GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

GEOTECHNICAL INVESTIGATION

FOR

LINCOLN EASTWOOD PTY LTD

9 Lincoln Street, Eastwood, New South Wales

Report No: 22/2883

Project No: 31900/6747D-G

August 2022

14/1 Cowpasture Place, Wetherill Park, NSW 2164, Australia
(PO Box 6989, Wetherill Park, NSW 2164, Australia)
T +61 2 9756 2166 | **F** +61 2 9756 1137
www.stsgeo.com.au | enquiries@stsgeo.com.au
ABN 45 636 179 729 | **ACN** 636 179 729

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Table of Contents

DOCUMENT CONTROL 2

1. INTRODUCTION 3

2. NATURE OF THE INVESTIGATION 3

 2.1. Fieldwork 3

 2.2. Laboratory Testing 4

3. GEOLOGY AND SITE CONDITIONS 4

4. SUBSURFACE CONDITIONS 4

5. GEOTECHNICAL DISCUSSION 5

 5.1. Site Classification 5

 5.2. Excavation Conditions 6

 5.3. Temporary and Permanent Batter Slopes and Support 7

 5.4. Foundation Design 8

 5.5 Soil Aggressiveness and Salinity 8

6. FINAL COMMENTS 9

DRAWING NO. 22/2883 – BOREHOLE AND PENETROMETER LOCATIONS

NOTES RELATING TO GEOTECHNICAL REPORTS

APPENDIX A – BOREHOLE LOGS AND EXPLANATION SHEETS

APPENDIX B – LABORATORY TEST RESULTS

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

DOCUMENT CONTROL

REPORT TITLE: Geotechnical Investigation

REPORT NO: 22/2883

Revision	Details	Date	Amended By
0	Original	August 17, 2022	

Following advice from the Building Commissioner, the advice, recommendations and design parameters provided in this report are only valid and to be relied upon if geotechnical inspections of footings and support/shoring systems are conducted by STS Geotechnics during construction.

1. INTRODUCTION

This report presents the results of a Geotechnical Investigation carried out by STS Geotechnics Pty Limited (STS) for the proposed new childcare facility to be constructed at 9 Lincoln Street, Eastwood. At the time of writing this report STS were not provided with architectural drawings for the project. The report has been prepared assuming site development includes a basement car parking that will require excavating up to about 3 metres below the existing ground surface.

The purpose of the investigation was to provide information on:

- Site conditions and regional geology,
- Subsurface conditions,
- Site Classification according to AS2870,
- Excavation conditions and support, including vibration control during rock excavation,
- Maximum permissible temporary and permanent batter slopes and retaining wall design parameters,
- Foundation design parameters including foundation options, and
- Soil aggressiveness to buried steel and concrete in accordance with AS2870 and AS2159.

The investigation was undertaken in accordance with STS proposal P21-594 dated November 22, 2021.

Our scope of work did not include a contamination assessment.

2. NATURE OF THE INVESTIGATION

2.1. Fieldwork

The fieldwork consisted of drilling three (3) boreholes numbered BH1 to BH3 inclusive. Except for BH3, the boreholes were drilled using a utility mounted Edson RP70 Drilling rig, owned, and operated by STS. Restricted site access dictated the borehole locations. ***Because there was no access for the drilling rig, BH3 was drilled using a push tube***. Soil strengths were assessed by carrying out a Dynamic Cone Penetrometer (DCSP) test adjacent to each borehole location. The borehole and penetrometer locations are shown on Drawing No. 22/2883.

Drilling operations were undertaken by one of STS's senior technical officers who also logged the subsurface conditions encountered.

Representative soil samples were collected from the boreholes for subsequent laboratory testing.

2.2. Laboratory Testing

To assess the soils for their aggressiveness and level of salinity, selected representative soil samples were tested to determine the following:

- pH,
- Sulphate content (SO_4),
- Chloride (Cl)
- Electrical Conductivity (EC).

To assist with determining the site classification, one Shrink Swell test was carried out on representative samples retrieved from the site.

Detailed test report is given in Appendix B.

3. GEOLOGY AND SITE CONDITIONS

The Sydney geological series sheet at a scale of 1:100,000 shows the site is underlain by Triassic Age Ashfield Shale of the Wianamatta Group. Rocks within this formation typically comprise black to dark grey shale and laminite.

At the time of the fieldwork, the site was occupied by existing single-storey house with a basement. Site vegetation comprises grasses, trees, and shrubs. The ground surface fall approximately 1 metre to the south - west.

The site is bound by Lincoln Street to the north, a basketball court to the south and residential dwelling in the adjoining properties.

4. SUBSURFACE CONDITIONS

When assessing the subsurface conditions across a site from a limited number of boreholes, there is the possibility that variations may occur between test locations. The data derived from the site investigation programme are extrapolated across the site to form a geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour regarding the proposed development. The actual condition at the site may differ from those inferred, since no subsurface exploration programme, no matter how comprehensive, can reveal all subsurface details and anomalies, particularly on a site such as this where there has been previous development.

The subsurface conditions generally consist of topsoil or fill overlying silty clays and weathered shale. Topsoil and fill are present from surface to depths of 0.2 to 0.4 metres. Stiff, becoming very stiff with depth, silty clays underlie the topsoil and fill materials to a depth of 2.7 metres in BH1 and BH2 and could not be penetrated below a depth of 1.3 metres using a push tube in BH3. In BH1 and BH2, weathered shale underlies the silty clays to the depth of auger refusal, 3.5 to 4.0 metres.

The subsurface conditions observed are recorded on the borehole logs given in Appendix A. An explanation of the terms used on the logs is also given in Appendix A. Notes relating to geotechnical reports are also attached.

Groundwater was not observed during drilling works.

5. GEOTECHNICAL DISCUSSION

5.1. Site Classification

A site classification to AS2870 is not technically relevant for a development involving basement construction such as this, however it does provide a useful indication of the potential shrink/swell movements onsite due to soil reactivity.

The classification has been prepared in accordance with the guidelines set out in the "Residential Slabs and Footings" Code, AS2870 – 2011.

To assist with determining the site classification, one shrink/swell test was carried out on the representative sample retrieved from the site. The detailed testing report is attached and summarised in Table 5.1.

Table 5.1 – Shrink Swell Test Summary

Location	Depth (m)	Material Description	Shrink/Swell Index (% per ΔpF)
BH1	0.7 – 0.9	Silty Clay: brown	3.0

Because there are trees and existing dwellings present, abnormal moisture conditions (AMC) prevail at the site. (Refer to Section 1.3.3 of AS2870).

Because of the AMC, the site is classified a *Problem Site (P).* Provided the recommendations given below are adopted and the footings bear in natural soils, the site may be reclassified *Highly Reactive (H1).*

Foundation design and construction consistent with this classification shall be adopted as specified in the above referenced standard and in accordance with the following design parameters provided below.

5.2. Excavation Conditions

Based on the subsurface conditions observed in boreholes, the proposed basement excavation is expected to encounter topsoil/ fill, silty clay, and weathered Shale. Excavators without assistance should be able to remove the soils and most of the weathered shale.

Medium strength shales or ironstone bands may be encountered prior to reaching bulk excavation level. Care will be required to ensure that the structures on the subject site and buildings or other developments on adjacent properties are not damaged when excavating the rock. Excavation methods should be adopted which limit ground vibrations at the adjoining structures to not more than 5 mm/sec. Vibration monitoring may be required to verify that this is achieved.

Table 5.2 – Recommendations for Rock Breaking Equipment

Distance from adjoining structure (m)	**Maximum Peak Particle Velocity 5 mm/sec**	
	Equipment	Operating Limit (% of Maximum Capacity)
1.5 to 2.5	Hand operated jackhammer only	100
2.5 to 5.0	300 kg rock hammer	50
5.0 to 10.0	300 kg rock hammer or 600 kg rock hammer	100 50

The limits of 5 mm/sec are expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 5.2.

Use of other techniques (e.g., grinding, rock sawing), although less productive, would reduce or possibly eliminate risks of damage to property through vibration effects transmitted via the ground. Such techniques may be considered if an alternative to rock breaking is required.

If rock sawing is carried out around excavation boundaries in not less than 1-metre-deep lifts, a 900 kg rock hammer could be used at up to 100% maximum operating capacity with an assessed peak particle velocity not exceeding 5 mm/sec, subject to observation and confirmation by a geotechnical engineer at the commencement of excavation.

It should be noted that vibrations that are below threshold levels for building damage may be experienced at adjoining developments.

It would be appropriate before commencing excavation to undertake a dilapidation survey of any adjacent structures that may potentially be damaged. This will provide a reasonable basis for assessing any future claims of damage.

5.3. Temporary and Permanent Batter Slopes and Support

In the short term, dry cut soil slopes should remain stable at an angle of 1(H) to 1(V). In the long-term dry cut slopes formed at an angle of 2(H) to 1(V) should remain stable. Slopes cut at this angle would be subject to erosion unless protected by topsoil and diversion drains at the crest of the slopes. Dry cut slopes in the weathered shale should remain stable at an angle of 1(H) to 1(V). The above temporary batters should remain stable provided that all surcharge loads, including construction loads, are kept at a distance of at least 2h (where 'h' is the height of the batter in metres) from the crest of the batter. If steeper batters are to be used, then these must be supported by shotcrete and soil nail system designed by a suitable experienced structural or geotechnical engineer.

Where space for temporary batters is not available, a suitable retention system will be required for the support of the entire depth of excavation within soils or weathered shale materials. Reinforced concrete piles with shotcrete infill are probably the most cost-effective option for providing this support. The support system will need to be embedded an adequate depth into the weathered rock below the basement excavation. STS recommends a minimum embedment of 1 metre.

It is of course important that the onsite excavations do not endanger the adjacent properties. Excavations on the subject site should not extend below the zone of influence of any adjacent structure footings, without first installing temporary support or discussing the works with a geotechnical engineer.

The major consideration when selecting earth pressure coefficients for the design of retaining walls is the need to limit deformations that can take place outside the excavation. When considering the design of the supports, it will be necessary to allow for the loading from structures in adjoining properties, any ground surface slope, and any water table present. The surcharge load from the existing structures must be considered when designing the temporary and permanent retaining structures. Where structures in adjoining properties are within the zone of influence of the excavation, it will be necessary to adopt K_o conditions when designing the temporary support.

The parameters used to proportion retaining wall support depends on whether the walls can be permitted to deflect. For walls, which cannot be permitted to deflect, an at rest earth pressure coefficient (Ko) of 0.6 should be adopted for the soils. For walls that can be allowed to deflect, an active earth pressure coefficient (Ka) of 0.4 should be adopted for the clayey soils. Passive earth pressure coefficient (Kp) of 2.5 may be used for the stiff and very stiff silty clays and 4.5 for the weathered shale. A bulk density of 17 kN/m^3 may be used for soils, and 22 kN/m^3 for the weathered shale.

As noted above, no groundwater was observed. Therefore, no dewatering will be required during construction or the longer term. Vertical strip drains placed behind the shotcrete will be required to intercept any long-term seepage that may occur. The strip drains are to be connected to drains that transfer the seepage to a sump and pump.

5.4. Foundation Design

Any high-level pad and/or strip footings founded in the stiff and very stiff natural silty clays may be proportioned using an allowable bearing pressure of 100 kPa. The minimum depth of founding must comply with the requirements of AS2870.

Piles founded in stiff and very stiff silty clays below any topsoil and fill, may be proportioned using an allowable bearing pressure of 300 kPa.

Piles, strip, and pad footings founded in weathered rock at the base of the proposed excavation, may be proportioned using an allowable end bearing pressure of 700 kPa. An allowable adhesion value of 70 kPa may be adopted for the portion of the shaft in weathered rock.

To ensure the bearing values given can be achieved, care should be taken to ensure that the base of excavations is free of all loose material prior to concreting. It is recommended that all shallow footing excavations be protected with a layer of blinding concrete as soon as possible, preferably immediately after excavating, cleaning, inspection, and approval.

During foundation construction, should the subsurface conditions vary to those inferred in this report, a suitably experienced geotechnical engineer should review the design and recommendations given above to determine if any alterations are required.

5.5 Soil Aggressiveness and Salinity

The aggressiveness or erosion potential of an environment in building materials, particularly concrete and steel is dependent on the levels of soil pH and the types of salts present, generally sulfates and chlorides. To determine the degree of aggressiveness, the test values obtained are compared to Tables 6.4.2 (C) and 6.5.2 (C) in AS2159 – 2009 Piling – Design and Installation. The test results are summarised in Table 5.3.

Table 5.3 – Soil Aggressiveness Summary

Sample No.	Location	Depth (m)	pH	Sulfate (mg/kg)	Electrical Conductivity (dS/m)	
					$EC_{1:5}$	EC_e
S1	BH2	0.4	5.0	110	0.068	0.5

The soils samples were cohesive and above groundwater. Therefore, soil conditions B are considered appropriate (AS2159).

In accordance with AS2159-2009 the exposure classification for the onsite soils is mildly aggressive to concrete and non-aggressive to steel. In accordance with AS2870-2011 the soils are classified as A2.

Reference to DLWC (2002) "Site Investigations for Urban Salinity" indicates that an EC_e value of 0.5 dS/m is consistent with the presence of non-saline soils.

6. FINAL COMMENTS

During construction, should the subsurface conditions vary from those inferred above, we would be contacted to determine if any changes should be made to our recommendations.

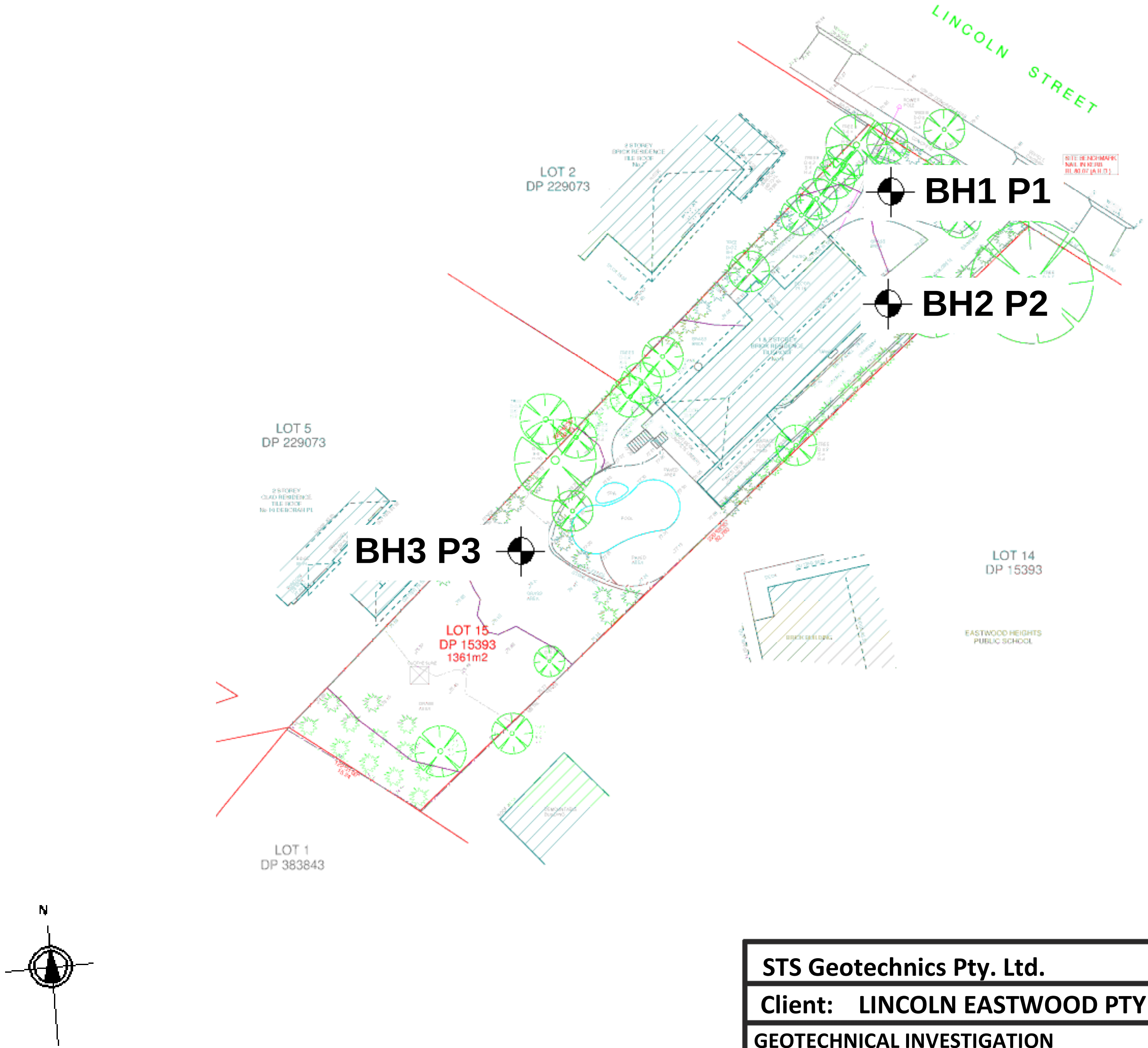
As discussed above, the shoring system must be installed up to the bottom of the shale, below the depth of bulk excavation level. Further it is important the excavation is inspected regularly as it progresses. Also, the exposed bearing surfaces for footings should be inspected by a geotechnical engineer to ensure the allowable pressure given has been achieved.

Yours faithfully,

Krishna Shakya
Geotechnical Engineer
STS Geotechnics Pty Ltd

Ian Watts
Geotechnical Engineer
STS Geotechnics Pty Ltd

Laurie Ihnativ
Principal Geotechnical Engineer
STS Geotechnics Pty Ltd



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: August 2022
Client: LINCOLN EASTWOOD PTY LTD		
GEOTECHNICAL INVESTIGATION **9 LINCOLN STREET, EASTWOOD** **BOREHOLE AND PENETROMETER LOCATIONS**		Project No. 31900/6747D-G Drawing No: 22/2883

NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

These notes have been provided to outline the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

When copies of reports are made, they should be reproduced in full.

Geotechnical Reports

Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work and is supplemented by knowledge of the local geology and experience of the range of properties that may be exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (eg. design of a three-storey building), the information and interpretation may not be appropriate if the design is changed (eg. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by STS Geotechnics Pty Limited in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, STS Geotechnics Pty Limited would be pleased to resolve the matter through further investigation, analysis or advice.

Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, STS Geotechnics Pty Limited should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

Subsurface Information

Logs of a borehole, recovered core, test pit, excavated face or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling and/or observation spacings and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume or material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements outside of specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localised perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures mask or prevent groundwater inflow.

The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

Supply of Geotechnical Information or Tendering Purposes

It is recommended tenderers are provided with as much geological and geotechnical information that is available and that where there are uncertainties regarding the ground conditions, prospective tenders should be provided with comments discussing the range of likely conditions in addition to the investigation data.

APPENDIX A – BOREHOLE LOGS AND EXPLANATION SHEETS

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Lincoln Eastwood Pty Ltd	Project / STS No. 31900/6747D-G	**BOREHOLE NO.: BH 1**
Project: 9 Lincoln Street, Eastwood	Date: August 8, 2022	
Location: Refer to Drawing No. 22/2883	Logged: EJ Checked By: KS	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			TOPSOIL: SILTY CLAY: dark grey	CL	-	M
			SILTY CLAY: brown, high plasticity	CH	STIFF	M
	U50				VERY STIFF	
		1.0	SILTY CLAY: pale grey - brown, medium plasticity	CH	VERY STIFF	M-D
		2.0				
		3.0	WEATHERED ROCK: grey, shale fragments		EXTREMELY LOW STRENGTH	D
		4.0	AUGER REFUSAL AT 4.0 M ON WEATHERED ROCK			
		5.0				

D - disturbed sample	U - undisturbed tube sample	B - bulk sample	Contractor: STS
WT - level of water table or free water		N - Standard Penetration Test (SPT)	Equipment: Edson RP70
S - jar sample			Hole Diameter (mm): 100
NOTES:	See explanation sheets for meaning of all descriptive terms and symbols		Angle from Vertical (^{o}): 0
			Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Lincoln Eastwood Pty Ltd	Project / STS No. 31900/6747D-G	**BOREHOLE NO.: BH 2**
Project: 9 Lincoln Street, Eastwood	Date: August 8, 2022	
Location: Refer to Drawing No. 22/2883	Logged: EJ Checked By: KS	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: COBBLES AND CLAY: white pebbles, dark grey clay, low plasticity		-	M
		1.0	SILTY CLAY: brown, high plasticity	CH	STIFF / VERY STIFF	M
		2.0	SILTYCLAY; grey - brown, medium plasticity		VERY STIFF	M
		3.0	WEATHERED SHALE: grey, shale fragments		EXTREMELY LOW STRENGTH	D
		4.0 5.0	AUGER REFUSAL AT 3.5 M ON WEATHERED SHALE			

D - disturbed sample U - undisturbed tube sample B - bulk sample

WT - level of water table or free water N - Standard Penetration Test (SPT)

S - jar sample

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: STS
Equipment: Edson RP70
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Lincoln Eastwood Pty Ltd	Project / STS No. 31900/6747D-G	**BOREHOLE NO.: BH 3**
Project: 9 Lincoln Street, Eastwood	Date: August 8, 2022	
Location: Refer to Drawing No. 22/2883	Logged: EJ Checked By: KS	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			TOPSOIL: SILTY CLAY: dark grey, medium plasticity	CL	-	M
			SILTY CLAY: brown, high plasticity	CH	STIFF VERY STIFF	M
		1.0				
			PUSH TUBE REFUSAL AT 1.3 M			
		2.0				
		3.0				
		4.0				
		5.0				

D - disturbed sample	U - undisturbed tube sample	B - bulk sample
WT - level of water table or free water		N - Standard Penetration Test (SPT)
S - jar sample		

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

Contractor: STS
Equipment: Push Tube
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

STS Geotechnics Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 | Email: enquiries@stsgeo.com.au

NATA
Accredited for Compliance with ISO/IEC 17025 - Testing
No. 2750

Dynamic Cone Penetrometer Test Report

Project: 9 LINCOLN STREET, EASTWOOD	Project No.: 31900/6747D-G
Client: LINCOLN EASTWOOD PTY LTD	Report No.: 22/2822
Address: 2 Toyer Avenue, Sans Souci	Report Date: 10/08/2022
Test Method: AS 1289.6.3.2	Page: 1 of 1

Site No.	P1	P2	P3			
Location	Refer to Drawing No. 22/2883	Refer to Drawing No. 22/2883	Refer to Drawing No. 22/2883			
Date Tested	5/8/2022	5/8/2022	5/8/2022			
Starting Level	Surface Level	Surface Level	Surface Level			
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	6	3	4			
0.15 - 0.30	3	2	3			
0.30 - 0.45	5	6	4			
0.45 - 0.60	7	8	9			
0.60 - 0.75	8	10	10			
0.75 - 0.90	10	10	9			
0.90 - 1.05	13	11	13			
1.05 - 1.20	22/D	13	16			
1.20 - 1.35	10/150	15	19			
1.35 - 1.50	Bouncing	22/D	18			
1.50 - 1.65		140/150	19			
1.65 - 1.80			17			
1.80 - 1.95			19			
1.95 - 2.10			21			
2.10 - 2.25			22/D			
2.25 - 2.40						
2.40 - 2.55						
2.55 - 2.70						
2.70 - 2.85						
2.85 - 3.00						
3.00 - 3.15						
3.15 - 3.30						
3.30 - 3.45						
3.45 - 3.60						
3.60 - 3.75						

Remarks: * Pre drilled prior to testing

Approved Signatory..
Orlando Mendoza - Laboratory Manager

Technician: EJ

E1. CLASSIFICATION OF SOILS

E1.1 Soil Classification and the Unified System

An assessment of the site conditions usually includes an appraisal of the data available by combining values of engineering properties obtained by the site investigation with descriptions, from visual observation of the materials present on site.

The system used by STS Geotechnics Pty Ltd (STS) in the identification of soil is the Unified Soil Classification system (USC) which was developed by the US Army Corps of Engineers during World War II and has since gained international acceptance and has been adopted in its metricated form by the Standards Association of Australia.

The Australian Site Investigation Code (AS1726-1981, Appendix D) recommends that the description of a soil includes the USC group symbols which are an integral component of the system.

The soil description should contain the following information in order:

Soil composition

- SOIL NAME and USC classification symbol (IN BLOCK LETTERS)
- plasticity or particle characteristics
- colour
- secondary and minor constituents (name estimated proportion, plasticity or particle characteristics, colour

Soil condition

- moisture condition
- consistency or density index

Soil structure

- structure (zoning, defects, cementing)

Soil origin

interpretation based on observation eg FILL, TOPSOIL, RESIDUAL, ALLUVIUM.

E1.2 Soil Composition

(a) Soil Name and Classification Symbol

The USC system is summarised in Figure E1.2.1. The primary division separates soil types on the basis of particle size into:

- Coarse grained soils - more than 50% of the material less than 60 mm is larger than 0.06 mm (60 µm).
- Fine grained soils - more than 50% of the material less than 60 mm is smaller than 0.06 mm (60 µm).

Initial classification is by particle size as shown in Table E1.2.1. Further classification of fine grained soils is based on plasticity.

TABLE E1.2.1 - CLASSIFICATION BY PARTICLE SIZE

NAME	SUB-DIVISION	SIZE
Clay (1)		< 2 µm
Silt (2)		2 µm to 60 µm
Sand	Fine Medium Coarse	60 µm to 200 µm 200 µm to 600 µm 600 µm to 2 mm
Gravel (3)	Fine Medium Coarse	2 mm to 6 mm 6 mm to 20 mm 20 mm to 60 mm
Cobbles (3)		60 mm to 200 mm
Boulders (3)		> 200 mm

Where a soil contains an appropriate amount of secondary material, the name includes each of the secondary components (greater than 12%) in increasing order of significance, eg sandy silty clay.

Minor components of a soil are included in the description by means of the terms “some” and “trace” as defined in Table E1.2.2.

TABLE E1.2.2 - MINOR SOIL COMPONENTS

TERM	DESCRIPTION	APPROXIMATE PROPORTION (%)
Trace	presence just detectable, little or no influence on soil properties	0-5
Some	presence easily detectable, little influence on soil properties	5-12

The USC group symbols should be included with each soil description as shown in Table E1.2.3

TABLE E1.2.3 - SOIL GROUP SYMBOLS

SOIL TYPE	PREFIX
Gravel	G
Sand	S
Silt	M
Clay	C
Organic	O
Peat	Pt

The group symbols are combined with qualifiers which indicate grading, plasticity or secondary components as shown on Table E1.2.4

TABLE E1.2.4 - SOIL GROUP QUALIFIERS

SUBGROUP	SUFFIX
Well graded	W
Poorly Graded	P
Silty	M
Clayey	C
Liquid Limit <50% - low to medium plasticity	L
Liquid Limit >50% - medium to high plasticity	H

(b) Grading

"Well graded"	Good representation of all particle sizes from the largest to the smallest.
"Poorly graded"	One or more intermediate sizes poorly represented
"Gap graded"	One or more intermediate sizes absent
"Uniformly graded"	Essentially single size material.

(c) Particle shape and texture

The shape and surface texture of the coarse grained particles should be described.

Angularity may be expressed as "rounded", "sub-rounded", "sub-angular" or "angular".

Particle **form** can be "equidimensional", "flat" or elongate".

Surface texture can be "glassy", "smooth", "rough", pitted" or striated".

(d) Colour

The colour of the soil should be described in the moist condition using simple terms such as:

Black	White	Grey	Red
Brown	Orange	Yellow	Green
Blue			

These may be modified as necessary by "light" or "dark". Borderline colours may be described as a combination of two colours, eg red-brown.

For soils that contain more than one colour terms such as:

- Speckled Very small (<10 mm dia) patches
- Mottled Irregular
- Blotched Large irregular (>75 mm dia)
- Streaked Randomly oriented streaks

(e) Minor Components

Secondary and minor components should be individually described in a similar manner to the dominant component.

*E1.3 **S**oil Condition*

(a) Moisture

Soil moisture condition is described as "dry", "moist" or "wet".

The moisture categories are defined as:
Dry (D) - Little or no moisture evident. Soils are running.
Moist (M) - Darkened in colour with cool feel. Granular soil particles tend to adhere. No free water evident upon remoulding of cohesive soils.

In addition the moisture content of cohesive soils can be estimated in relation to their liquid or plastic limit.

(b) Consistency

Estimates of the consistency of a clay or silt soil may be made from manual examination, hand penetrometer test, SPT results or from laboratory tests to determine undrained shear or unconfined compressive strengths. The classification of consistency is defined in Table E1.3.1.

TABLE E1.3.1 - CONSISTENCY OF FINE-GRAINED SOILS

TERM	UNCONFINED STRENGTH (kPa)	FIELD IDENTIFICATION
Very Soft	<25	Easily penetrated by fist. Sample exudes between fingers when squeezed in the fist.
Soft	25 - 50	Easily moulded in fingers. Easily penetrated 50 mm by thumb.
Firm	50 - 100	Can be moulded by strong pressure in the fingers. Penetrated only with great effort.
Stiff	100 - 200	Cannot be moulded in fingers. Indented by thumb but penetrated only with great effort.
Very Stiff	200 - 400	Very tough. Difficult to cut with knife. Readily indented with thumb nail.
Hard	>400	Brittle, can just be scratched with thumb nail. Tends to break into fragments.

Unconfined compressive strength as derived by a hand penetrometer can be taken as approximately double the undrained shear strength ($q_u = 2\ c_u$).

(c) Density Index

The insitu density index of granular soils can be assessed from the results of SPT or cone penetrometer tests. Density index should not be estimated visually.

TABLE E1.3.2 - DENSITY OF GRANULAR SOILS

TERM	SPT N VALUE	STATIC CONE VALUE q_c (MPa)	DENSITY INDEX (%)
Very Loose	0 - 3	0 - 2	0 - 15
Loose	3 - 8	2 - 5	15 - 35
Medium Dense	8 - 25	5 - 15	35 - 65
Dense	25 - 42	15 - 20	65 - 85
Very Dense	>42	>20	>85

E1.4 Soil Structure

(a) Zoning

A sample may consist of several zones differing in colour, grain size or other properties. Terms to classify these zones are:

Layer - continuous across exposure or sample
Lens - discontinuous with lenticular shape
Pocket - irregular inclusion
Each zone should be described, their distinguishing features, and the nature of the interzone boundaries.

(b) Defects

Defects which are present in the sample can include:

- fissures
- roots (containing organic matter)
- tubes (hollow)
- casts (infilled)

Defects should be described giving details of dimensions and frequency. Fissure orientation, planarity, surface condition and infilling should be noted. If there is a tendency to break into blocks, block dimensions should be recorded

E1.5 Soil Origin

Information which may be interpretative but which may contribute to the usefulness of the material description should be included. The most common interpreted feature is the origin of the soil. The assessment of the probable origin is based on the soil material description, soil structure and its relationship to other soil and rock materials.

Common terms used are:

"Residual Soil" - Material which appears to have been derived by weathering from the underlying rock. There is no evidence of transport.

"Colluvium" - Material which appears to have been transported from its original location. The method of movement is usually the combination of gravity and erosion.

"Landslide Debris" - An extreme form of colluvium where the soil has been transported by mass movement. The material is obviously distributed and contains distinct defects related to the slope failure.

"Alluvium" - Material which has been transported essentially by water. usually associated with former stream activity.

"Fill" - Material which has been transported and placed by man. This can range from natural soils which have been placed in a controlled manner in engineering construction to dumped waste material. A description of the constituents should include an assessment of the method of placement.

E1.6 Fine Grained Soils

The physical properties of fine grained soils are dominated by silts and clays.

The definition of clay and silt soils is governed by their Atterberg Limits. Clay soils are characterised by the properties of cohesion and plasticity with cohesion defines as the ability to deform without rupture. Silts exhibit cohesion but have low plasticity or are non-plastic.

The field characteristics of clay soils include:

- dry lumps have appreciable dry strength and cannot be powdered
- volume changes occur with moisture content variation
- feels smooth when moist with a greasy appearance when cut.

The field characteristics of silt soils include:

- dry lumps have negligible dry strength and can be powdered easily
- dilatancy - an increase in volume due to shearing - is indicted by the presence of a shiny film of water after a hand sample is shaken. The water disappears upon remoulding. Very fine grained sands may also exhibit dilatancy.
- low plasticity index
- feels gritty to the teeth

E1.7 Organic Soils

Organic soils are distinguished from other soils by their appreciable content of vegetable matter, usually derived from plant remains.

The soil usually has a distinctive smell and low bulk density.

The USC system uses the symbol Pt for partly decomposed organic material. The O symbol is combined with suffixes "O" or "H" depending on plasticity.

Where roots or root fibres are present their frequency and the depth to which they are encountered should be recorded. The presence of roots or root fibres does not necessarily mean the material is an "organic material" by classification.

Coal and lignite should be described as such and not simply as organic matter.

APPENDIX B – LABORATORY TEST RESULTS

STS Geotechnics Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 | Email: enquiries@stsgeo.com.au

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

NATA Accredited for Compliance with ISO/IEC 17025 - Testing No. 2750

Shrink Swell Index Report

Project: 9 Lincoln St., Eastwood | Project No.: 31900/6747D-G
Client: Lincoln Eastwood P/L | Report No.: 22/2878
Address: 2 Toyer Ave, Sans Souci | Report Date: 10/08/2022
Test Method: AS 1289.7.1.1 | Page: 1 of 1

Sampling Procedure: AS 1289.1.3.1 Clause 3.1.3.2 - Thin Walled Sampler

STS / Sample No.		6747D-G/S1					
Sample Location		Borehole 1					
Material Description		Silty Clay, red brown light grey					
Depth (m)		0.5 - 0.7					
Sample Date		5/08/2022					
Shrink	Moisture Content (%)	28.0					
	Soil Crumbling	Nil					
	Extent of Cracking	Nil					
	Strain (%)	4.3					
Swell	Moisture Content Initial (%)	21.2					
	Moisture Content Final (%)	25.9					
	Strain (%)	2.3					
Inert Inclusions (%)		44682.0					
Shrink Swell Index (%)		**3.0**					

Remarks:

Approved Signatory..

Technician: PI

Philip Ihnativ - Senior Geotechnician

Form: RPS41 | Date of Issue: 31/05/21 | Revision: 2

CERTIFICATE OF ANALYSIS

Work Order	: **ES2228031**	Page	: 1 of 4
Client	: **STS Geotechnics**	Laboratory	: Environmental Division Sydney
Contact	: ENQUIRES STS	Contact	: Customer Services ES
Address	: Unit 14/1 Cowpasture Place Wetherill Park 2164	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: 30055 / 30060 / 31887 / 31899 / 31900	Date Samples Received	: 08-Aug-2022 12:40
Order number	: 2022-254	Date Analysis Commenced	: 09-Aug-2022
C-O-C number	: ----	Issue Date	: 11-Aug-2022 15:29
Sampler	: EJ, MB		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 6		
No. of samples analysed	: 6		

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)

Compound	CAS Number	LOR	Unit	30055/8530	30055/8532	30060/1689	31887/S2	31899/S1
Sampling date / time				05-Aug-2022 00:00	05-Aug-2022 00:00	05-Aug-2022 00:00	05-Aug-2022 00:00	05-Aug-2022 00:00
				ES2228031-001	ES2228031-002	ES2228031-003	ES2228031-004	ES2228031-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.5	6.3	7.1	8.4	5.0
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	223	155	301	41	182
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	12.1	10.2	14.4	13.1	21.9
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	100	60	480	<10	230
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	<10	160

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	31900/S1	----	----	----	----
			Sampling date / time	05-Aug-2022 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	ES2228031-006	--------	--------	--------	--------
				Result	----	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.0**	----	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**68**	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**22.1**	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**110**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**20**	----	----	----	----