GeoEnvironmental Pty Ltd

Geotechnical and Environmental Solutions

GEOTECHNICAL INVESTIGATION, ACID SULFATE SOILS ASSESSMENT AND PRELIMINARY LANDSLIP ASSESSMENT

FOR

BERGE DE SARKISSIAN

72 Carrington Parade, Curl Curl, New South Wales

Report No: 18/3658

Project No: 22311/1319D

December 2018

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1. INTRODUCTION

This report presents the results of a combined Geotechnical Investigation, Acid Sulfate Soils Assessment and Preliminary Landslip Assessment carried out carried out by STS GeoEnvironmental Pty Limited (STS) for proposed new residential dwelling to be constructed at 72 Carrington Parade, Curl Curl. We have been informed the development comprises construction of a double storey residential dwelling including a non-habitable basement storage level. Construction of the basement level will require excavating to depths of between 2.0 and 3.0 metres below existing ground surface levels. In addition, we understand that the site is located within a Class V Acid Sulfate Soils area, and is located with Landslip Zone A. It is therefore likely that Northern Beaches Council will require an assessment addressing these restrictions.

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, and
- provide parameters for the temporary and permanent support of the basement excavation,
- undertake a Preliminary Landslip Assessment in accordance with councils' guidelines,
- undertake an Acid Sulfate Soils Assessment, and
- determine if an Acid Sulfate Soils Management Plan is required.

The investigation was undertaken at the request of Cantilever Engineers on behalf of Berge Der Sarkissian.

Our scope of work did not include a contamination assessment.

2. FIELDWORK DETAILS

The fieldwork consisted of drilling of two (2) boreholes numbered BH1 and BH2, and undertaking two (2) Perth Sand Penetrometers (PSP's) numbered P1 and P2, at the locations shown on Drawing No. 18/3658. Restricted site access dictated the borehole locations. BH1 was drilled using rotary augers attached to a track mounted Christie drilling rig owned and operated by STS. ***Due to restricted site access, BH2 was drilled using a hand auger.***

To assist in determining groundwater levels, a PVC standpipe piezometer was installed in BH1.

Drilling operations were undertaken by one of STS's senior technical officers 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.

3. GEOLOGY AND SITE CONDITIONS

The Sydney geological series sheet, at a scale of 1:100,000 indicates that the site is underlain by Triassic Age bedrock belonging to the Hawkesbury Sandstone formation. Bedrock within this formation comprises fine to medium grained quartz sandstone. The site is located close a geological boundary with Quaternary Age alluvial soils comprising medium to fine grained marine sands. The soils were deposited as a foredune system.

The site is roughly rectangular in shape with an area of approximately 322m^2. At the time of the fieldwork, the site was occupied by a single level clad residence with tile roof, separate fibro clad garage and shed. Site vegetation comprised grass, trees and shrubs.

The ground surface falls approximately 2.0 metres to the east from RL12.0 metres to RL10.0 metres.

To the north of the site is Gardere Avenue and to the east is Carrington Parade. To the south of the site is a double storey brick rendered residential dwelling and to the west is a split-level residential dwelling. The dwelling to the west is retained from the subject site by a concrete block retaining wall. To the east of the site beyond Carrington Parade is the South Pacific Ocean.

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 topsoil overlying natural sands, silty sands and silty clayey sands. Topsoil was encountered in both boreholes to depths of 0.25 to 0.4 meters and could not be penetrated with a hand auger in BH2 due to the continual collapse of the loose sands. In BH1 natural sands, silty sands and silty clayey sands underlie the site to the maximum depth of drilling, 6.0 metres. The sands are typically loose to depths of 0.4 to 1.0

meters, becoming loose to medium dense below these depths and medium dense below depths pf 1.1 to 2.2 metres.

Groundwater seepage was not observed during the auger drilling of the boreholes and the piezometer installed in BH1 remained dry after a period of 6 days.

5. 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.

Due to the presence of loose sands the site is classified a *problem site (P).* However, provided the recommendations given below are adopted and the footings bear in loose to medium dense or better natural sands, the site may be classified a *stable site (A).*

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.

5.2. Excavation Conditions and Support

Based on subsurface conditions observed in the boreholes, it is expected that the proposed basement excavations will encounter topsoil and natural sands. Excavators without assistance should be able to remove the soils to the proposed depth of excavation, 3.0 metres. Excavation using hydraulic hammers is not anticipated.

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 sandy soils may be constructed at a maximum angle of 2H:1V. Where there is insufficient room for batter slopes, it will be necessary to provide temporary support using contiguous piles. To prevent the loose sandy soils from running between the piles, any gaps that have formed between the piles during installation should be progressively packed with grout during the bulk excavation process. The 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. 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:

Active Earth Pressure Coefficient (K_a)	=	0.33
At Rest Pressure Coefficient (K_o)	=	0.55
Passive Earth Pressure Coefficient (K_p)	=	3.30
Total (Bulk) Density	=	20 kN/m^3

5.3. Foundation Design

The loose sands are not suitable for foundation support. High level pad/strip footings founded in loose to medium dense sands below a depth of 1.0 metre may be proportioned using an allowable bearing pressure of 100 kPa.

Medium dense sands appear to be present at the proposed basement bulk excavation depth. Pad and/or strip footings founded in medium dense natural sands may be proportioned using the allowable bearing pressures given below in Table 5.1. The footings must be sufficiently stiff enough to distribute the load evenly over the whole footing area.

Table 5.1 – Allowable Bearing Pressures for Medium Dense Sands

Footing Width (m)	0.5	1.0	1.5
Allowable Bearing Pressure (kPa)	200	270	340

The above bearing pressures assume the footings are embedded a minimum of 0.5 metres of the final adjoining ground surface. We have estimated if the above allowable bearing pressures are applied they will likely result in settlements of between 10 to 20 mm.

It is possible that on completion of the bulk excavation works, shallow footings constructed over the eastern portion of the site will encounter loose sands. It may therefore be necessary to either deepen the footings to reach medium dense sands, or suspend this section of the dwelling on piles extending to the underlying medium dense sands.

Should you wish to suspend the structures on piles then we would be happy to determine the capacity of the piles once the working loads are known.

Due to the sandy nature of the soils the site may not be suitable for conventional bored cast in-situ piles. In this regard either steel sheet piles, steel screw piles or continuous flight auger (CFA) grout/concrete injected piles are better suited to the site conditions.

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.

5.4. Preliminary Landslip Assessment

The development will comprise the construction of a double storey residential dwelling with single level basement. The maximum depth of excavation for the basement is in the order or 3.0 metres. The Council landslip hazards map shows the property is within the Class A area.

The preliminary landslip carried out is based on Council's check list. The assessment follows:

- Does the site or adjacent properties have a history of slope instability – No.
- Are excavations or fills greater than 2 metres proposed – Yes.
- Is the site developed – Yes.
- Is fill greater than 1m present on the site: No
- Are cuts / excavations greater than 2 metres present on the site: No.

Based on our observations and Council's check list, a detailed landslip assessment will be required due to the proposed depth of excavation exceeding 2.0 metres.

5.5. Further Landslip Assessment

The stability of a slope is governed by three factors. These are:

- Ground surface slope,
- soil strength, and
- water

The existing ground surface has a slope of less than 5 degrees. The onsite soils comrprise loosee becoming medium dense sands. No ground water was observed.

For the site in its current condition our assessment is that if slope instability did occur there would be minor damage that would require repairs to only a part of the site. The likelihood of slope instability occurring is considered to be rare. Therefore, using the Australian Geomechanics Landslide Risk procedure, the site is assessment to have a very low level of risk. This means, there are no limitations on site development other than normal good engineering practices and good hillside construction practices are adopted. Examples of good and poor hillside practices are attached.

The proposed basement excavation poses an increase to the risk of instability if the works are not undertaken in accordance with the recommendations given in this report. However, provided the works are undertaken in accordance with the recommendations given in this report, in particular Section 5.2, we see no reason why the proposed basement excavation works would result in increase in the slope risk level for the site.

Based on the site inspection and the discussion given above, it is our opinion the site will not be subjected to unacceptable land slip or slope failure.

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 Sydney Heads 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 RL10 m AHD and is underlain by aeolian windblown sands. 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 in the piezometers, 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.

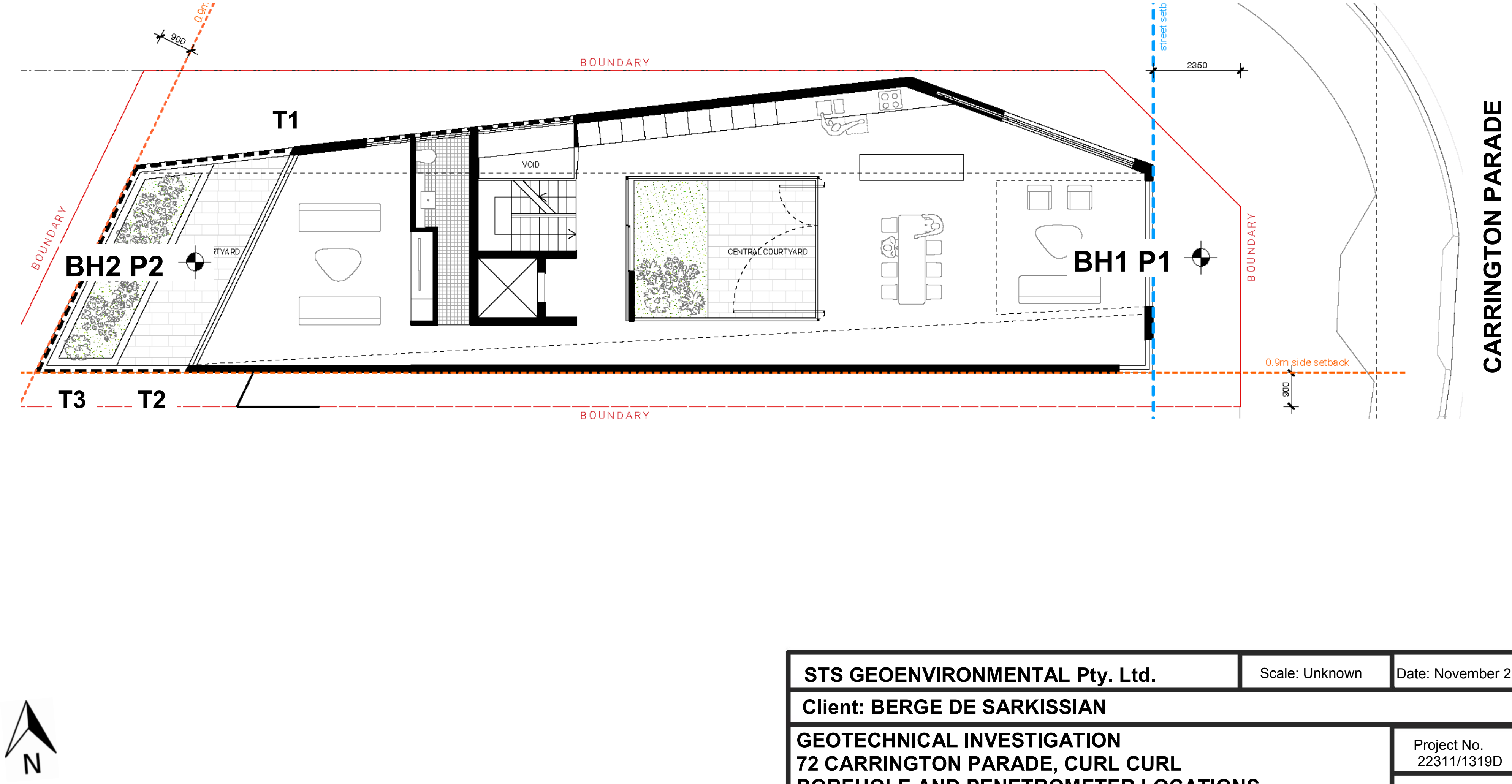
7. FINAL COMMENTS

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.

Matt Green
Senior Engineering Geologist

Laurie Ihnativ
Principal Geotechnical Engineer



STS GEOENVIRONMENTAL Pty. Ltd.	Scale: Unknown	Date: November 2018
Client: BERGE DE SARKISSIAN		
GEOTECHNICAL INVESTIGATION 72 CARRINGTON PARADE, CURL CURL BOREHOLE AND PENETROMETER LOCATIONS		Project No. 22311/1319D Drawing No: 18/.3658

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 SMEC Testing Services 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, SMEC Testing Services 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, SMEC Testing Services 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 GeoEnvironmental Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Berge Der Sarkissian	Project / STS No.: 22311/1319D	**BOREHOLE NO.: BH 1**
Project: 72 Carrington Parade, Curl Curl	Date: November 27, 2018	
Location: Refer to Drawing No. 18/3658	Logged: DL 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**
			SILTY SAND: brown with dark grey, medium grained, trace of gravel TOPSOIL	SM	LOOSE	D
			SILTY SAND: brown with grey, medium grained, trace of gravel	SM	LOOSE TO MEDIUM DENSE	D-M
		1.0				
			SILTY SAND: dark brown with brown, medium grained, trace of gravel	SM	MEDIUM DENSE	M
		2.0				
			SILTY SAND: grey brown with dark brown, medium grained, trace of gravel	SM	MEDIUM DENSE	M
		3.0				
			SILTY CLAYEY SAND: orange brown with some light brown, medium grained, trace of gravel	SM	MEDIUM DENSE	M
		4.0				
		5.0	STANDPIPE PIEZOMETER INSTALLED			
			BOREHOLE DISCONTINUED AT 6.0 M			

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: Mini Christie
S - jar sample	Hole Diameter (mm): 100
NOTES: See explanation sheets for meaning of all descriptive terms and symbols	Angle from Vertical (^{o}):
	Drill Bit: V/Spiral/Two Prong

STS GeoEnvironmental Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Berge Der Sarkissian	Project / STS No.: 22311/1319D		**BOREHOLE NO.: BH 2**
Project: 72 Carrington Parade, Curl Curl	Date: November 27, 2018		
Location: Refer to Drawing No. 18/3658	Logged: DL	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**
			SILTY SAND: brown with dark grey, medium grained, trace of gravel TOPSOIL	SM	LOOSE	D
			BOREHOLE COLLAPSING AT 0.25 M DUE TO LOOSE DRY SANDS		LOOSE	D
		1.0			LOOSE TO MEDIUM DENSE	
		2.0			LOOSE TO MEDIUM DENSE	
		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		

Contractor: STS
Equipment: Hand Auger
Hole Diameter (mm): 100/200/300
Angle from Vertical (^{o}):
Drill Bit: V/Spiral/Two Prong

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

SMEC Testing Services Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
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Perth Sand Penetrometer

Project: 72 CARRINGTON PARADE, CURL CURL
Client: BERGE DER SARKISSIAN
Address: 70 Carrington Parade, Curl Curl
Test Method: AS 1289.6.3.3

Project No.: 22311/1319D
Report No.: 18/3658
Report Date: 30/11/2018

Site No.	P1	P2				P1	P2		
Location	Refer to Drawing No. 18/3658	Refer to Drawing No. 18/3658							
Starting Level	Surface Level	Surface Level							
Depth (m)	Penetration Resistance (blows / 150mm)				Depth (m)	Penetration Resistance (blows / 150mm)			
0.00 - 0.15	1	1			3.00 - 3.15	5	5		
0.15 - 0.30	1	1			3.15 - 3.30	5	5		
0.30 - 0.45	2	1			3.30 - 3.45	8	6		
0.45 - 0.60	2	1			3.45 - 3.60	10	6		
0.60 - 0.75	3	1			3.60 - 3.75	10	5		
0.75 - 0.90	2	1			3.75 - 3.90	11	7		
0.90 - 1.05	4	1			3.90 - 4.05	9	7		
1.05 - 1.20	3	2			4.05 - 4.20	11	6		
1.20 - 1.35	4	2			4.20 - 4.35	11	7		
1.35 - 1.50	5	2			4.35 - 4.50	11	7		
1.50 - 1.65	5	3			4.50 - 4.65	11	8		
1.65 - 1.80	5	3			4.65 - 4.80	10	10		
1.80 - 1.95	6	4			4.80 - 4.95	11	10		
1.95 - 2.10	5	2			4.95 - 5.10	12	11		
2.10 - 2.25	7	3			5.10 - 5.25	12	9		
2.25 - 2.40	7	4			5.25 - 5.40	9	9		
2.40 - 2.55	7	6			5.40 - 5.55	9	9		
2.55 - 2.70	8	6			5.55 - 5.70	10	8		
2.70 - 2.85	7	4			5.70 - 5.85	9	10		
2.85 - 3.00	6	4			5.85 - 6.00	11/D	10/D		

Remarks: * = Pre-drilled hole prior to testing

Approved Signatory..
Laurie Ihnativ - Manager

Technician: DL

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 SMEC 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 Soil 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.