GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

GEOTECHNICAL INVESTIGATION & ACID SULFATE SOILS (ASS) ASSESSMENT

FOR

NSW LAND AND HOUSING CORPORATION

48 New Orleans Crescent, Maroubra, NSW (BGZ4J)

Report No: 22/2859

Project No: 31865/6657D-G

September 2022

4/1 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

Table of Contents

DOCUMENT CONTROL

REPORT TITLE: Geotechnical Investigation

REPORT NO: 22/2859

Revision	Details	Date	Amended By
0	Original	September 14, 2022	

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

1. INTRODUCTION

This report presents the results of a combined Geotechnical Investigation and Acid Sulfate Soils (ASS) Assessment carried out by STS Geotechnics Pty Limited (STS) for the proposed new construction at 48 New Orleans Crescent, Maroubra. At the time of writing this report STS were not provided with architectural drawings for the project. It is understood, the proposed development comprises 3 or 4 above ground levels and a basement that will require excavating to a depth of 3 metres below the existing ground surface.

Reference to the Randwick Council LEP indicates the site is located within a Class 5 area with respect to ASS.

The purpose of the investigation was to provide information on:

- Site conditions and regional geology,
- Subsurface conditions,
- Site Classification according to AS2870,
- Excavation conditions and support, including vibration control during rock excavation,
- Maximum permissible temporary and permanent batter slopes and retaining wall design parameters,
- WALLAP design parameters for all materials encountered,
- Foundation design parameters including foundation options,
- Soil aggressiveness to buried steel and concrete in accordance with AS2870 and AS2159, and
- Acid Sulfate Soils (ASS) assessment and need for an ASS Management Plan.

The investigation was undertaken in accordance with STS proposal P22-386 dated July 5, 2022.

Our scope of work did not include a contamination assessment.

2. FIELDWORK DETAILS

The fieldwork consisted of drilling four (4) boreholes numbered BH1 to BH4, inclusive, at the locations shown on Drawing No. 22/2859. Restricted site access dictated the borehole locations. BH1 and BH2 were drilled using a track mounted Geo 205 drilling rig equipped with Tungsten-Carbide (T-C) bit, owned and operated by GeoSense Drilling. BH3 was drilled using a limited access track mounted Mini Christie Drilling rig and BH4 using a utility mounted Edson RP70 drilling rig. The Mini and the Edson drilling rigs are owned and operated by STS.

Soils were drilled using rotary solid flight augers. Soil strengths were determined by undertaking a combination of Standard Penetration Tests (SPT) and Perth Sand Penetrometer (PSP) tests adjacent to the borehole locations and visual observation of the recovered soil samples at each borehole location. To measure the groundwater levels, a monitoring well was installed in BH2.

3. LABORATORY TESTING

To assess the soils for their aggressiveness, representative soil samples were tested to determine the following:

- Electrical Conductivity,
- pH,
- Sulfate content as $S0_4$,
- Chloride content as CL.

Detailed test reports are given in Appendix B.

4. GEOLOGY AND SITE CONDITIONS

The Sydney geological series sheet at a scale of 1:100,000 shows the site is underlain by Quaternary Age deposits. These materials typically comprise medium to fine grained marine sand with podsols, which were deposited as transgressive dunes.

At the time of the fieldwork, the site was occupied by an existing single-storey house. Site vegetation comprised grass and shrubs. The ground surface falls approximately 1 metre to the east.

The site is bound by New Orleans Crescent to the east and residential dwellings in the adjoining properties.

5. SUBSURFACE CONDITIONS

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

The subsurface conditions generally consist of topsoil overlying silty sands and sands. The topsoil is present from surface to a depth of 0.2 metres. Very loose becoming loose natural sands underlie the topsoil to depths of 5.6 to 6.0 metres. Medium dense natural sands underlie the loose sands to the maximum depth of drilling 7.5 to 10.0 metres.

No ground water was observed during the drilling. To determine whether groundwater is present a monitoring well was installed in BH2. To measure the groundwater level a secondary site visit was carried out on August 16, 2022. The monitoring well was dry at that time.

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 given in Appendix A.

6. GEOTECHNICAL DISCUSSION

6.1. Site Classification

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

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

Because of the underlying very loose sands to a depth greater than the proposed depth of excavation, 3.0 metres, the site is classified as a *Problem Site (P).* Because of the presence of low strength sands, it is not appropriate to reclassify the site.

6.2. Excavation Conditions

Based on the subsurface conditions observed in boreholes, the proposed basement excavation is expected to encounter topsoil, silty sands, and sands. Excavators without assistance should be able to remove the soils to the assumed depth of excavation of up to 3.0 metres.

In the highly unlikely event, weathered sandstone bedrock is encountered prior to reaching the required bulk excavation level excavators alone, without assistance, will not be able to remove any significant amount of the sandstone. Hydraulic breakers mounted on an excavator or jack hammers will be required to break up most of the rock before it can be removed using an excavator.

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

The limits of 5 mm/sec are expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 6.1.

Table 6.1 - Recommendations for Rock Breaking Equipment

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

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

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

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

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

6.3. Safe Batter Slope and Retaining Wall Design Parameters

In the short term, dry cut slopes in the natural sands should remain stable at an angle of 2(H) to 1(V). In the long-term dry cut slopes formed at an angle of 3(H) to 1(V) should remain stable. Slopes cut at this angle would be subject to erosion unless protected by topsoil and diversion drains at the crest of the slopes. The above temporary batters are stable provided that all surcharge loads, including construction loads, are kept at a distance of at least 2h (where 'h' is the height of the batter in metres) from the crest of the batter. If steeper batters are to be used, then these must be supported by shotcrete and soil nail system designed by a suitable experienced structural or geotechnical engineer. Where space for temporary batters is not available, a suitable retention system will be required for the support of the entire depth of excavation within the soils.

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

Due to the sandy nature of the soils, it will be necessary to provide temporary support of the excavations using either contiguous piles, secant piles, (only where there is a groundwater issue), or steel sheet piles. Sheet piles should not be used unless careful consideration has been given to the effects of vibration on adjoining structures during installation. The support system will need to be embedded an adequate depth into the medium dense sands.

It is not uncommon for contiguous piles to deviate from the vertical axis, particularly if the piles are drilled by hand. This deviation can result in gaps forming between the piles. Sands can flow between these gaps creating voids behind the piles which can result in the settlement of structures and pavements behind the piles. Therefore, if contiguous piles are used adopted the excavation should be routinely inspected to ensure any gaps between piles are appropriately packed/sealed with grout as the excavation progresses.

The major consideration when selecting earth pressure coefficients for the design of retaining walls is the need to limit deformations that can take place outside the excavation. When considering the design of the supports, it will be necessary to allow for the loading from structures in adjoining properties, any ground surface slope, and the water table present. The surcharge load from the existing retaining wall must be considered when designing the temporary and permanent retaining structures. 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 parameters used to proportion retaining wall support depends on whether the walls can be permitted to deflect. For walls, which cannot be permitted to deflect, an at rest earth pressure coefficient (K_o) of 0.6 should be adopted for the loose sands. For walls that can be allowed to deflect, an active earth pressure coefficient (K_a) of 0.4 should be adopted for the very loose and loose sands. A passive earth pressure coefficient (K_p) of 2.5 may be used for the very loose and loose sands. A bulk density of 17 kN/m^3 may be used for the very loose to loose sands and 19 kN/m^3 may be used for the medium dense sands.

Lateral toe restraint may be achieved in some cases by embedding the retention system to sufficient depth below bulk excavation level to satisfy stability and foundation considerations.

The retaining walls should be designed as drained, and measures taken to provide permanent and effective drainage of the ground behind the walls. Subsurface drains should incorporate a non-woven geotextile fabric such as Bidim A34, to act as a filter against subsoil erosion.

Since the retaining walls are expected to comprise contiguous pile walls it will not be feasible to install back-of-wall drainage. Wall drainage must be by means of spitter pipes leading into the garage; it is usual of such spitters to discharge to the perimeter dish drain but a piped system can also be used.

6.4. Foundation Design

We do not recommend founding any structural loads in topsoil and very loose and loose sands. Upon completion of bulk excavation, the exposed material will likely comprise very loose to loose sands. The site is not considered suitable for slab on ground construction. Piles will be required to suspend the basement slab. Piles founded into medium dense sands and better which appear to be present at approximate depths of 5.6 to 6.0 metres below existing ground level may be designed for this purpose. The slab should be designed for movements consistent with a *stable site (A)* classification.

The capacity of the pile will depend on the depth of founding. We will be happy to determine the required founding depth once the pile loads have been provided to us. As a guide the working loads (kN) for different diameter piles at different depths are given in Table 6.2. The founding depth is below the basement level.

Table 6.2 – Pile Working Loads

Founding Depth (m)[1]	Working Load (kN)		
	Pile Diameter (m)		
	0.3	0.45	0.6
3.0	45	110	300
6.0	75	200	550

[1] Below the basement level

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 screw piles or continuous flight auger (CFA) grout/concrete injected piles are better suited to the site conditions.

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.

Geotechnical inspections of foundations are recommended to determine that the required bearing capacity has been achieved and to determine any variations that may occur between the boreholes and inspected locations.

6.5. WALLAP PARAMETERS

In the event a finite element assessment (WALLAP) is required, the relevant soil parameters are provided below, in Table 6.3.

Table 6.3 – Design Parameters

Material[1]		Topsoil	Very Loose to Loose Silty Sand and Sand	Medium Dense Sand
Bulk Unit Weight ϒ (kN/m³)		17	17	19
Friction Angle ϕ' (°)		25	25	30
Cohesion, c' (kPa)		0	0	0
Poisson's ratio, v'		0.3	0.3	0.3
Young's Modulus of Elasticity, E' (MPa)		35	35	35
Earth Pressure Coefficients	At rest K_o[2]	0.6	0.6	0.6
	Active K_a[2]	0.4	0.4	0.4
	Passive K_p[2]	-	-	2.5

Notes:

1 More detailed descriptions of subsurface conditions are available on the borehole logs presented in **Appendix A.**

2 Earth pressures are provided on the assumption that the ground behind the retaining walls is horizontal.

6.6. 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 sulfates and chlorides. To determine the degree of aggressiveness, the test values obtained are compared to Tables 6.4.2 (C) and 6.5.2 (C) in AS2159 – 2009 Piling – Design and Installation. The test results are summarised in Table 6.4.

Table 6.4 – Soil Aggressiveness Summary

Sample No.	Location	Depth (m)	pH	Chloride (mg/kg)	Sulfate (mg/kg)	Electrical Conductivity (dS/m)	
						$EC_{1:5}$	EC_e
S1	BH1	0.4	6.7	<10	<10	0.010	0.1
S2	BH2	0.4	6.6	<10	<10	0.009	0.1

The soils on the site consist of high permeability soils constituting of silty sands and sands which are above groundwater. Therefore, the soil conditions B are considered appropriate (AS2159).

A review of the durability aspects indicates that:

- pH : minimum value of 6.6
- SO_4 : maximum value of <10 mg/kg (ppm) < 5000 ppm
- Cl : maximum value of <10 mg/kg (ppm) < 5000 ppm
- EC_e : maximum value of 0.1 dS/m

In accordance with AS2159-2009, the exposure classification for the onsite soils is non-aggressive for concrete as well as steel. In accordance with AS2870-2011 the soils are classified as A1.

Reference to DLWC (2002) "Site Investigations for Urban Salinity" indicates that an ECe value of 0.1 dS/m is consistent with the presence of non-saline soils.

7. ACID SULFATE SOIL ASSESSMENT

7.1. Introduction

ASS is the common name given to sediments and soils containing iron sulfides which, when exposed to oxygen generate sulfuric acid. Natural processes formed most 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. 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, back swamps 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 uncovers 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 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 consider the specific nature of the site and the environmental consequences of development. While it is preferable that sites exhibiting acid sulfate characteristics are not 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.

7.2. Presence of ASS

The Botany Bay ASS Risk Map (Edition Two, December 1997) indicates that the property is within an area with no known occurrence 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 epoch)
- soil horizons less than 5 in AHD
- marine or estuarine sediments and tidal lakes
- in coastal wetlands or back swamp areas

7.3. Assessment

A geomorphological assessment for PASS was undertaken by a review of available geomorphic mapping and aerial photography (Google Earth and SIX Maps (https://maps.six.nsw.gov.au/)) to identify, interpret, and compare features against site geomorphic characteristics (sediment, landscape and vegetation) noted in Tables 2.1 and 4.1 of NASSG 2018a that indicate typical locations of PASS. The typical PASS features and results of review are presented in Table 7.1.

Table 7.1 PASS Features and results of review

Geomorphological Indicator Type	Indicator of ASS	Site Presence of Feature
Sediment characteristics	Sediments of recent geological age (Holocene)	Observed, however, they are dune sand not backwater sediments
	Marine or estuarine sediments	Not observed

Geomorphological Indicator Type	Indicator of ASS	Site Presence of Feature
	Iron sulfide minerals, former marine or shales and sediments, coal deposits, and mineral sand deposits	Not observed
	Deep estuarine sediments >10m below ground surface, Holocene or Pleistocene age (only if deep excavation or drainage is proposed)	Deep excavation is not proposed
	Areas known to contain peat or a build-up of organic material.	No peat observed
Landscape characteristics	Land with elevation less than 5 m AHD	Minimum ground RL onsite is approximately 17 m AHD (from Google Earth)
	Areas where the highest known water table level is within 3 m of the surface.	Not observed
	Waterlogged or scalded area	Not observed
	Tidal lakes	Not observed
	Coastal wetlands or back swamp areas	Not applicable
	Interdune swales or coastal sand dunes (if deep excavation or drainage is proposed)	Not present
	Any areas (including inland areas) where a combination of all the following factors exist: organic matter, iron minerals, waterlogged conditions or high water table, and sulfidic minerals.	Not present
Vegetation characteristic	Areas where the dominant vegetation is mangroves, reeds, rushes and other vegetation associated with areas of shallow water tables such as flooded gums (Eucalyptus rudis) (Eucalyptus robusta), paperbarks (Melaleucaspp.) and casuarinas (Casuarina spp.).	Not observed

The observed site conditions are generally not consistent with the geomorphic criteria necessary for the presence of ASS. No groundwater was observed in the boreholes during the fieldwork. Therefore, site development is extremely unlikely to result in the lowering of the groundwater where nearby ASS may be present. Therefore, the proposed works will not result in exposure of ASS allowing oxidation to take place and resulting in the development of acidic conditions. Based on our onsite observations, it is our opinion that the proposed construction will not intercept any ASS in the area nor cause lowering of any groundwater.

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

8. 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.

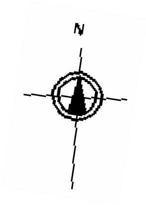
The exposed bearing surfaces should be inspected by a geotechnical engineer to ensure the parameters given have been achieved.

Yours faithfully,

Krishna Shakya
Geotechnical Engineer
STS Geotechnics Pty Ltd

Ian Watts
Geotechnical Engineer
STS Geotechnics Pty Ltd

Laurie Ihnativ
Principal Geotechnical Engineer
STS Geotechnics Pty Ltd



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: August 2022
Client: NSW LAND & HOUSING CORPORATION		
GEOTECHNICAL INVESTIGATION 48 NEW ORLEANS CRESCENT, MAROUBRA BOREHOLE & PENETROMETER LOCATIONS		Project No. 31865/6657D-G Drawing No: 22/2859

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: NSW Land & Housing Corporation	Project / STS No. 31865/6657D-G		**BOREHOLE NO.: BH 1**
Project: 48 New Orleans Crescent, Maroubra	Date: July 29, 2022		
Location: Refer to Drawing No. 22/2859	Logged: KS	Checked By: IW	Sheet 1 of 2

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 SAND: brown, fine to medium grained	SM	-	M
	S1@0.4m SPT 0.5-0.95 m 3, 4, 4 N = 8		SILTY SAND: yellow brown, fine to medium grained, poorly graded	SM	LOOSE	M
		1.0	SAND: yellow brown, fine to medium grained, poorly graded	SP	LOOSE	M
	SPT 1.5-1.95 m 1, 5, W N = 0		grading to orange brown with some sandstone gravel			
		2.0	grading to grey/dark grey		VERY LOOSE	
			grading to fine to medium to coarse grained, well graded)	SW		W
	SPT 3.0-3.45 m 0, 1, 2 N = 3	3.0				
		4.0				
	SPT 4.5-4.95 m 2, 3, 4 N = 7					
		5.0			LOOSE	
			grading to light grey/brown			

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: Geosense
Equipment: Commachio Geo205
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 31865/6657D-G		**BOREHOLE NO.:** **BH 1**
Project: 48 New Orleans Crescent, Maroubra	Date: August 25, 2022		
Location: Refer to Drawing No. 22/2859	Logged: EJ	Checked By: KS	Sheet 2 of 2

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
			grading to medium dense, trace of silt	SW	MEDIUM DENSE	W
		7.0				
			DRILLING DISCONTINUED AT 7.5 M			
		8.0				
		9.0				
		10.0				
		11.0				

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

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

Contractor: Geosense
Equipment: Commachio Geo205
Hole Diameter (mm): 100Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 31865/6657D-G		**BOREHOLE NO.: BH 2**
Project: 48 New Orleans Crescent, Maroubra	Date: July 29, 2022		
Location: Refer to Drawing No. 22/2859	Logged: KS	Checked By: IW	Sheet 1 of 2

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 SAND: brown, fine to medium grained	SM	-	M
	S2@0.4m SPT 0.5-0.95 m 1, 3, 3 N = 6		SILTY SAND: yellow brown, fine to medium grained, poorly graded	SM	VERY LOOSE	M
			SAND: yellow brown, fine to medium grained, poorly graded	SP	VERY LOOSE	M
		1.0	grading to light grey			
	SPT 1.5-1.95 m 1, 1, 2 N = 3	2.0	primarily white, slightly grey			
			light brown, fine to medium to coarse grained, well graded	SW		
	SPT 3.0-3.45 m 1, 2, 5 N = 7	3.0	ironstone and trace of highway weathered sandstone gravel		LOOSE	
		4.0				
	SPT 4.5-4.95 m 2, 3, 5 N = 8		mottled light brown and dark brown, trace of silt			
		5.0				

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

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

Contractor: Geosense
Equipment: Commachio Geo205
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

Client: NSW Land & Housing Corporation	Project / STS No. 31865/6657D-G		**BOREHOLE NO.:** **BH 2**
Project: 48 New Orleans Crescent, Maroubra	Date: July 29, 2022		
Location: Refer to Drawing No. 22/2859	Logged: KS	Checked By: IW	Sheet 2 of 2

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
	SPT 6.0-6.45 m 4, 6, 6 N = 12		grading to medium dense, trace of silt	SW	MEDIUM DENSE	W
		7.0				
	SPT 7.5-7.95 m 1, 4, 7 N = 11					
		8.0	DRILLING DISCONTINUED AT 7.95 M STANDPIPE PIEZOMETER INSTALLED			
		9.0				
		10.0				
		11.0				

D - disturbed sample	U - undisturbed tube sample	B - bulk sample	Contractor: Geosense
WT - level of water table or free water		N - Standard Penetration Test (SPT)	Equipment: Commachio Geo205
S - jar sample			Hole Diameter (mm): 100
NOTES:	See explanation sheets for meaning of all descriptive terms and symbols		Angle from Vertical (^{o}): 0
			Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 31865/6657D-G	**BOREHOLE NO.: BH 3**
Project: 48 New Orleans Crescent, Maroubra	Date: August 25, 2022	
Location: Refer to Drawing No. 22/2859	Logged: EJ Checked By: KS	Sheet 1 of 2

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 SAND: brown, fine to medium grained	SM	-	M
			SILTY SAND: yellow brown, fine to medium grained, poorly graded	SM	VERY LOOSE	M
			SAND: yellow brown, fine to medium grained, poorly graded	SP	VERY LOOSE	M
		1.0				
			grading to pale grey			
		2.0				
			primarily white, slightly grey			
			grading to fine to medium to coarse grained, well graded)			
				SW	LOOSE	
		3.0				
		4.0				
		5.0				
					MEDIUM DENSE	
			mottled brown, trace of silt			

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: Mini Christie
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 31865/6657D-G		**BOREHOLE NO.: BH 3**
Project: 48 New Orleans Crescent, Maroubra	Date: August 25, 2022		
Location: Refer to Drawing No. 22/2859	Logged: EJ	Checked By: KS	Sheet 2 of 2

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
			grading to medium dense, trace of silt	SW	MEDIUM DENSE	M
		7.0				
			DRILLING DISCONTINUED AT 7.5 M			
		8.0				
		9.0				
		10.0				
		11.0				

D - disturbed sample	U - undisturbed tube sample	B - bulk sample	Contractor: STS
WT - level of water table or free water		N - Standard Penetration Test (SPT)	Equipment: 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}): 0
			Drill Bit: Spiral

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 31865/6657D-G	**BOREHOLE NO.: BH 4**
Project: 48 New Orleans Crescent, Maroubra	Date: September 8, 2022	
Location: Refer to Drawing No. 22/2859	Logged: TS Checked By: IW	Sheet 1 of 2

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: yellow brown, fine to medium grained	SM		M
			SAND: yellow brown, fine to medium grained	SP		M
		1.0				
		2.0				
			SAND: white, fine to medium grained	SP		M
		3.0				
			SAND: brown, fine to medium grained	SP	LOOSE TO MEDIUM DENSE MEDIUM DENSE	M
		4.0				
			SAND: light grey, fine to medium grained	SP	MEDIUM DENSE	M-W
		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: Edson RP70
Hole Diameter (mm): 100
Angle from Vertical (^{o}): 0
Drill Bit: Spiral

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

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: NSW Land & Housing Corporation	Project / STS No. 31865/6657D-G	**BOREHOLE NO.: BH 4**
Project: 48 New Orleans Crescent, Maroubra	Date: September 8, 2022	
Location: Refer to Drawing No. 22/2859	Logged: TS Checked By: IW	Sheet 2 of 2

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
			SAND: light grey, fine to medium grained	SP	MEDIUM DENSE	M-W
		7.0				
		8.0				
		9.0	SAND: grey, fine to medium grained	SP	MEDIUM DENSE	M-W
		10.0				
			BOREHOLE DISCONTINUED AT 10.0 M			
		11.0				

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

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

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

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

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

Perth Sand Penetrometer

Project: 48 NEW ORLEANS CRESCENT, MAROUBRA
Client: NSW LAND & HOUSING CORPORATION
Address: 12 Darcy Street, Parramatta
Test Method: AS 1289.6.3.3

Project No.: 31865/6657D
Report No.: 22/3112
Report Date: August 26, 2022
Page: 1 of 2

Site No.	P1	P3	P4			P1	P3	P4	
Location	Refer to Drawing No. 22/2859	Refer to Drawing No. 22/2859	Refer to Drawing No. 22/2859						
Date Tested	25/8/2022	25/8/2022	8/9/2022						
Starting Level	Surface Level	Surface Level	Surface Level						
Depth (m)	Penetration Resistance (blows / 150mm)				Depth (m)	Penetration Resistance (blows / 150mm)			
0.00 - 0.15	*	2	*		3.00 - 3.15	*	10	4	
0.15 - 0.30	*	4	*		3.15 - 3.30	*	9	4	
0.30 - 0.45	*	6	*		3.30 - 3.45	*	10	5	
0.45 - 0.60	*	2	*		3.45 - 3.60	*	11	7	
0.60 - 0.75	*	3	*		3.60 - 3.75	*	11	8	
0.75 - 0.90	*	4	*		3.75 - 3.90	*	17	8	
0.90 - 1.05	*	5	*		3.90 - 4.05	*	12	8	
1.05 - 1.20	*	4	*		4.05 - 4.20	*	11	10	
1.20 - 1.35	*	6	*		4.20 - 4.35	*	13	12	
1.35 - 1.50	*	3	*		4.35 - 4.50	*	14	12	
1.50 - 1.65	*	4	*		4.50 - 4.65	*	14	13	
1.65 - 1.80	*	6	*		4.65 - 4.80	*	16	15	
1.80 - 1.95	*	6	*		4.80 - 4.95	*	15	16/R	
1.95 - 2.10	*	9	*		4.95 - 5.10	*	14	*	
2.10 - 2.25	*	6	*		5.10 - 5.25	*	14	*	
2.25 - 2.40	*	6	*		5.25 - 5.40	*	12	*	
2.40 - 2.55	*	6	*		5.40 - 5.55	*	14	*	
2.55 - 2.70	*	7	*		5.55 - 5.70	*	17	*	
2.70 - 2.85	*	9	*		5.70 - 5.85	*	15	*	
2.85 - 3.00	*	9	*		5.85 - 6.00	*	15	*	

Remarks: * = Pre-drilled hole prior to testing

Approved Signatory........ ....
Orlando Mendoza - Laboratory Manager

Technician: EJ

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

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

Perth Sand Penetrometer

Project: 48 NEW ORLEANS CRESCENT, MAROUBRA | Project No.: 31865/6657D
Client: NSW LAND & HOUSING CORPORATION | Report No.: 22/3112
Address: 12 Darcy Street, Parramatta | Report Date: August 26, 2022
Test Method: AS 1289.6.3.3 |

Site No.	P1	P3	P4						
Location	Refer to Drawing No. 22/2859	Refer to Drawing No. 22/2859	Refer to Drawing No. 22/2859						
Date Tested	25/8/2022	25/8/2022	8/9/2022						
Starting Level	Surface Level	Surface Level	Surface Level						
Depth (m)	Penetration Resistance (blows / 150mm)				Depth (m)	Penetration Resistance (blows / 150mm)			
6.00 - 6.15	17	16	6						
6.15 - 6.30	19	18	12						
6.30 - 6.45	27	17	31						
6.45 - 6.60	30	22/R	30						
6.60 - 6.75	31		D						
6.75 - 6.90	33/R		*						
6.90 - 7.05			*						
7.05 - 7.20			*						
7.20 - 7.35			*						
7.35 - 7.50			*						
7.50 - 7.65			*						
7.65 - 7.80			*						
7.80 - 7.95			*						
7.95 - 8.00			*						
8.00 - 8.15			8						
8.15 - 8.30			17						
8.30 - 8.45			34						
8.45 - 8.60			D						

Remarks: * = Pre-drilled hole prior to testing

Approved Signatory..... ....
Orlando Mendoza - Laboratory Manager

Technician: EJ

E1. CLASSIFICATION OF SOILS

E1.1 Soil Classification and the Unified System

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

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

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

The soil description should contain the following information in order:

Soil composition

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

Soil condition

- moisture condition
- consistency or density index

Soil structure

- structure (zoning, defects, cementing)

Soil origin

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

E1.2 Soil Composition

(a) Soil Name and Classification Symbol

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

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

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

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

TABLE E1.2.1 - CLASSIFICATION BY PARTICLE SIZE

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

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

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

TABLE E1.2.2 - MINOR SOIL COMPONENTS

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

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

TABLE E1.2.3 - SOIL GROUP SYMBOLS

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

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

TABLE E1.2.4 - SOIL GROUP QUALIFIERS

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

(b) Grading

"Well graded" Good representation of all particle sizes from the largest to the smallest.

"Poorly graded" One or more intermediate sizes poorly represented

"Gap graded" One or more intermediate sizes absent

"Uniformly graded" Essentially single size material.

(c) Particle shape and texture

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

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

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

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

(d) Colour

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

Black	White	Grey	Red
Brown	Orange	Yellow	Green
Blue			

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

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

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

(e) Minor Components

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

E1.3 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.

APPENDIX B – LABORATORY TEST RESULTS

CERTIFICATE OF ANALYSIS

Work Order	: **ES2227105**	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	: 3055/30060/31354/31864/31865	Date Samples Received	: 01-Aug-2022 15:10
Order number	: 2022-245	Date Analysis Commenced	: 02-Aug-2022
C-O-C number	: ----	Issue Date	: 04-Aug-2022 14:34
Sampler	: EJ, KS, MB		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 10		
No. of samples analysed	: 10		

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

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

General Comments

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

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

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

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

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

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

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

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

Compound	CAS Number	LOR	Unit	30055/8517	30055/8519	30055/8520	30055/8521	30060/1688
Sampling date / time				29-Jul-2022 00:00	29-Jul-2022 00:00	29-Jul-2022 00:00	29-Jul-2022 00:00	29-Jul-2022 00:00
				ES2227105-001	ES2227105-002	ES2227105-003	ES2227105-004	ES2227105-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.4	5.9	6.8	5.4	7.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	27	31	93	36	33
EA055: Moisture Content								
Moisture Content	----	1.0	%	22.3	19.8	19.4	21.7	16.9
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	<10	20	50	<10

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	31354/084	31864/S1	31864/S2	31865/S1	31865/S2
			Sampling date / time	29-Jul-2022 00:00	28-Jul-2022 00:00	28-Jul-2022 00:00	29-Jul-2022 00:00	29-Jul-2022 00:00
Compound	CAS Number	LOR	Unit	ES2227105-006	ES2227105-007	ES2227105-008	ES2227105-009	ES2227105-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.5	----	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	----	5.9	6.5	6.7	6.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	116	----	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	----	8	14	10	9
EA055: Moisture Content								
Moisture Content	----	1.0	%	21.7	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	----	4.5	5.4	4.3	4.3
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	140	<10	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	<10	<10	<10	<10