GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

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

March 1, 2021
Project No. 30055/7307
Report No. 21/0600
SS/ms

SUMMARY SHEET

Client: McDonald Jones Homes
Address: Lot 27A, 27 Fourth Avenue, Llandilo
Reference: 606239/016/01

SITE CLASSIFICATION	H1	AS2870-2011
WIND CLASSIFICATION	N1	AS4055-2012
EXPOSURE CLASSIFICATION	A2	AS2870-2011

This summary sheet must be read in conjunction with the full report.

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

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

March 1, 2021
Project No. 30055/7307
Report No. 21/0600
SS/ms

SITE INVESTIGATION REPORT

Client: McDonald Jones Homes
Address: Lot 27A, 27 Fourth Avenue, Llandilo
Proposed Development: Residential dwelling

Site Description

Approx. area (m^2): 10,000
Approx. fall: 0.5 metres to the east, poor site drainage
Vegetation: Grass and trees
Improvements: Vacant

Geology, Fieldwork Details and Subsurface Conditions

The Penrith geological series sheet at a scale of 1:100,000 shows the site is underlain by Tertiary Age Londonderry Clay. Soils within this formation comprise mainly clay with patches of ferruginised sand.

Two boreholes were drilled and two Dynamic Cone penetrometer (DCP) tests were carried out on February 22, 2021 at the locations shown on Drawing No. 21/0600. The subsurface conditions encountered are shown on the attached borehole logs. Explanation sheets and notes relating to geotechnical reports are also attached.

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.

The subsurface conditions consist of topsoil overlying topsoil, fill, silty clays and ferruginised sand. The topsoil is present to a depth of 0.2 metres. Fill underlies the topsoil in BH1 and is present to a depth of 0.5 metres. Firm to stiff becoming very stiff natural silty clays underlie the topsoil and fill to a depth of 1.6 metres. Hard ferruginised sand underlies the soils to the depth of drilling, 2.5 metres.

No groundwater was observed in the boreholes during the fieldwork.

Wind Classification

The classification given below has been carried out in accordance with the guidelines set out in AS4055-2012 “Wind loads for housing”.

Region	A
Terrain Category	TC2.5
Topographic Classification	T0
Shielding	PS
Rating	**N1**

Laboratory Testing

To assist with determining the site classification, a shrink/swell test was carried out on a representative sample retrieved from the site. The detailed test report is attached and summarised below:

Location	Depth (m)	Material Description	Shrink/Swell Index (% per ΔpF)
BH1	0.8-1.0	Brown with grey silty clay	1.5

Site Classification

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

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

Because of the AMC and due to the presence of greater than 400mm of fill, the site is classified a *Problem Site (P)*. However, provided the footings bear in natural material the site may be re-classified highly *reactive (H1).* After cutting and filling the classification remains unchanged.

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 details.

Foundation Design and Construction

Pad and/or strip footings founded in the firm to stiff, natural silty clays or fill that has written certification that it was placed as controlled engineering fill, may be proportioned using an allowable bearing pressure of 100 kPa. The minimum depth of founding must comply with the requirements of AS2870. To overcome the presence of trees, the foundations should be designed in accordance with the procedures given in Appendices H and CH of AS2870-2011. Tree information is attached.

Piles founded in very stiff natural clays may be proportioned using an allowable end bearing pressure of 450 kPa, provided their depth to diameter ratio of the pile exceeds a value of 4. An allowable adhesion value of 20 kPa may be adopted for the portion of the shaft within the natural soils.

Footings and piers founded in the ferruginised sand may be proportioned using an allowable end bearing pressure of 600 kPa. An allowable adhesion of 20 kPa may be adopted for the portion of the shaft within the weathered rock.

To ensure the bearing values given can be achieved, care should be taken to ensure the base of the excavations is free of all loose material prior to concreting. To this end, it is recommended that all excavations be concreted as soon as possible, preferably immediately after excavating, cleaning, inspecting and approval. Pier excavations should not be left open overnight. The possibility of groundwater inflow needs to be considered when drilling the piers and pouring concrete.

The site is considered suitable for slab on ground construction provided due regard is given to the ground surface slope and the fill is certified as being placed in a controlled manner. Otherwise, piers may be required to suspend the slab.

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.

Soil Aggressiveness

The exposure classification for the concrete has been determined for the onsite soils. The exposure classification is obtained from Tables 5.1 and 5.2 of AS2870-2011. In regard to the electrical conductivity, the laboratory test results have been multiplied by the appropriate factor to convert the results to EC_e.

Detailed test reports are attached and summarised below, together with the exposure classification.

Sample No.	Electrical Conductivity (dS/m)		pH	Sulfate (ppm)	Exposure Classification
	$EC_{1:5}$	EC_e			
S1/7307	0.142	1.6	5.2	40	A2

The minimum concrete strength and reinforcement cover required for the various exposure classifications are given in Tables 5.3 and 5.4 of AS2870-2011 (see attached).

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Additional Comments

Attention is drawn to Appendix B of AS2870 - 2011 regarding the need to properly maintain the foundations. Surface drainage should be provided to avoid the possibility of water ponding near the building and the finished ground surface should fall at least 50 mm over one metre away from the building.

The above classification has been made assuming that all footings will bear in either natural ground or in controlled filling. Prior to the placement of any filling the existing surface should be stripped of all vegetation and topsoil.

If excavations for rainwater or detention tanks are to be made within 6 metres of the building foundations, advice should be sought regarding their effect on the foundations.

Placing absorption trenches on the high side of the property may create abnormal moisture conditions for the foundations (Refer to Section 1.3.3 of AS2870). This could have a negative effect on the foundation performance and more than likely alter the site classification provided above.

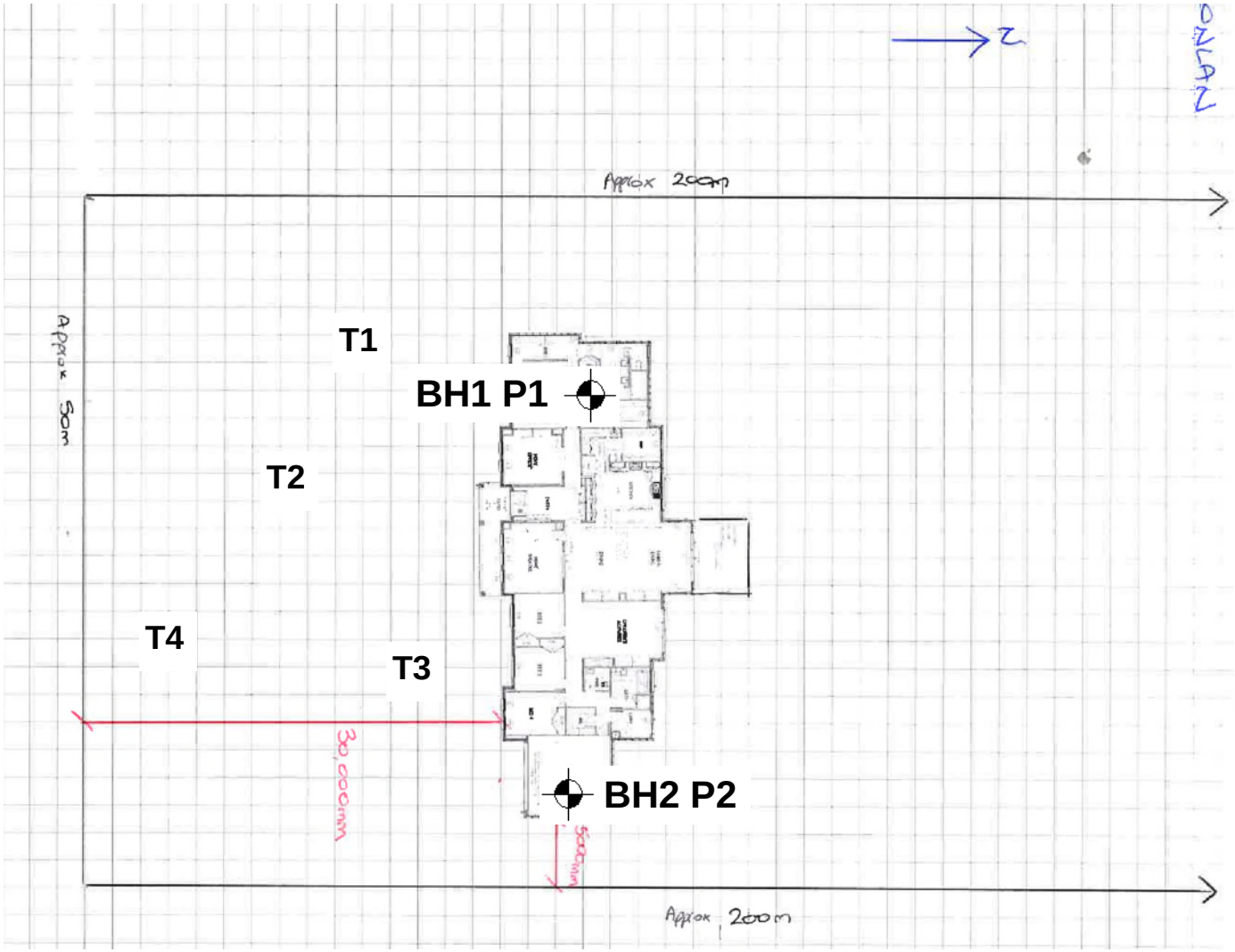
This report has been prepared assuming that no trees other than those noted will be present on the site. If future tree planting is planned, e.g. there is a landscaping plan, their effect on the foundation performance must be considered.

This report has been prepared assuming the site development will be limited to one or two storey residential buildings. The information and interpretation may not be relevant if the design proposal changes (e.g. to a five-storey building involving major cuts during the site preparation). If changes occur, we would be pleased to review the report and advise on the adequacy of the investigation.

Yours faithfully,

Slaiman Shirzai
Geotechnical Engineer
STS Geotechnics Pty Limited

FOURTH AVENUE



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: February 2021
Client: McDONALD JONES HOMES		
SITE INVESTIGATION **LOT 27A, 27 FOURTH AVENUE, LLANDILO** **BOREHOLE AND PENETROMETER LOCATIONS**	Project No. 30055/7307	Drawing No: 21/0600

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.

TABLE 5.1 FROM AS2870-2011

EXPOSURE CLASSIFICATION FOR CONCRETE IN SALINE SOILS

Saturated Extract Electrical Conductivity (EC_c), dS/m	Exposure Classification
<4	A1
4-8	A2
8-16	B1
>16	B2

NOTES:

1. Guidance on concrete in saline environments can be found in CCAA T56.

2. Exposure classifications are from AS3600.

3. The currently accepted method of determining the salinity level of the soil is by measuring the extract electrical conductivity (EC) of a soil and water mixture in deciSiemens per metre (dS/m) and using conversion factors that allow for the soil texture to determine the saturated extract electrical conductivity (EC_e).

4. The division between a non-saline and saline soil is generally regarded as an EC_e value of 4 dS/m, therefore no increase in the minimum concrete strength is required below this value.

TABLE 5.2 FROM AS2870-2011

EXPOSURE CLASSIFICATION FOR CONCRETE IN SULFATE SOILS

Exposure Conditions			Exposure Classification	
Sulfates (expressed as SO_4)*		pH	Soil Conditions A†	Soil Conditions B‡
In Soil ppm	In Groundwater ppm			
<5000	<1000	>5.5	A2	A1
5000-10 000	1000-3000	4.5-5.5	B1	A2
10 000-20 000	3000-10 000	4-4.5	B2	B1
>20 000	>10 000	<4	C2	B2

* Approximately 100 ppm SO_4 = 80 ppm SO_3.

† Soil conditions A – high permeability soils (eg. Sands and gravels) that are in groundwater.

‡ Soil conditions B – low permeability soils (eg. Silts and clays) or all soils have groundwater.

TABLE 5.3 FROM AS2870-2011

MINIMUM DESIGN CHARACTERISTIC STRENGTH (f'_c)
AND CURING REQUIREMENTS FOR CONCRETE

Exposure Classification	Minimum f'_c MPa	Minimum Initial Curing Requirement
A1	20	Cure continuously for at least 3 days
A2	25	
B1	32	Cure continuously for at least 7 days
B2	40	
C1	≥50	
C2	≥50	

TABLE 5.4 – FROM AS2870-2011

MINIMUM REINFORCEMENT COVER FOR CONCRETE

Exposure Classification	Minimum Cover in Saline Soils* (mm)	Minimum Cover in Sulfate Soils† (mm)
A1	See Clause 5.3.2	40
A2	45	50
B1	50	60
B2	55	65
C1	‡	70
C2	‡	85

* Where a damp-proofing membrane is installed, the minimum reinforcement cover in saline soils may be reduced to 30 mm.

† Where a damp-proofing membrane is installed, the minimum reinforcement cover in sulfate soils may be reduced by 10 mm.

‡ Saline soils have a maximum exposure classification of B2 as per Table 5.1.

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: McDonald Jones Homes	Project / STS No. 30055/7307	**BOREHOLE NO.: BH 1**
Project: Lot 27A, 27 Fourth Avenue, Llandilo	Date: February 22, 2021	
Location: Refer to Drawing No. 21/0600	Logged: MB Checked By: SS	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: brown, low plasticity, trace of organics	CL	FIRM TO STIFF	D-M
	S1 @ 0.3m		FILL: SILTY CLAY: dark brown, low plasticity	CL	STIFF TO VERY STIFF	D-M
		0.5	SILTY CLAY: brown with grey, low to medium plasticity	CL	VERY STIFF	D-M
	U50	1.0				
			SILTY CLAY: grey with red, low to medium plasticity	CL	VERY STIFF	D-M
		1.5	FERRUGINISED SAND: brown, clay seams		HARD	D
		2.0				
		2.5	BOREHOLE DISCONTINUED AT 2.5 M ON FERRUGINISED SAND			

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: Christie

Hole Diameter (mm): 100

Angle from Vertical (°): 0

Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: McDonald Jones Homes	Project / STS No. 30055/7307	**BOREHOLE NO.: BH 2**
Project: Lot 27A, 27 Fourth Avenue, Llandilo	Date: February 22, 2021	
Location: Refer to Drawing No. 21/0600	Logged: MB Checked By: SS	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: brown, low plasticity, trace of organics	CL	FIRM TO STIFF	D-M
			SILTY CLAY: brown, low to medium plasticity	CL	FIRM TO STIFF	D-M
		0.5			STIFF	
					VERY STIFF	
		1.0				
			SILTY CLAY: grey, low plasticity	CL	VERY STIFF	D
		1.5				
			FERRUGINISED SAND: brown, clay seams		HARD	D
		2.0				
		2.5				
			BOREHOLE DISCONTINUED AT 2.5 M ON FERRUGINISED SAND			

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: Christie

Hole Diameter (mm): 100

Angle from Vertical (°): 0

Drill Bit: Spiral

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

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Dynamic Cone Penetrometer Test Report

Project: LOT 27A, 27 FOURTH AVENUE, LLANDILO
Client: MCDONALD JONES HOMES
Address: 62 Norwest Boulevarde, Baulkham Hills
Test Method: AS 1289.6.3.2

Project No.: 30055/7307
Report No.: 21/0600
Report Date: 26/2/2021
Page: 1 of 1

NATA
Accredited for compliance with ISO/IEC 17025 - Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards
NATA Accreditation Number 2750

Site No.	P1	P2				
Location	Refer to Drawing No. 21/0600	Refer to Drawing No. 21/0600				
Date Tested	22/2/2021	22/2/2021				
Starting Level	Surface Level	Surface Level				
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	4	4				
0.15 - 0.30	4	3				
0.30 - 0.45	6	4				
0.45 - 0.60	6	5				
0.60 - 0.75	9	5				
0.75 - 0.90	11	16				
0.90 - 1.05	14	18				
1.05 - 1.20	16	23+				
1.20 - 1.35	23+	Refusal				
1.35 - 1.50	Refusal					
1.50 - 1.65						
1.65 - 1.80						
1.80 - 1.95						
1.95 - 2.10						
2.10 - 2.25						
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.....
Technician: MB
Orlando Mendoza - Laboratory Manager

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

Tree Heights and Type

Project: Lot 27A, 27 Fourth Avenue, Llandilo — Project No. / STS No.: 30055/7307

Client: McDonald Jones Homes — Technician: MB

Tree No.	Canopy Radius (m)	Distance from Tree Along Ground (m)	Uphill / Level / Downhill	Height of Tree (m)	Native (Y / N)	Growing/Mature
T1	10 - 15			15 - 20	Y	M
T2	10 - 15			15 - 20	Y	M
T3	10 - 15			15 - 20	Y	M
T4	10 - 15			15 - 20	Y	M

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

Shrink Swell Index Report

Project: LOT 27A, 27 FOURTH AVENUE, LLANDILO
Client: McDonald Jones Homes
Address: 62 Norwest Boulevarde, Baulkham Hills NSW 2153
Test Method: AS1289.7.1.1

Project No.: 30055/4883D-L
Report No.: 21/0596
Report Date: 26/02/2021
Page: 1 of 1

Sampling Procedure: AS 1289.1.3.1 Clause 3.1.3.2 - Thin Walled Sampler

STS / Sample No.		7307/1					
Sample Location		Borehole 1 Refer to Drawing No.21/0600					
Material Description		Gravelly Clay, red/grey					
Depth (m)		0.8 - 1.0					
Sample Date		22/02/2021					
Shrink	Moisture Content (%)	11.9					
	Soil Crumbling	Nil					
	Extent of Cracking	Fine Cracks					
	Strain (%)	2.1					
Swell	Moisture Content Initial (%)	12.8					
	Moisture Content Final (%)	15.3					
	Strain (%)	1.1					
Inert Inclusions (%)		<50					
Shrink Swell Index (%)		**1.5**					

Remarks:

Accredited for compliance with ISO/IEC 17025 - Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards
NATA Accreditation Number 2750

Approved Signatory.....

Technician: DH

Orlando Mendoza - Laboratory Manager

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2106318**	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	Date Samples Received	: 23-Feb-2021 12:30
Order number	: E-2021-0066	Date Analysis Commenced	: 24-Feb-2021
C-O-C number	: ----	Issue Date	: 25-Feb-2021 16:25
Sampler	: ----		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 8		
No. of samples analysed	: 8		

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	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Celine Conceicao	Senior Spectroscopist	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 Contact 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	30055/7307	30055/7328	30055/7355	30055/7372	30055/7381
			Sampling date / time	22-Feb-2021 00:00	23-Feb-2021 00:00	22-Feb-2021 00:00	22-Feb-2021 00:00	22-Feb-2021 00:00
Compound	CAS Number	LOR	Unit	ES2106318-001	ES2106318-002	ES2106318-003	ES2106318-004	ES2106318-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.2**	**6.8**	**6.1**	**7.0**	**7.5**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**142**	**16**	**35**	**147**	**380**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**22.0**	**8.6**	**3.5**	**5.8**	**9.9**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**70**	<10	<10	**20**	**340**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	30055/7382	30055/7385	30060/1387	----	----
			Sampling date / time	22-Feb-2021 00:00	22-Feb-2021 00:00	23-Feb-2021 00:00	----	----
Compound	CAS Number	LOR	Unit	ES2106318-006	ES2106318-007	ES2106318-008	--------	--------
				Result	Result	Result	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**8.7**	**5.2**	**5.5**	**----**	**----**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**478**	**85**	**20**	**----**	**----**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**10.2**	**15.4**	**19.0**	**----**	**----**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**330**	**80**	**10**	**----**	**----**

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.