proprietary systems should be provided to all permanent batter slopes. Dish drains should also be provided along the crest and toe of all permanent batter slopes to intercept surface water run-off. Discharge should be piped to the stormwater system.

10.6 Retaining Walls

We anticipate that low height retaining walls will be required in some areas where permanent batter slopes are note preferred. We assume these retaining walls will be constructed within temporarily battered excavations, and then backfilled in accordance with Section 10.4 above.

It is suggested that design of permanent retaining structures of no more than 1.5m height be based on an average bulk unit weight for the retained material of 18kN/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 6 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 6.

Table 6: Earth Pressure Coefficients (non-sloping crest surface)

Material	Unit Weight (kN/m³)	C' (kPa)	Ø' In degrees	E' (MPa)	Earth Pressure Coefficient		
					K_0	K_a	K_p
Fill	16	N/A	N/A	N/A	N/A	N/A	N/A
Probably Sandstone rock	21	20	30	50	0.5	0.33	3.00

Note:

1. K_0 - coefficient of earth pressure at rest, K_a - coefficient of active earth pressure, K_p - coefficient of passive earth pressure.
2. C' – Drained cohesion; Ø' - angle of internal soil friction; E' – long term Young's modulus.
3. N/A – No geotechnical parameters have been assigned to manmade fill layers due no records o the fill;
4. The estimated values of K_0 are based on initial conditions before the construction of the perimeter retention system.
5. 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.
6. 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.
7. Inferred from AS 4678.
8. All parameters inferred from Reference 1 and 2.

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 6 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.

11 Footings

Following completion of the proposed earthworks, we expect that bedrock may be present below any proposed buildings. However, fill could also be present depending on final surface levels. To limit the potential for future differential movements, all buildings should be founded in uniform material, e.g. all in engineered fill, or all in bedrock. While we have provided recommendations for high level footings in fill, given the likely variable subsurface conditions and the need to rework existing fill, we expect it would be preferable to support any new structures on footings founded within the bedrock.

11.1 AS2870-2011 Site Classification

Although not relevant to the proposed three commercial building development proposed for this site a site classification was assessed using a change of suction at the surface of 1.2 pF and suction depth of 1.5m. 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 trees, existing structures and presence of fill.

In the absence of the abnormal moisture conditions and fill material, the designing engineer should recognise that the natural soil encountered on this site result in a class “Class H1” site classification applying to this site. It is anticipated that the characteristic surface movement under normal moisture condition of approximately, Ys, of 60mm.

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 G.

No footings should be constructed within two (2) metres of the top of any unsupported batter or a retaining wall unless the footings are piered below the toe of the wall.

11.2 Footings in Engineered Fill

For high level footings founded in engineered fill placed under Level 1 control to the specification in Section 10.4 above, which are not underlain by existing fill which has not been placed with the same degree of control and testing, or natural clayey soils of at least very stiff strength, an allowable bearing pressure of 100kPa may be adopted for footings embedded at least 1m 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.

11.3 Pile Foundations

Pile foundations may be used to support any part of the proposed building structure to transfer proposed building loads to the more competent unit at depth to mitigate the predicted differential foundation settlement issues described in Section 10.3 above.

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 would be the preferred option for this project. Preliminary pile design parameters are presented in Table 7.0

Table 7: Summary of Preliminary Pile Design Parameters

Soil Unit	**Allowable End Bearing pressure (Compression)**	
	Shaft (kPa)	**Base (kPa)**
Probably Sandstone rock	50	1,000

Notes: The shaft capacity and passive resistance provided by the soil to a depth of 1.5 pile diameters below basement slab must be ignored

Minimum pile embedment depth in the layer is 3 x pile diameter;

Capacities provided are ultimate values in compression. The designer must apply appropriate reductions based on the piling technique adopted and if used in tension.

The foundation design parameters given in the Table 7 assume 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 an experienced 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.

12 Aggressivity

Based on the pH/EC, sulphate content and chloride content test results, a ‘Non-aggressive’ exposure classification for concrete piles in accordance with Table 6.4.2 (C) in AS2159-2009 and a ‘Non-aggressive’ exposure classification for steel piles in accordance with Table 6.5.2 (C) in AS2159-2009 ‘Piling – Design and Construction’ is applicable.

13 Further Geotechnical Inspections

It is recommended that the following review/inspections be undertaken to assess geotechnical conditions and to further reduce the risk of slope instability.

- Structural drawings for footings should be reviewed and approved by an experienced Consultant.
- Additional geotechnical investigation near BH01 and BH09 to confirm the depth to bedrock;
- All footings must be inspected and approved by an experienced Geotechnical Engineer prior to pouring concrete.
- 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.

14 Closure

This report has been prepared for Sydney Environmental Group Pty Ltd in accordance with CG’s proposal dated 11 August 2022 (Ref. QU22-0286 Rev 0) 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 boreholes. 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.

15 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. Based on Classification of Sandstones and Shales in the Sydney Region: A forty year review, P.J.N. Pells1, G. Mostyn2, R. Bertuzzi2 and P. K. Wong3, Volume 54: No.2 June 2019.
7. Sydney 1:100,000 Geological map Geological Series Sheet 9130 (Edition 1) 1983

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:

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.

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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.

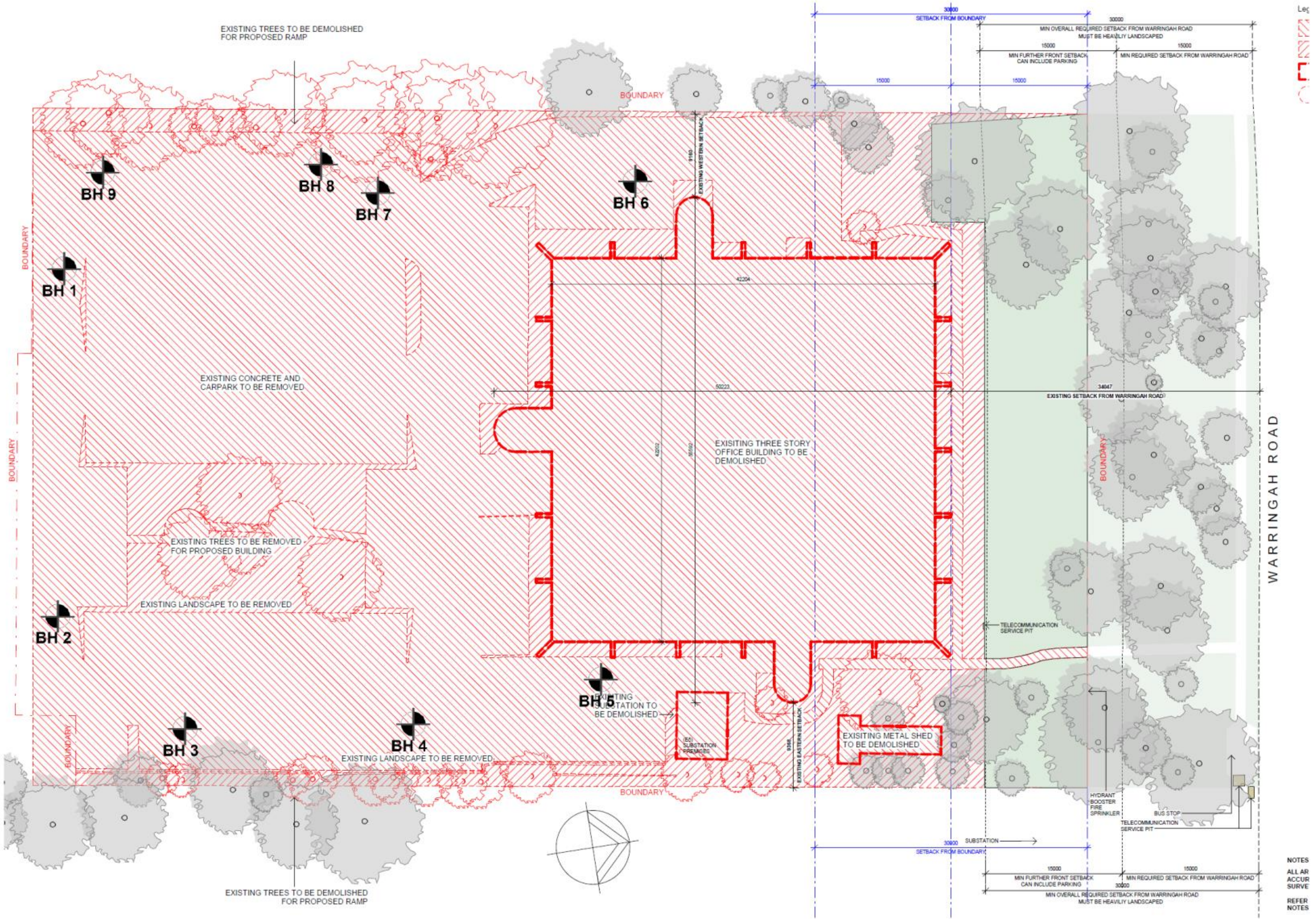
Interpretation of Data: Data obtained from nominated discrete locations, subsequent laboratory testing and empirical or external sources are interpreted by trained professionals in order to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended 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
Borehole Location Plan
Drawing No. CG22-0774-1



	LEGEND:	Core Geotech	Scale: A4 - NOT TO SCALE	Client: SYDNEY ENVIRONMENTAL GROUP PTY LTD
✦	APPROXIMATE BOREHOLE LOCATION		Date: 14/10/2022	Project: PROPOSED LIGHT INDUSTRIES, AND/OR WAREHOUSE AND DISTRIBUTION
		31 Lilburn Street, *Tallawong NSW 2762* *Tel: 0479 154 977* *Email: rsingh@coregeotech.com.au*	Drawing: RS	Location: 323-327 WARRINGAH ROAD, FRENCHS FOREST NSW
			Drawing No: CG22-0774-1	Sheet: 1 of 1 — **SITE PLAN**

Appendix C
Borehole Logs

Core Geotech
Core Geotech Pty Ltd
31 Lilburn Street
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Telephone: +61 0479 154 977

BOREHOLE NUMBER BH01

PAGE 1 OF 1

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Light Industries, Warehouse and Distribution
PROJECT NUMBER CG22-0774
PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22 **COMPLETED** 24/8/22
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Precise Drilling
SLOPE -90°
BEARING ---
EQUIPMENT Pixy 41T
HOLE LOCATION Refer to Drawing No. CG22-0774-1
HOLE SIZE 110mm
LOGGED BY RS
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered			■				PAVEMENT
				▨	SP	SAND, fine to medium grained, grey with fine to medium gravel, moist		ROAD BASE
				▨	CI	CLAY, medium plasticity, red, fine to medium grained, >plastic limit		PROBABLE FILL
			0.5	▨			DCP = 5	
				▨			5	
				▨			3	
				▨			5	
				▨			4	
			1.0	▨			4	
				▨			3	
				▨			2	
				▨			3	
				▨			2	
			1.5	▨	ML	SILT, low plasticity, dark grey with clay and fine to medium sandstone gravel, <plastic limit	2	
				▨			4	
				▨			4	
				▨			3	
				▨			2	
			2.0	▨			4	
			2.5	▨				
			3.0			Borehole BH01 terminated at 2.9m		

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BOREHOLE NUMBER BH02

PAGE 1 OF 1

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Light Industries, Warehouse and Distribution
PROJECT NUMBER CG22-0774
PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22 **COMPLETED** 24/8/22
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Precise Drilling
SLOPE -90°
BEARING ---
EQUIPMENT Pixy 41T
HOLE LOCATION Refer to Drawing No. CG22-0774-1
HOLE SIZE 110mm
LOGGED BY RS
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered			■				PAVEMENT
				▨	SP	Gravelly SAND, fine to medium grained, brown grey, fine to medium gravel, moist		ROAD BASE
				▨	CL	CLAY, low plasticity, red mottled grey, some fine to medium gravel, <plastic limit		FILL
			0.5				DCP = 18	
							3	
							5	
							4	
							3	
			1.0				2	
							2	
							1	
				▨	CL	Sandy CLAY/CLAY, low plasticity, grey, fine to medium grained, some fine to medium gravel, <plastic limit	2	
							2	
			1.5				2	
							3	
							2	
							2	
							2	
			2.0					
				⁘		SANDSTONE, extremelly to distinctly weathered, fine to medium grained, grey, very low to low strength		PROBABLE ROCK
			2.5					
			3.0					

Borehole BH02 terminated at 3m

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BOREHOLE NUMBER BH03

PAGE 1 OF 1

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Light Industries, Warehouse and Distribution
PROJECT NUMBER CG22-0774
PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22
COMPLETED 24/8/22
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Precise Drilling
SLOPE -90°
BEARING ---
EQUIPMENT Pixy 41T
HOLE LOCATION Refer to Drawing No. CG22-0774-1
HOLE SIZE 110mm
LOGGED BY RS
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered			■				PAVEMENT
				▩	SP	Gravelly SAND, fine to medium grained, brown grey, fine to medium gravel, moist		ROAD BASE
			0.5	▩	CL/CI	CLAY, low to medium plasticity, red mottled grey, trace fine gravel		PROBABLE FILL
			1.0 1.5 2.0 2.5 3.0	▤		SHALE, extremelly to distinctly weathered, fine to medium grained, grey, very low to low strength		ROCK

Borehole BH03 terminated at 3m

Core Geotech

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BOREHOLE NUMBER BH04

PAGE 1 OF 1

CLIENT Sydney Environmental Group Pty Ltd

PROJECT NAME Proposed Light Industries, Warehouse and Distribution

PROJECT NUMBER CG22-0774

PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22

COMPLETED 24/8/22

R.L. SURFACE

DATUM

DRILLING CONTRACTOR Precise Drilling

SLOPE -90°

BEARING ---

EQUIPMENT Pixy 41T

HOLE LOCATION Refer to Drawing No. CG22-0774-1

HOLE SIZE 110mm

LOGGED BY RS

CHECKED BY RS

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered			■				PAVEMENT
				▩	SP	Gravelly SAND, fine to medium grained, brown grey, fine to medium gravel, moist		ROAD BASE
			0.5 1.0 1.5	▩	CI	CLAY, medium plasticity, red mottled grey, some ironstone		FILL
			2.0 2.5 3.0	▤		SHALE, extremelly to distinctly weathered, fine to medium grained, grey, very low to low strength		ROCK

Borehole BH04 terminated at 3m

Core Geotech

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Telephone: +61 0479 154 977

BOREHOLE NUMBER BH05

PAGE 1 OF 1

CLIENT Sydney Environmental Group Pty Ltd

PROJECT NAME Proposed Light Industries, Warehouse and Distribution

PROJECT NUMBER CG22-0774

PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22 **COMPLETED** 24/8/22

R.L. SURFACE

DATUM

DRILLING CONTRACTOR Precise Drilling

SLOPE -90°

BEARING ---

EQUIPMENT Pixy 41T

HOLE LOCATION Refer to Drawing No. CG22-0774-1

HOLE SIZE 110mm

LOGGED BY RS

CHECKED BY RS

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered							PAVEMENT
					GP	Sandy GRAVEL/Gravelly SAND, fine to medium, grey green, sand fine to medium grained, moist		ROAD BASE
			0.5		GP	Sandy GRAVEL, fine to medium grained, dark grey, some medium to high plasticity clay, moist		FILL
			1.0		CI	CLAY, medium plasticity, red mottled grey, trace irnostone, >plastic limit	DCP = 2 4 7	
			1.5 2.0			SANDSTONE, extremelly to distinctly weathered, fine to medium grained, grey, very low to low strength	+15	ROCK
			2.5 3.0			SHALE, extremelly to distinctly weathered, fine to medium grained, grey, very low to low strength		

Borehole BH05 terminated at 3m

BOREHOLE NUMBER BH06

PAGE 1 OF 1

Core Geotech

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Tallawong NSW 2762
Telephone: +61 0479 154 977

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Light Industries, Warehouse and Distribution
PROJECT NUMBER CG22-0774
PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22
COMPLETED 24/8/22
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Precise Drilling
SLOPE -90°
BEARING ---
EQUIPMENT Pixy 41T
HOLE LOCATION Refer to Drawing No. CG22-0774-1
HOLE SIZE 110mm
LOGGED BY RS
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered			■				PAVEMENT
				▨	GP	Sandy GRAVEL, fine to medium, grey, sand fine to medium grained, moist		ROAD BASE
			0.5 1.0	▨	CI/CH	CLAY, medium to high plasticity, red mottled grey, some fine to medium gravel, >plastic limit	6 6 8 6 4 7 7	FILL
			1.5 2.0 2.5 3.0	⁘		INTERBEDDED SANDSTONE/SHALE, extremelly to distinctly weathered, fine to medium grained, grey, very low to low strength	22 +19	ROCK

Borehole BH06 terminated at 3m

Core Geotech

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Telephone: +61 0479 154 977

BOREHOLE NUMBER BH07

PAGE 1 OF 1

CLIENT Sydney Environmental Group Pty Ltd

PROJECT NAME Proposed Light Industries, Warehouse and Distribution

PROJECT NUMBER CG22-0774

PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22 **COMPLETED** 24/8/22

R.L. SURFACE

DATUM

DRILLING CONTRACTOR Precise Drilling

SLOPE -90°

BEARING ---

EQUIPMENT Pixy 41T

HOLE LOCATION Refer to Drawing No. CG22-0774-1

HOLE SIZE 110mm

LOGGED BY RS

CHECKED BY RS

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered			■				PAVEMENT
			0.5	▨	SP	SAND, fine to medium grained, yellow, moist		FILL
						Borehole BH07 terminated at 0.8m	DCP = 1 1 1 2 6 15	
			1.0					
			1.5					
			2.0					
			2.5					
			3.0					

Core Geotech

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BOREHOLE NUMBER BH08

PAGE 1 OF 1

CLIENT Sydney Environmental Group Pty Ltd

PROJECT NAME Proposed Light Industries, Warehouse and Distribution

PROJECT NUMBER CG22-0774

PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22 **COMPLETED** 24/8/22

R.L. SURFACE

DATUM

DRILLING CONTRACTOR Precise Drilling

SLOPE -90°

BEARING ---

EQUIPMENT Pixy 41T

HOLE LOCATION Refer to Drawing No. CG22-0774-1

HOLE SIZE 110mm

LOGGED BY RS

CHECKED BY RS

NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered			■				PAVEMENT
				▩	SP	Gravelly SAND, fine to medium, grey, gravel fine to medium, moist		ROAD BASE
			0.5	▩	CI/CH	CLAY, medium to high plasticity, red mottled grey, some fine to medium gravel, >plastic limit		FILL
			1.0 1.5 2.0 2.5 3.0	░		SANDSTONE, extremelly to distinctly weathered, fine to medium grained, grey, very low to low strength		ROCK increase in drilling resistance at 1.4m depth

Borehole BH08 terminated at 3m

Core Geotech

Core Geotech Pty Ltd
31 Lilburn Street
Tallawong NSW 2762
Telephone: +61 0479 154 977

BOREHOLE NUMBER BH09

CLIENT Sydney Environmental Group Pty Ltd
PROJECT NAME Proposed Light Industries, Warehouse and Distribution
PROJECT NUMBER CG22-0774
PROJECT LOCATION 323-327 Warringah Road, Frenchs Forest, NSW

DATE STARTED 24/8/22 **COMPLETED** 24/8/22
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Precise Drilling
SLOPE -90°
BEARING ---
EQUIPMENT Pixy 41T
HOLE LOCATION Refer to Drawing No. CG22-0774-1
HOLE SIZE 110mm
LOGGED BY RS
CHECKED BY RS
NOTES

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
ADV	None Encountered			■				PAVEMENT
				▨	SP	Gravelly SAND, fine to medium, grey, gravel fine to medium, moist		ROAD BASE
			0.5 1.0 1.5 2.0	▨	SP	Gravelly SAND, fine to medium grained, grey/dark grey becoming pale grey, fine to medium gravel, some shale gravel	DCP = 3 7 9 7 6 8 8 10 +15	FILL
			2.5 3.0	⁚		SANDSTONE, extremelly to distinctly weathered, fine to medium grained, grey white, very low to low strength		PROBABLE ROCK

Borehole BH09 terminated at 3m

Abbreviations, Notes & Symbols

Core Geotech

SUBSURFACE INVESTIGATION

METHOD

Borehole Logs

AS#	Auger screwing (#-bit)
AD#	Auger drilling (#-bit)
B	Blank bit
V	V-bit
T	TC-bit
HA	Hand auger
R	Roller/tricone
W	Washbore
AH	Air hammer
AT	Air track
LB	Light bore push tube
MC	Macro core push tube
DT	Dual core push tube

Excavation Logs

BH	Backhoe/excavator bucket
NE	Natural exposure
HE	Hand excavation
X	Existing excavation

Cored Borehole Logs

NMLC	NMLC core drilling
NQ/HQ	Wireline core drilling

SUPPORT

Borehole Logs

C	Casing
M	Mud

Excavation Logs

S	Shoring
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

RS	Residual Soil
XW	Extremely Weathered
HW	Highly Weathered
MW	Moderately Weathered
DW*	Distinctly Weathered
SW	Slightly Weathered
FR	Fresh

**covers both HW & MW*

STRENGTH

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

ROCK QUALITY DESIGNATION (%)

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

CORE RECOVERY (%)

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

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

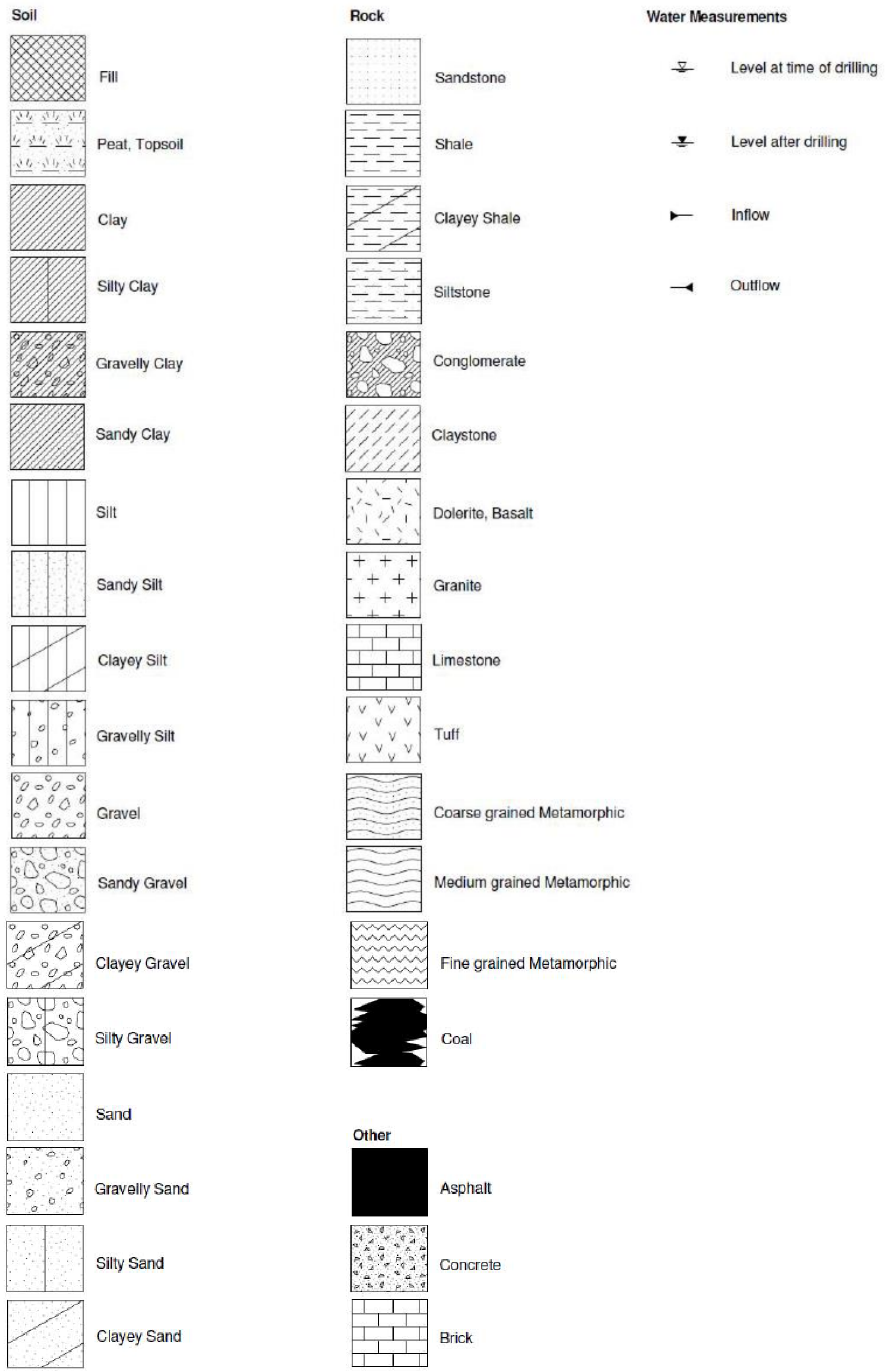
Shape	Description
Planar	Consistent orientation
Curved	Gradual change in orientation
Undulose	Wavy surface
Stepped	One or more well defined steps
Irregular	Many sharp changes in orientation

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

Graphic Symbols Index



Appendix D
Laboratory Test Results

Material Test Report

Benchmark Geotechnical Pty Ltd
146 Clifton Avenue Kemps Creek NSW 2178
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:	**P220271-1**
Issue Number:	1
Date Issued:	09/09/2022
Client:	Core Geotech 31 Lilburn Street, Tallawong NSW 2762
Contact:	Raj Singh, 0479 154 977
Project Number:	P220271
Project Name:	Proposed Light Industries and/or Warehouse & Distribution
Project Location:	323 - 327 Warringah Road, Frenchs Forest
Client Reference:	CG22-0774
Work Request:	1112
Sample Number:	22-1112B
Date Sampled:	24/08/2022
Dates Tested:	05/09/2022 - 07/09/2022
Sampling Method:	Sampled by Client *The results apply to the sample as received*
Site Selection:	Selected by Client
Sample Location:	**BH08 , Depth: 0.8 - 1.0 m**
Material:	Mottled Brown Silty Clay with Gravel
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 (%)	53		
Plastic Limit (%)	19		
Plasticity Index (%)	**34**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	9.0		
Cracking Crumbling Curling	None		

Material Test Report

Report Number: **P220271-1**
Issue Number: 1
Date Issued: 09/09/2022
Client: Core Geotech
31 Lilburn Street, Tallawong NSW 2762
Contact: Raj Singh, 0479 154 977
Project Number: P220271
Project Name: Proposed Light Industries and/or Warehouse & Distribution
Project Location: 323 - 327 Warringah Road, Frenchs Forest
Client Reference: CG22-0774
Work Request: 1112
Dates Tested: 05/09/2022 - 05/09/2022
Location: 323 - 327 Warringah Road, Frenchs Forest

BENCHMARK GEOTECHNICAL
Benchmark Geotechnical Pty Ltd
146 Clifton Avenue Kemps Creek NSW 2178
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

Moisture Content AS 1289 2.1.1

Sample Number	Sample Location	Moisture Content (%)	Material
22-1112A	BH06 , Depth: 1.5- 1.7 m	11.0 %	Grey Silty Clay with Gravel
22-1112B	BH08 , Depth: 0.8 - 1.0 m	21.2 %	Mottled Brown Silty Clay with Gravel
22-1112C	BH08 , Depth: 1.5 - 1.7 m	7.3 %	Grey Silty Clay with Gravel
22-1112D	BH09 , Depth: 1.2 - 1.5 m	9.8 %	Dark Brown Silty Clay with Gravel

ALS Environmental

CERTIFICATE OF ADDITIONAL

Work Order	: **ES2230712**	Page	: 1 of 2
Client	: **Core Geotech Pty Ltd**	Laboratory	: Environmental Division Sydney
Contact	: Mr Raj Singh	Contact	: Olivia Barbato
Address	: 31 Lilburn Street Tallawong 2762	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: CG22-0774	Date Samples Received	: 30-Aug-2022 12:30
Order number	: -	Date Analysis Commenced	: 02-Sep-2022
C-O-C number	: 41717	Issue Date	: 06-Sep-2022 18:44
Sampler	: Raj Singh		
Site	: 323-327 Warringah Road, Frenchs Forest, NSW		
Quote number	: Compass Quote		
No. of samples received	: 2		
No. of samples analysed	: 2		

ilac-MRA NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL)**			*Sample ID*	**BH02 2.5-2.8m**	**BH09 2.8-3.0m**	**----**	**----**	**----**
			Sampling date / time	28-Aug-2022 21:10	28-Aug-2022 21:11	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**ES2230712-001**	**ES2230712-002**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.8**	**5.6**	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**26**	**140**	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	**8.1**	**11.3**	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**20**	**200**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	**70**	----	----	----

QUALITY CONTROL REPORT

Work Order : **ES2230712**

Client : **Core Geotech Pty Ltd**
Contact : Mr Raj Singh
Address : 31 Lilburn Street
Tallawong 2762
Telephone : ----
Project : CG22-0774
Order number : -
C-O-C number : 41717
Sampler : Raj Singh
Site : 323-327 Warringah Road, Frenchs Forest, NSW
Quote number : Compass Quote
No. of samples received : 2
No. of samples analysed : 2

Page : 1 of 3

Laboratory : Environmental Division Sydney
Contact : Olivia Barbato
Address : 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone : +61-2-8784 8555
Date Samples Received : 30-Aug-2022
Date Analysis Commenced : 02-Sep-2022
Issue Date : 06-Sep-2022

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EA002: pH 1:5 (Soils) (QC Lot: 4557297)									
ES2230680-001	Anonymous	EA002: pH Value	----	0.1	pH Unit	7.3	6.8	7.2	0% - 20%
EA010: Conductivity (1:5) (QC Lot: 4557299)									
ES2230712-001	BH02 2.5-2.8m	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	26	22	13.8	0% - 20%
EA055: Moisture Content (Dried @ 105-110°C) (QC Lot: 4557301)									
ES2230361-005	Anonymous	EA055: Moisture Content	----	0.1	%	36.4	36.0	1.1	0% - 20%
ES2230712-002	BH09 2.8-3.0m	EA055: Moisture Content	----	0.1	%	11.3	11.4	1.0	0% - 50%
ED045G: Chloride by Discrete Analyser (QC Lot: 4557300)									
ES2230712-001	BH02 2.5-2.8m	ED045G: Chloride	16887-00-6	10	mg/kg	<10	<10	0.0	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA002: pH 1:5 (Soils) (QCLot: 4557297)								
EA002: pH Value	----	----	pH Unit	---- ----	4 pH Unit 7 pH Unit	100 100	98.8 99.2	101 100
EA010: Conductivity (1:5) (QCLot: 4557299)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	100	92.0	108
ED040S: Soluble Major Anions (QCLot: 4557298)								
ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	750 mg/kg	100	80.0	120
ED045G: Chloride by Discrete Analyser (QCLot: 4557300)								
ED045G: Chloride	16887-00-6	10	mg/kg	<10 <10	250 mg/kg 5000 mg/kg	104 91.8	75.0 79.0	125 117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED045G: Chloride by Discrete Analyser (QCLot: 4557300)							
ES2230712-001	BH02 2.5-2.8m	ED045G: Chloride	16887-00-6	250 mg/kg	104	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **ES2230712**	Page	: 1 of 4
Client	: **Core Geotech Pty Ltd**	Laboratory	: Environmental Division Sydney
Contact	: Mr Raj Singh	Telephone	: +61-2-8784 8555
Project	: CG22-0774	Date Samples Received	: 30-Aug-2022
Site	: 323-327 Warringah Road, Frenchs Forest, NSW	Issue Date	: 06-Sep-2022
Sampler	: Raj Singh	No. of samples received	: 2
Order number	: -	No. of samples analysed	: 2

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Analysis Holding Time Compliance

Matrix: **SOIL**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA002: pH 1:5 (Soils)						
Soil Glass Jar - Unpreserved						
BH02 2.5-2.8m, BH09 2.8-3.0m	----	----	----	05-Sep-2022	02-Sep-2022	**3**

Outliers : Frequency of Quality Control Samples

Matrix: **SOIL**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Major Anions - Soluble	0	2	0.00	10.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **SOIL**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA002: pH 1:5 (Soils)							
Soil Glass Jar - Unpreserved (EA002)							
BH02 2.5-2.8m, BH09 2.8-3.0m	**28-Aug-2022**	**02-Sep-2022**	04-Sep-2022	✓	**05-Sep-2022**	02-Sep-2022	✗
EA010: Conductivity (1:5)							
Soil Glass Jar - Unpreserved (EA010)							
BH02 2.5-2.8m, BH09 2.8-3.0m	**28-Aug-2022**	**02-Sep-2022**	04-Sep-2022	✓	**05-Sep-2022**	30-Sep-2022	✓
EA055: Moisture Content (Dried @ 105-110°C)							
Soil Glass Jar - Unpreserved (EA055)							
BH02 2.5-2.8m, BH09 2.8-3.0m	**28-Aug-2022**	**----**	----	----	**02-Sep-2022**	11-Sep-2022	✓
ED040S : Soluble Sulfate by ICPAES							
Soil Glass Jar - Unpreserved (ED040S)							
BH02 2.5-2.8m, BH09 2.8-3.0m	**28-Aug-2022**	**02-Sep-2022**	25-Sep-2022	✓	**05-Sep-2022**	30-Sep-2022	✓
ED045G: Chloride by Discrete Analyser							
Soil Glass Jar - Unpreserved (ED045G)							
BH02 2.5-2.8m, BH09 2.8-3.0m	**28-Aug-2022**	**02-Sep-2022**	25-Sep-2022	✓	**05-Sep-2022**	30-Sep-2022	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		*Count*		*Rate (%)*			*Quality Control Specification*
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	2	**50.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	0	2	**0.00**	**10.00**	✗	NEPM 2013 B3 & ALS QC Standard
Moisture Content	EA055	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	1	10	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Chloride Soluble By Discrete Analyser	ED045G	2	2	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH (1:5)	EA002	2	10	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Electrical Conductivity (1:5)	EA010	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Soluble	ED040S	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH (1:5)	EA002	SOIL	In house: Referenced to Rayment and Lyons 4A1 and APHA 4500H+. pH is determined on soil samples after a 1:5 soil/water leach. This method is compliant with NEPM Schedule B(3).
Electrical Conductivity (1:5)	EA010	SOIL	In house: Referenced to Rayment and Lyons 3A1 and APHA 2510. Conductivity is determined on soil samples using a 1:5 soil/water leach. This method is compliant with NEPM Schedule B(3).
Moisture Content	EA055	SOIL	In house: A gravimetric procedure based on weight loss over a 12 hour drying period at 105-110 degrees C. This method is compliant with NEPM Schedule B(3).
Major Anions - Soluble	ED040S	SOIL	In house: Soluble Anions are determined off a 1:5 soil / water extract by ICPAES.
Chloride Soluble By Discrete Analyser	ED045G	SOIL	In house: Referenced to APHA APHA 4500 Cl - G. The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm. Analysis is performed on a 1:5 soil / water leachate.

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of reagent grade water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.

CHAIN OF CUSTODY

ALS COC#: **41717** *ALS Laboratory:* ES Sydney

RELINQUISHED BY:	RECEIVED BY: Mo / AY	RELINQUISHED BY:	RECEIVED BY:
DATE TIME:	DATE TIME: 30/8/22 1230	DATE TIME:	DATE TIME:

CLIENT: CORGEO - Core Geotech Pty Ltd
PROJECT: CG22-0774
SITE: 323-327 Warringah Road, Frenchs Forest, NSW
ORDER NO:
PROJECT MANAGER: Raj Singh
PRIMARY SAMPLER: Raj Singh
EMAIL REPORTS TO: rsingh@coregeotech.com.au
EMAIL INVOICES TO: pkaur@coregeotech.com.au

TURNAROUND REQUIREMENTS : 5 Days
Biohazard info:

CONTACT PH: 0479154977
QUOTE NO: Compass Quote
SAMPLER MOBILE: 0479154977
/ ES2021CORGEO0002

LABORATORY USE ONLY (Circle)
Custody Seal intact? Yes No [✓ N/A]
Free ice / frozen ice bricks present upon receipt? Yes [✓ No] N/A
Random Sample Temperature on Receipt: 22.7 °C
Other comments:

SAMPLE DETAILS							ANALYSIS REQUIRED			
SAMPLE	NAME	DESCRIPTION	DATE / TIME	MATRIX	TOTAL BOTTLES	ON HOLD	Aggressivity SOIL	pH and EC SOIL	ALTERNATIVE ANALYSIS	ADDITIONAL INFORMATION
001	BH02 2.5-2.8m		28/08/2022 09:10 PM	Soil	ALS: 1 Non ALS: 0	No	X	X		
002	BH09 2.8-3.0m		28/08/2022 09:11 PM	Soil	ALS: 1 Non ALS: 0	No	X	X		

Environmental Division
Sydney
Work Order Reference
ES2230712

Telephone : + 61-2-8784 8555

CHAIN OF CUSTODY

COC#: 41717 *ALS Laboratory:* ES Sydney

RELINQUISHED BY:
DATE TIME:

RECEIVED BY: AH
DATE TIME: 30/8/22 1230

RELINQUISHED BY:
DATE TIME:

RECEIVED BY:
DATE TIME:

CLIENT: CORGEO - Core Geotech Pty Ltd
PROJECT: CG22-0774
SITE: 323-327 Warringah Road, Frenchs Forest, NSW
ORDER NO:
PROJECT MANAGER: Raj Singh
PRIMARY SAMPLER: Raj Singh
CONTACT PH: 0479154977
SAMPLER MOBILE: 0479154977
QUOTE NO: Compass Quote / ES2021CORGEO0002
EMAIL REPORTS TO: rsingh@coregeotech.com.au
EMAIL INVOICES TO: pkaur@coregeotech.com.au

TURNAROUND REQUIREMENTS : 5 Days
Biohazard info:

LABORATORY USE ONLY (Circle)
Custody Seal intact? Yes No [✓ N/A]
Free ice / frozen ice bricks present upon receipt? Yes [✓ No] N/A
Random Sample Temperature on Receipt: 22.7 °C
Other comments:

SAMPLE	SAMPLE NAME	BOTTLE NAME	VOLUME	BARCODE	TYPE	FILTERED	REASON
001	BH02 2.5-2.8m	Soil Glass Jar - Unpreserved	250 mL	00260322014509	Orange	No	
002	BH09 2.8-3.0m	Soil Glass Jar - Unpreserved	250 mL	00260322014510	Orange	No	

Total Bottle Count: ALS: 2, Non ALS: 0

Appendix E
Site Photography

Photo 1: Site view looking towards south boundary

Photo 2: Site view looking towards north boundary

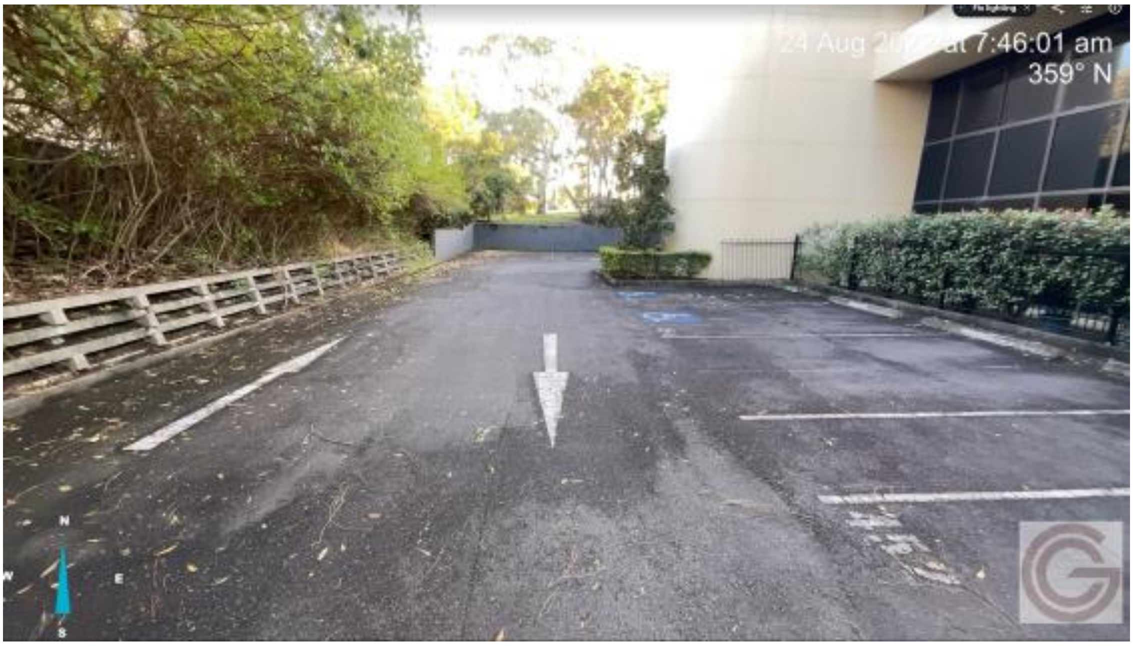


Photo 3: Site view showing retainign walls on the north and west boundary

Photo 4: Site view showing the exisitng carpark area

Appendix F
Historical Aerial Images

Photo 5: Historical Aerial Image of Year 1955

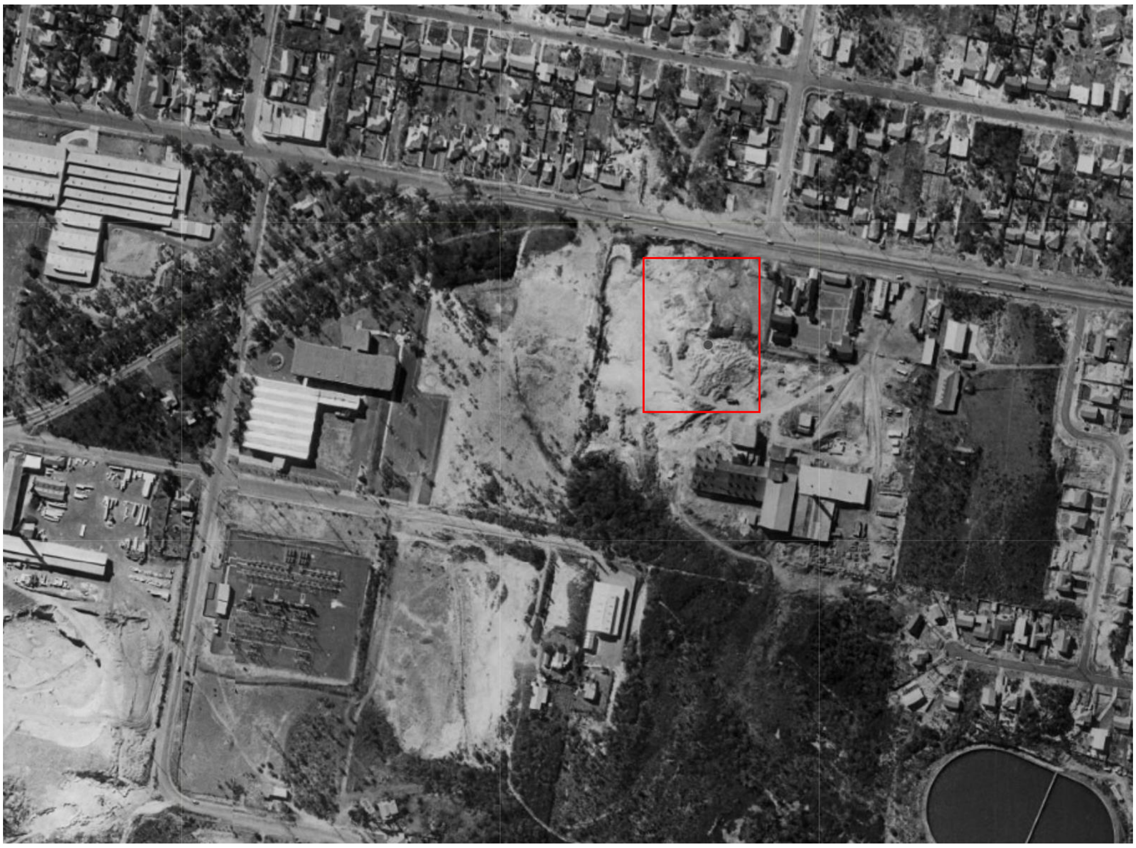


Photo 6: Historical Aerial Image of Year 1965

Photo 7: Historical Aerial Image of Year 1970

Photo 8: Historical Aerial Image of Year 1971

Photo 9: Historical Aerial Image of Year 1975

Appendix G
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.

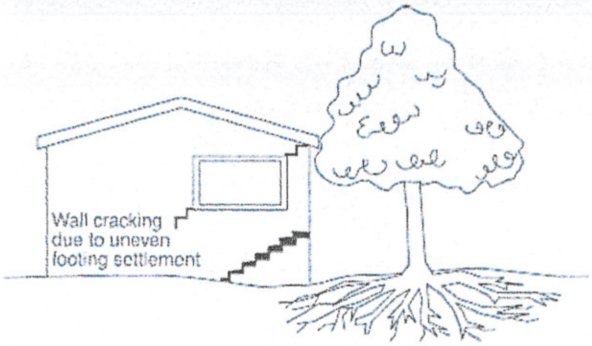
Seasonal swelling/shrinkage in clay

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

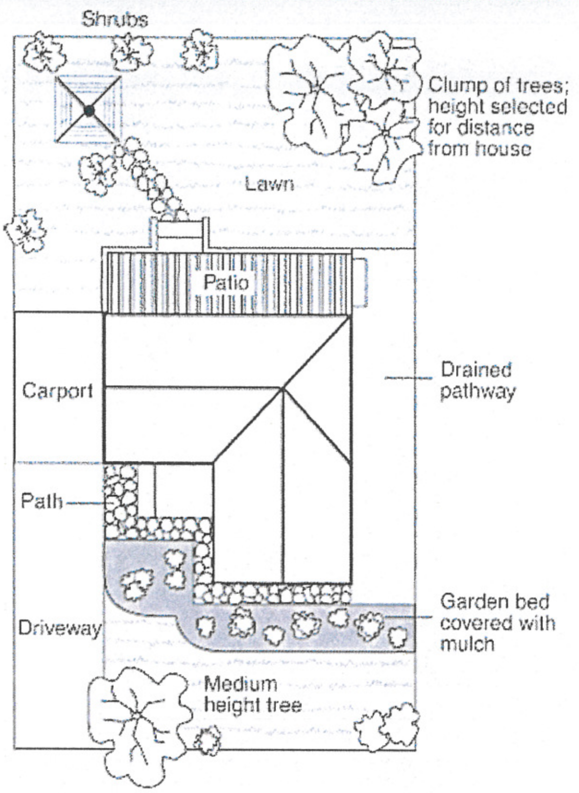
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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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