GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

GEOTECHNICAL INVESTIGATION AND ACID SULFATE SOIL ASSESSMENT

FOR

MJ HOLDINGS 1 PTY LTD

2 Eastbourne Road, Homebush, New South Wales

Report No: 20/1824

Project No: 30418/3915D-G

June 2020

STRATHFIELD COUNCIL
RECEIVED

ADDITIONAL INFORMATION

DA2020/080
19 June 2020

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1. INTRODUCTION

This report presents the results of a combined Geotechnical Investigation and Acid Sulfate Soil (ASS) assessment carried out by STS GeoEnvironmental Pty Limited (STS) for a proposed new residential development to be constructed at 2 Eastbourne Road, Homebush. We have been informed the development includes construction of a five level residential unit type building with two levels of basement car parking. Construction of the basement car parking will require excavating to depths up to 6 metres below the existing ground surface level. We understand that the site is located within a Class 5 Acid Sulfate Soil area and therefore Council requires an assessment to be undertaken.

The purpose of the investigation was to:

- assess the subsurface conditions over the site,
- provide a Site Classification to AS2870,
- provide recommendations regarding the appropriate foundation system for the site including design parameters,
- provide recommendations regarding vibration control during rock excavation,
- provide parameters for the temporary and permanent support of the excavation,
- comment on soil aggressiveness to buried steel and concrete,
- undertake an ASS assessment, and
- determine if an ASS Management Plan is required.

The investigation was undertaken at the request of Jaycorp Group on behalf of MJ Holdings 1 Pty Limited.

Our scope of work did not include a contamination assessment.

2. NATURE OF THE INVESTIGATION

2.1. Fieldwork

The fieldwork consisted of drilling two (2) boreholes numbered BH1 and BH2, at the locations shown on Drawing No. 20/1824. Boreholes were drilled using a utility mounted Edson RP70 drilling rig owned and operated by STS. Soils and weathered rock were drilled using rotary solid flight augers. Soil strengths were determined by undertaking Dynamic Cone Penetrometer (DCP) tests at each borehole location. In order to monitor groundwater levels, a PVC standpipe piezometer was installed in BH1.

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

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.

2.2. Laboratory Testing

In order to assess the soils for their aggressiveness selected representative soil samples were tested to determine the following:

- pH,
- Sulphate Content (SO_4),
- Chloride Content (CL), and
- Electrical Conductivity (EC).

Detailed test reports are given in Appendix B.

3. GEOLOGY AND SITE CONDITIONS

The Sydney geological series sheet at a scale of 1:100,000 shows Triassic Age Ashfield Shale of the Wianamatta Group underlies the site. Rocks within this formation comprise shale, claystone and laminite. Sandstone lenses are known to exist.

The site is roughly trapezoidal in shape with an area of approximately 1,572 m^2. At the time of the fieldwork, the site was occupied by a series of two storey brick residential townhouse units with tile roofs and concrete driveway. Site vegetation comprised grass, trees and shrubs in the gardens.

The ground surface falls approximately 1.5 metres to the north.

To the west of the site is Eastbourne Road. There is a brick rendered place of worship along the north-western portion of the site boundary and to the remaining sides are residential properties. The surrounding residential properties typically comprise two storey unit type structures and have been constructed close to the site boundaries.

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.

The subsurface conditions generally consist of fill overlying silty clays, and weathered shale. Fill was present in both boreholes to depths of 0.3 to 1.0 metre. Natural silty clays are present to depths of 1.5 to 1.8 metres. The consistency of the clays varies from firm to stiff becoming stiff to very stiff. Weathered shale underlies the site to the depth of auger refusal, 4.6 to 5.3 metres.

Groundwater was not observed during auger drilling of the boreholes. Five days later the piezometer installed in BH1 was inspected and no groundwater was observed.

5. GEOTECHNICAL DISCUSSION

5.1. Site Classification to AS2870

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

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

Because of the AMC present, the site is classified *a problem site (P).* Provided the recommendations given below are adopted and the footings bear in the underlying natural soils, the site may be reclassified *Moderately Reactive (M).*

5.2. Excavation Conditions and Support

Based on the subsurface conditions observed in the boreholes, it is expected that the proposed basement excavation will encounter fill, silty clays and weathered shale. Excavators without assistance should be able to remove the soils and some of the weathered bedrock.

Excavators alone without assistance will not be able to remove any significant amount of the rock below the depth of auger refusal as shown on the borehole logs. Hydraulic breakers mounted on an excavator or jack hammers will be required to break up the majority of the rock below these depths before it can be removed using an excavator.

Particular care will be required to ensure that buildings or other developments on adjacent properties are not damaged when excavating the rock. The structures on the adjacent properties may be founded directly on the shale bedrock. Buildings founded directly on rock can often be very susceptible to damage from vibrations.

Excavations methods should be adopted which limit ground vibrations at the adjoining developments to not more than 10 mm/sec. Vibration monitoring will be required to verify that this is achieved. However, if the contractor adopts methods and/or equipment in accordance with the recommendations in Table 5.1 for a ground vibration limit of 5 mm/sec, vibration monitoring may not be required.

Table 5.1 – Recommendations for Rock Breaking Equipment

Distance from adjoining structure (m)	Maximum Peak Particle Velocity 5 mm/sec		Maximum Peak Particle Velocity 10 mm/sec	
	Equipment	Operating Limit (% of Maximum Capacity)	Equipment	Operating Limit (% of Maximum Capacity)
1.5 to 2.5	Hand operated jackhammer only	100	300 kg rock hammer	50
2.5 to 5.0	300 kg rock hammer	50	300 kg rock hammer or 600 kg rock hammer	100 50
5.0 to 10.0	300 kg rock hammer or 600 kg rock hammer	100 50	600 kg rock hammer or 900 kg rock hammer	100 50

*Vibration monitoring is recommended for 10 mm/sec vibration limit.

The limits of 5 mm/sec and 10 mm/sec are expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 5.1.

At all times, the excavation equipment must be operated by experienced personnel, according to the manufacturer's instructions and in a manner consistent with minimising vibration effects.

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.

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

Saw cutting should be carried out before any rock breaking is commenced on the site. 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.

It is of course important that the onsite excavations are adequately supported at all times and do not endanger the adjacent properties.

Temporary slopes in the soils and weathered rock may be constructed at a maximum angle of 1 to 1. Where this is not possible it will be necessary to provide temporary support. Support will probably need to be drilled and fixed into the materials below the base of 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 the water table present. Where the 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. Anchors or props can be used to provide the required support. If anchors extend into adjoining property, it will be necessary to obtain the permission of the property owners. Anchors should be installed into the weathered rock. When props or anchors are used for support, a rectangular earth pressure distribution should be adopted on the active side of the support. K_o should also be used to design the permanent support.

The following parameters are suggested for the design of the retaining wall system where there is a level ground surface:

Soil and Weathered Shale (To the depth of auger refusal as shown on the borehole logs):

Active Earth Pressure Coefficient (Ka)	=	0.4
At Rest Pressure Coefficient (Ko)	=	0.55
Total (Bulk) Density	=	20 kN/m^3

Weathered Shale (Below the depth of auger refusal as shown on the borehole logs):

Earth Pressure Coefficient = 0.1 or 10 kPa (whichever is lesser)

Passive Earth Pressure Coefficient (Kp)	=	4.5 (shale only)
Total (Bulk) Density	=	22 kN/m^3

Based on the observations during drilling and in the piezometer, the basement excavation is not expected to encounter the groundwater table. However, some minor perched water seepage may flow into the excavation from the soil rock interface. The inflow rates are likely to be minor and therefore a sump and pump type system should be sufficient to control the anticipated seepage.

5.3. Foundation Design

Footings that bear in the firm to stiff natural clayey soils below any fill and soft clays at a high level may be proportioned using an allowable bearing pressure of 100 kPa. This value may be increased to 150 kPa when founding in stiff natural materials.

After the basement excavation has been completed the exposed material will likely comprise weathered shale. An allowable bearing pressure of 700 kPa may be used to proportion pad and/or strip footings or piles founded on weathered shale. For piles an allowable adhesion of 70 kPa may be adopted for the portion of the shaft within the weathered shale. These values may be increased to 1,000 kPa and 100 kPa, respectively, when founding below the depth of auger refusal as shown on the borehole logs. When piles are founded in rock the adhesion in the overlying soils must be ignored.

Should a combination of clays and shale bedrock be present in the base of the excavation, then bucket piles or the like will be required to ensure all loads are transferred to the underlying shale bedrock.

In order to ensure the bearing values given can be achieved, care should be taken to ensure that the base of excavations are free of all loose material prior to concreting. It is recommended that all footing excavations be protected with a layer of blinding concrete as soon as possible, preferably immediately after excavating, cleaning, inspection and approval. The possible presence of groundwater needs to be considered when drilling piers and pouring concrete.

5.4. Soil Aggressiveness

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 sulphates and chlorides. In order 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 and Tables 5.1 and 5.2 of AS2870-2011. In regards to the electrical conductivity, the laboratory test results have been multiplied by the appropriate factor to convert the results to EC_e. The test results are summarised in Table 5.2 below.

Table 5.2 – Soil Aggressiveness Summary Table

Sample No.	Location	Depth (m)	pH	Sulfate (mg/kg)	Chloride (mg/kg)	Electrical Conductivity (dS/m)	
						$EC_{1:5}$	EC_e
S1	BH1	1.5	5.6	180	500	0.266	1.9
S2	BH2	0.6	5.9	60	20	0.034	0.2

The report results range between:

- pH - 5.6 and 5.9
- soluble SO_4 - 60 and 180 mg/kg (ppm)
- soluble Cl - 20 and 500 mg/kg (ppm)
- EC_e - 0.2 and 1.9 dS/m

The soils on the site consist of low permeability clays. Therefore, the soil conditions B are considered appropriate.

A review of the durability aspects indicates that:

- pH : minimum value of 5.6
- SO_4 : maximum value of 180 mg/kg (ppm) < 5000 ppm
- Cl : maximum value of 500 mg/kg (ppm) < 5000 ppm
- EC_e : maximum value of 1.9 dS/m

The exposure classification for the onsite soils is non-aggressive to steel and concrete in accordance with AS2159-2009. The soils are classified as A1 in accordance with AS2870-2011.

Reference to DLWC (2002) “Site Investigations for Urban Salinity” indicates that EC_e values of 0.2 dS/m and 1.9 dS/m are consistent with the presence of non-saline soils.

6. ACID SULFATE SOIL ASSESSMENT

6.1. Introduction

ASS are the common name given to sediments and soils containing iron sulfides which, when exposed to oxygen generate sulfuric acid. Natural processes formed the majority of acid sulfate sediments when certain conditions existed in the Holocene geological period (the last 10,000 years). Formation conditions require the presence of iron-rich sediments, sulfate (usually from seawater), removal of reaction products such as bicarbonate, the presence of sulfate reducing bacteria and a plentiful supply of organic matter. It should be noted that these conditions exist in mangroves, salt marsh vegetation or tidal areas, and at the bottom of coastal rivers and lakes.

The relatively specific conditions under which acid sulfate soils are formed usually limit their occurrence to low lying parts of coastal floodplains, rivers and creeks. This includes areas with saline or brackish water such as deltas, coastal flats, backswamps and seasonal or permanent freshwater swamps that were formerly brackish. Due to flooding and stormwater erosion, these sulfidic sediments may continue to be re-distributed through the sands and sediments of the estuarine floodplain region. Sulfidic sediment may be found at any depth in suitable coastal sediments – usually beneath the water table.

Any lowering in the water table that covers and protects potential ASS will result in their aeration and the exposure of iron sulfide sediments to oxygen. The lowering in the water table can occur naturally due to seasonal fluctuations and drought or any human intervention, when carrying out any excavations during site development. Potential ASS can also be the exposed to air during physical disturbance with the material at the disturbance face, as well as the extracted material, both potentially being oxidised. The oxidation of iron sulfide sediments in potential ASS results in ASS soils.

Successful management of areas with ASS is possible but must take into account the specific nature of the site and the environmental consequences of development. While it is preferable that sites exhibiting acid sulfate characteristics not be disturbed, management techniques have been devised to minimise and manage impacts in certain circumstances.

When works involving the disturbance of soil or the change of groundwater levels are proposed in coastal areas, a preliminary assessment should be undertaken to determine whether acid sulfate soils are present and if the proposed works are likely to disturb these soils.

6.2. Presence of ASS

Reference to the Prospect Parramatta ASS Risk Map indicates the property is within an area where there are no known occurrences of ASS. It should be noted that maps are a guide only.

The following geomorphic or site criteria are normally used to determine if acid sulfate soils are likely to be present:

- sediments of recent geological age (Holocene)
- soil horizons less than 5 in AHD
- marine or estuarine sediments and tidal lakes
- in coastal wetlands or back swamp areas

6.3. Assessment

The property is at an elevation of about RL21 m AHD and is underlain by residual clayey soils overlying bedrock belonging to the Ashfield Shale formation. This is not consistent with the geomorphic criteria necessary for the presence of ASS. Based on our onsite observations and the subsurface conditions exposed in the boreholes, it is our opinion that the proposed construction will not intercept any ASS. Based on the observations undertaken during drilling, it appears that any seepage into the basement would be minor and as a consequence, construction will not result in the lowering of any groundwater that may be present in the area.

Our assessment is the proposed construction will not require the preparation of an Acid Sulfate Soil Management Plan.

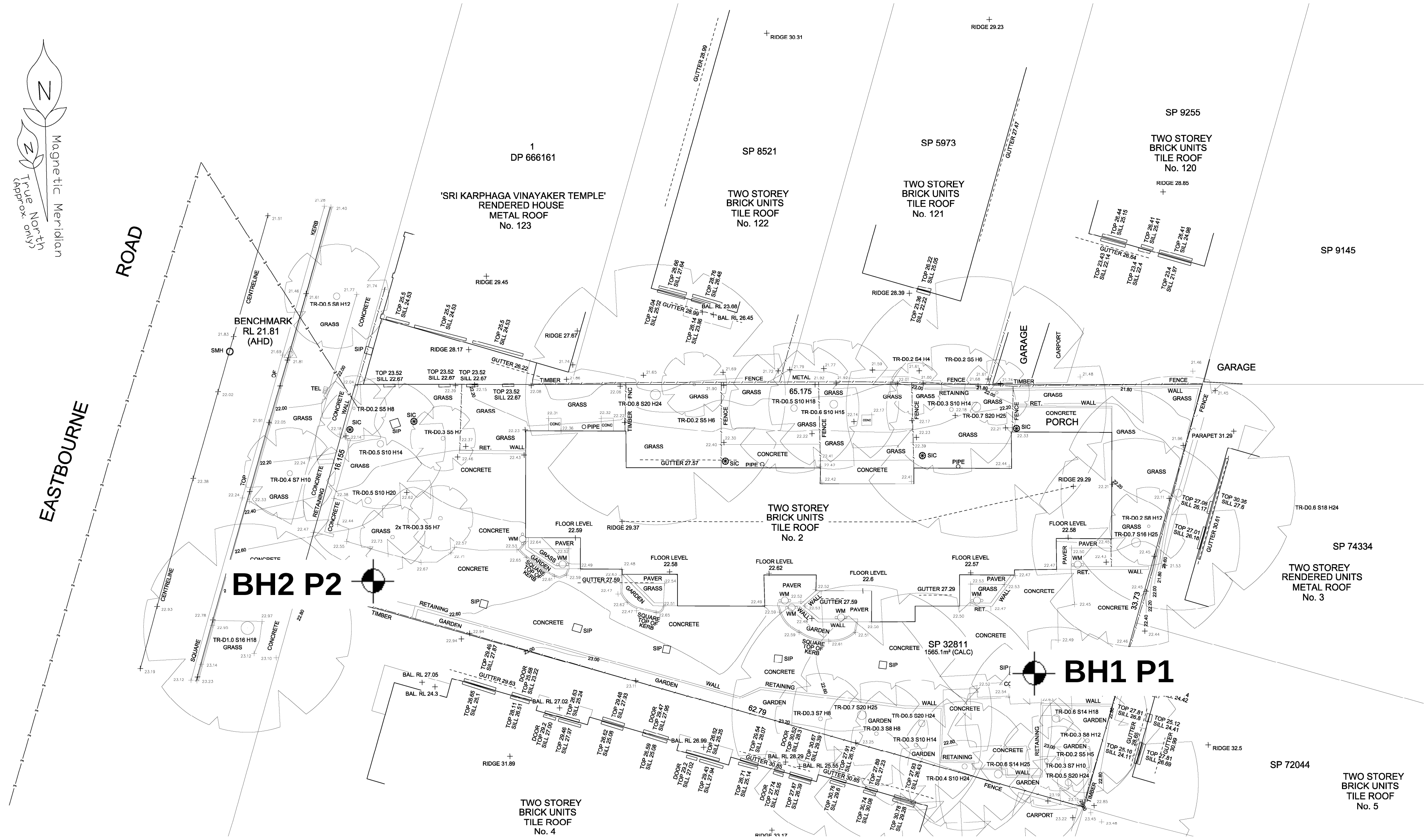
7. FINAL COMMENTS

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.

The exposed bearing surfaces for footings should be inspected by a geotechnical engineer to ensure the allowable pressure given has been achieved.

Rasoul Machiani
Senior Geotechnical Engineer
STS Geotechnics Pty Limited

Matthew Green
Principal Engineering Geologist
STS Geotechnics Pty Limited



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: June 2020
Client: MJ HOLDINGS 1 PTY LTD		
GEOTECHNICAL INVESTIGATION 2 EASTBOURNE STREET, HOMEBUSH BOREHOLE AND PENETROMETER LOCATIONS	Project No. 30418/3915D-G	Drawing No: 20/1824

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: MJ Holdings 1 Pty Ltd	Project / STS No. 30418/3915D-G		**BOREHOLE NO.: BH 1**
Project: 2 Eastbourne Street, Homebush	Date: June 11, 2020		
Location: Refer to Drawing No. 20/1824	Logged: JK	Checked By: MG	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: SILTY SANDY CLAY: dark grey/brown, fine grained, low plasticity, trace of gravel/metal (tree roots)	CL	VARIABLE	M
		1.0				
	S1 @ 1.5 m		SILTY CLAY: light grey with orange brown and red brown, medium to high plasticity, trace of shale gravel	CL/CH	STIFF VERY STIFF	M-D
		2.0	WEATHERED SHALE: red brown with light grey, clay seams		EXTREMELY LOW STRENGTH	D
			(becoming dark grey and harder to drill)			
		3.0				
		4.0				
		5.0				
			AUGER REFUSAL AT 5.3 M ON WEATHERED SHALE			
			STANDPIPE PIEZOMETER INSTALLED			

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: Two Prong

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: MJ Holdings 1 Pty Ltd	Project / STS No. 30418/3915D-G	BOREHOLE NO.: BH 2
Project: 2 Eastbourne Street, Homebush	Date: June 11, 2020	
Location: Refer to Drawing No. 20/1824	Logged: JK Checked By: MG	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: SILTY CLAY: dark brown, medium plasticity, trace of gravel	CL	VARIABLE	M
	S2 @ 0.6 m		SILTY CLAY: orange brown with light grey, medium to high plasticity	CL/CH	FIRM TO STIFF / STIFF	M
		1.0	SILTY CLAY: light grey with orange brown, medium to high plasticity, trace of shale gravel	CL/CH	VERY STIFF	M-D
		2.0	WEATHERED SHALE: dark grey with light grey and orange brown, clay seams (easy to drill)		EXTREMELY LOW STRENGTH	D
		3.0				
		4.0	(becoming dark grey and harder to drill)			
		5.0	AUGER REFUSLA AT 4.6 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		

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

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

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GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Dynamic Cone Penetrometer Test Report

Project: 2 EASTBOURNE STREET, HOMEBUSH — Project No.: 30418/3915D-G
Client: MJ HOLDINGS 1 PTY LTD — Report No.: 20/1824
Address: Suite 1, 32-36 Underwood Road, Homebush — Report Date: 17/06/2020
Test Method: AS 1289.6.3.2 — 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. 20/1824	Refer to Drawing No. 20/1824				
Date Tested	11/6/2020	11/6/2020				
Starting Level	Surface Level	Surface Level				
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	*	*				
0.15 - 0.30	2	*				
0.30 - 0.45	1	*				
0.45 - 0.60	3	2				
0.60 - 0.75	22	4				
0.75 - 0.90	Refusal	4				
0.90 - 1.05	*	6				
1.05 - 1.20	8	11				
1.20 - 1.35	10	13				
1.35 - 1.50	9	22				
1.50 - 1.65	12	Refusal				
1.65 - 1.80	22					
1.80 - 1.95	Refusal					
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: JK
Orlando Mendoza - Laboratory Manager

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.

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APPENDIX B – LABORATORY TEST RESULTS

CERTIFICATE OF ANALYSIS

Work Order	: **ES2020324**	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	: 30418/30539/30055/30060	Date Samples Received	: 12-Jun-2020 11:00
Order number	: E-20-0210	Date Analysis Commenced	: 15-Jun-2020
C-O-C number	: ----	Issue Date	: 17-Jun-2020 14:31
Sampler	: JK/MB/BH		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 9		
No. of samples analysed	: 9		

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. 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
Ivan Taylor	Analyst	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)			Client sample ID	30418/S1	30418/S2	30539/S1	30539/S2	30055/6596
			Client sampling date / time	11-Jun-2020 00:00	11-Jun-2020 00:00	11-Jun-2020 00:00	11-Jun-2020 00:00	11-Jun-2020 00:00
Compound	CAS Number	LOR	Unit	ES2020324-001	ES2020324-002	ES2020324-003	ES2020324-004	ES2020324-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	----	----	----	----	**6.3**
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.6**	**5.9**	**5.2**	**5.2**	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	----	----	----	----	**471**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**266**	**34**	**53**	**34**	----
EA055: Moisture Content								
Moisture Content	----	1.0	%	----	----	----	----	**16.7**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**13.7**	**18.7**	**24.7**	**19.6**	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**180**	**60**	**120**	**90**	**340**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**500**	**20**	<10	**20**	----

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL)**

			Client sample ID	30055/6597	30060/1163	30060/1164	30060/1166	----
			Client sampling date / time	11-Jun-2020 00:00	11-Jun-2020 00:00	11-Jun-2020 00:00	11-Jun-2020 00:00	----
Compound	*CAS Number*	*LOR*	*Unit*	ES2020324-006	ES2020324-007	ES2020324-008	ES2020324-009	--------
				Result	Result	Result	Result	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.0**	**8.7**	**5.9**	**5.5**	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**64**	**259**	**419**	**301**	----
EA055: Moisture Content								
Moisture Content	----	1.0	%	**11.4**	**7.4**	**10.0**	**13.7**	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**80**	**120**	**170**	**240**	----