GREEN GEOTECHNICS

GEOTECHNICAL INVESTIGATION & ACID SULFATE SOILS ASSESSMENT

FOR

DEVELOPER ENTITY PTY LIMITED

33 MACKENZIE STREET, HOMEBUSH

REPORT GG10455.001

17TH DECEMBER 2021

Geotechnical Investigation & Acid Sulfate Soils Assessment for a proposed residential townhouse development at 33 Mackenzie Street, Homebush

Prepared for

Developer Entity Pty Limited
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Prepared by

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17th December 2021

Document Authorisation

Our Ref: GG10455.001

For and on behalf of Green Geotechnics

Matthew Green
Principal Engineering Geologist

Document Control

Revision	Description	Format	Date	Author	Distributed to
-	Final	PDF	17/12/2021	MG	Developer Entity Pty Limited (Client)

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APPENDICIES

1. INTRODUCTION

This report presents the results of a combined Geotechnical Investigation and Acid Sulfate Soils Assessment for a proposed new residential townhouse development to be constructed at 33 Mackenzie Street, Homebush, NSW. The investigation was commissioned by Developer Entity Pty Limited by return acceptance of Proposal PROP-2021-0267, dated 19th August 2021.

We understand that the development comprises construction of a four-unit three storey residential townhouse type development with a single level of communal basement car parking. The finished floor level of the basement is RL 10.85 metres AHD. Construction of the basement will require excavating up to 3 metres below the existing ground surface with localised deeper excavations required for sump/pits and foundations. Further, we understand that the site is located within a Class 5 Acid Sulfate Soils area, and therefore a preliminary Acid Sulfate Soils assessment is required as part of the DA submission.

Structural loads have not been advised but we have assumed column loads in the moderate range will apply for this type of development.

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,
- comment on excavation conditions including recommendations for rock excavation and vibration control,
- provide parameters for the temporary and permanent support of the excavation,
- carry out a Preliminary Acid Sulfate Soils Assessment, and
- assess the requirement for an Acid Sulfate Soils Management Plan.

2. FIELDWORK DETAILS

The fieldwork was carried out on the 14th December 2021 and comprised the drilling of two (2) boreholes numbered BH1 and BH2. BH1 was drilled using rotary solid flight augers attached to a utility mounted Christie Engineering drilling rig owned and operated by Green Geotechnics. Due to restricted site access, BH2 was drilled using hand auger equipment.

The site location is shown in the attached Figure A. The borehole locations, as shown on Figure B, were determined by taped measurements from existing surface features overlain on available survey drawings of the site. Photographs of the site indicating the borehole locations are shown on Figure C.

The strength of the soils encountered in the boreholes was assessed by undertaking Dynamic Cone Penetrometer (DCP) tests adjacent to each borehole. The strength of the weathered bedrock was assessed by observation of the auger penetration resistance when using a tungsten carbide drilling bit, together with examination of the recovered rock cuttings.

Groundwater observations were made in all boreholes during drilling, on completion of drilling and a short time after completion of drilling. No longer term monitoring of groundwater was carried out.

The fieldwork was completed in the full-time presence of our senior field geologist who set out the boreholes, nominated the sampling and testing, and prepared the borehole logs. The logs are attached to this report, together with a glossary of the terms and symbols used in the logs.

For further details of the investigation techniques adopted, reference should be made to the attached explanation notes.

Environmental and contamination testing of the soils was beyond the agreed scope of the works.

3. RESULTS OF INVESTIGATION

3.1 Site Description

The site is identified as Lot 2 in DP 1035608, and is roughly rectangular in shape with an area of approximately 697m^2. At the time of the fieldwork the site occupied by a one and two storey brick residential dwelling with tile roof, carport, separate shed, pergola and concrete driveway. The dwelling also includes an in-ground concrete swimming pool in the rear garden which is to be removed. Site vegetation comprised grass, small trees and shrubs.

The ground surface across the site falls approximately 0.6 metres to the west, from RL13.6 metres AHD to RL 13.0 metres AHD.

To the east of the is Mackenzie Street and to the north and west are a series of residential townhouse dwellings which form No.31 to No.33 Mackenzie Street. The townhouses have a single level of basement car parking. The basement likely extends to the site boundary. To the south of the site are the rear gardens of No.1A, 1B, 3 and 5 Badgery Avenue. The structures on No.3 and No.5 are set back around 16 metres from the site boundary, however the dwelling on No.1A/1B is close to the site boundary.

3.2 Regional Geology & Subsurface Conditions

The 1:100,000 series geological map of Sydney (Geological Survey of NSW, Geological Series Sheet 9130) indicates that the site is underlain by Triassic Age bedrock belonging to the Ashfield Shale Formation of the Wianamatta Group. Bedrock within this formation comprises shale, claystone and laminite. Approximately 170 metres to the west of the site is a geological boundary with Quaternary Age alluvial soils comprising clays, silts, sands and gravels.

For the development of a site-specific geotechnical model, the observed subsurface conditions from the boreholes have been grouped into five (5) geotechnical units which are summarised below in Table 3.1.

TABLE 3.1 – Summary of Subsurface Conditions

Unit	Material Type	Depth to top of Layer (m)*	Depth to base of Layer (m)*	Material Description
1	Topsoil / Fill	Surface	0.3 to 0.5m	Silty clays, dark brown and orange brown, generally low to medium plasticity with some gravel and organics.
2	Firm clays and Firm to Stiff Clays	0.3 to 0.5m	0.7 to 1.2m	Silty clays, orange brown with grey, high plasticity and moist.
3	Stiff and Very Stiff Natural Clays	0.7 – 1.2m	1.6 to 2.2m	Silty clays, red brown with orange brown and light grey, medium to high plasticity and moist
4	Hard Residual Clays	1.6 to 2.2m	5.0	Hard, low to medium plasticity residual clays with shale and ironstone gravel. Generally dry to moist
5*	Class 5 Shale Bedrock	>5.0m		Extremely weathered extremely low strength shale bedrock, dry. Class 5.

* BH1 only

Groundwater seepage **was not** observed during auger drilling of the boreholes.

4. GEOTECHNICAL RECOMMENDATIONS

4.1 Primary Geotechnical Considerations

Based on the results of the assessment, we consider the following to be the primary geotechnical considerations for the development:

- Basement excavation and retention to limit lateral deflections and ground loss as a result of excavations, resulting in damage to nearby structures, and

- Foundation design for structural loads.

4.2 Site Classification to AS2870

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

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

Because of the AMC present, the site is classified a **Problem Site (P).** However, provided the recommendations provided in Section 4.7 of this report are adopted and the footings bear in the underlying firm to stiff or stiff natural soils, the site may be reclassified **Highly Reactive (H1).**

4.3 Excavation Conditions and Vibration Control

All excavation recommendations should be complemented with reference to the NSW Government Code of Practice for Excavation work, dated January 2020.

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.

Based on the subsurface conditions observed in boreholes, the proposed excavation of the basement is expected to encounter topsoil and fill, clayey soils and potentially shale bedrock. The bedrock was assessed to be extremely low strength to a depth of 6.0 metres.

Excavation of the soils and extremely low strength bedrock is expected to be achievable using conventional excavation equipment, such as toothed buckets attached to medium to large sized hydraulic excavators. Some ripping may also be required if bands of ironstone or higher strength shale are encountered. We do not anticipate the use of hydraulic rock hammers during bulk excavation, and therefore vibration monitoring is not considered necessary as part of the bulk excavation process.

In the highly unlikely event that the basement excavation works require the use of hydraulic rock hammers then we should be contacted, as further advise will be required to address vibration levels during their use.

4.4 Temporary Batter Slopes

Suggested temporary and permanent maximum batter slope angles for slopes not exceeding 3 metres in height are presented in Table 4.1 below. These recommendations are provided based on no surcharge loads, including construction loads and existing footing loads, being placed within H of the top of the batters, where H is the total batter height.

TABLE 4.1 – Recommended Temporary Batter Slopes

Material	Temporary Batter Slope Ratio (H:V)
Unit 1, 2, 3 and 4 - Topsoil, Fill and Residual Clays	1:1
Unit 5 – Shale bedrock	0.5:1

4.5 Retaining Wall Design

The proposed basement excavation extends to the northern and southern boundaries and is offset approximately 2 metres from the western boundary, therefore there may be insufficient space for temporary batters over sections of the site. Sections of the excavations may therefore require temporary lateral support to ensure that excavation stability is maintained.

Based on the subsurface conditions observed in the boreholes, the shoring / support system considered most suitable to retain the excavations is a bored reinforced pile wall. Depending on the loads and surcharge forces, either solider piles or contiguous piles may be considered.

When considering the design of the support system, it will be necessary to allow for the loading from structures in adjoining properties, any ground surface slope and the water table present. The design of the basement shoring system should also take into consideration the presence of the existing basement on the adjoining site to the north and west.

For the design of temporary structures where some ground movement is acceptable, an active earth pressure coefficient (K_a) may be adopted. However, where adjoining structures are within the zone of influence of the excavation, or it is necessary to limit lateral deflections, it will be necessary to adopt at rest (K_o) conditions. K_o conditions should also be used to design the permanent support system.

A triangular lateral earth pressure distribution should be adopted for cantilevered walls, and a rectangular or trapezoidal lateral earth pressure distribution should be adopted for walls that are progressively propped at their top and base, and/or where two or more rows of anchors are used. Excavations on the subject site will be limited to 3 metres depth, and therefore a triangular stress distribution is recommended.

Where required, anchors or internal props can also be considered. Where anchors are used and they extend into the adjoining property, it will be necessary to obtain the permission of the property owners.

The lateral earth pressure for a cantilevered wall should be determined as a proportion of the vertical stress, as given in the following formula:

$\sigma z = K z \gamma$, where σz = Horizontal pressure at depth z (kPa)

K = Earth pressure coefficient

z = Depth (m)

γ = Unit weight of soil or rock (kN/m^3)

Retaining walls may be designed using the parameters provided below in Table 4.2.

TABLE 4.2 – Retaining Wall Design Parameters

Material Unit	Unit Weight (kN/m^3)	Earth Pressure Coefficient		
		Active (K_a)	At Rest (K_o)	Passive (K_p)
1,2,3	19	0.4	0.6	-
4	19	0.35	0.55	2.5
5	22	-	-	3.5

The embedment of retaining walls can be used to achieve passive support. A triangular passive earth pressure distribution (increasing linearly with depth) may be assumed, starting from 0.5 m below excavation toe/base level.

During the fieldwork no groundwater was encountered on the part of the lot where the excavation is to be carried out. Therefore, based on the observations made during drilling, the basement excavations are not expected to encounter a regional groundwater table. However, some minor seepage may occur after periods of increased rainfall. Any seepage into the basement is however expected to be minor, and therefore a conventional sump and pump type system should be capable of removing any seepage during construction.

4.6 Drainage and Basement Floor Slab Construction

Adequate drainage will need to be provided for any subsurface structures and behind retaining walls to prevent the build-up of hydrostatic forces. In this regard, we would recommend that subsoil drains be installed around the perimeter of the basement, together with the installation of underfloor drainage. The underfloor drainage should comprise a strong durable single sized washed aggregate with perforated drains/pipes leading to the basement sump, which is to be fitted with a failsafe pump.

Where very stiff clayey soils or shale bedrock are exposed over the excavation footprint, no special treatment is required other than the removal of loose and softened material. Areas, which have to be built-up to infill low points in the excavations should be filled with properly compacted sub-base material.

Slab-on-grade construction is considered appropriate for the basement floor slab provided that it is isolated from the columns. Joints in the on-grade floor slabs should comprise dowels or keys.

4.7 Foundation Design

On completion of bulk excavation, hard clays or shale bedrock are expected to be exposed over the floor of the basement. Any slab on ground sections of the ground floor which are outside the basement footprint are likely to encounter firm to stiff clays at founding level.

Foundation design parameters for the various units are provided in Table 4.3 below

TABLE 4.3 – Foundation Design Parameters

(Unit) Material	Maximum Allowable (Serviceability) Values (kPa)		
	End Bearing Pressure	Shaft Friction in compression#	Shaft Friction in tension*
(1) Topsoil/Fill/Firm Clay	-	-	-
(2) Firm to Stiff Clay	100	-	-
(3) Stiff to Very Stiff Clay	225	20	10
(4) Hard Residual Clay	450	20	10
(5) Class 5 Shale	700	70	35

* Uplift capacity of piles in tension loading should also be checked for inverted cone pull out mechanism.

clean socket of roughness category R2 or better is assumed

Settlements for footings on rock are anticipated to be about 1% of the minimum footing dimension, based on serviceability parameters as per Table 4.3. Settlements for pad footings in soils are anticipated to be up to about 15mm where loading does not exceed the maximum allowable values.

Bored pile footings should be drilled, cleaned, inspected and poured with minimal delay, on the same day. Water should be prevented from ponding in the base of footings as this will tend to soften the foundation material, resulting in further excavation and cleaning being required.

Drilling of rock sockets into the low to medium strength or better sandstone will require the use of large excavators or piling rigs equipped with rock augers. Some limited groundwater inflow should be anticipated into the bored pile excavations. We expect any minor seepage to be controllable by conventional pumping methods. However, some contingency for pouring concrete by tremie methods should be allowed.

The initial stages of footing excavation/drilling, particularly if bored piles are adopted, should be inspected by a geotechnical engineer/engineering geologist to ascertain that the recommended foundation material has been reached and to check initial assumptions about foundation conditions and possible variations that may occur between borehole locations. The need for further inspections can be assessed following the initial visit.

5. FURTHER GEOTECHNICAL INPUT

The following summarises the scope of further geotechnical work recommended within this report. For specific details reference should be made to the relevant sections of this report.

- Complete dilapidation surveys of the adjoining buildings and structures.
- Inspection of footing excavations to ascertain that the recommended foundation has been reached and to check initial assumptions regarding foundation conditions and possible variations that may occur.
- We also recommend that Green Geotechnics view the proposed earthworks and structural drawings in order to confirm they are within the guidelines of this report.

Nevertheless, it will be essential during excavation and construction works that progressive geotechnical inspections be commissioned to check initial assumptions about excavation and foundation conditions and possible variations that may occur between inspected and tested locations and to provide further relevant geotechnical advice.

6. ACID SULFATE SOILS 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 Prescence of ASS

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

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

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

6.3 Assessment

The property is at an elevation of about RL13m AHD and is underlain by residual soils overlying Ashfield Shale bedrock. 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 during drilling, it appears that any seepage into the basement would be minor and as a consequence, construction will not result in the lowering of any groundwater that may be present in the area.

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

7. GENERAL RECOMMENDATIONS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and Green Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

Occasionally, the subsurface conditions may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of Green Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

REPORT INFORMATION

Introduction

These notes have been provided to amplify Green Geotechnics report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

Green Geotechnics reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several limitations, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. The borehole must be flushed, and any water must be extracted from the hole if further water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, Green Geotechnics will be pleased to assist with investigations or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Copyright

FIGURES

View looking at Borehole 1

View looking at Borehole 2

GREEN GEOTECHNICS	Project No: GG10455.001	Geotechnical Investigation 33 Mackenzie Street, Homebush **SITE PHOTOGRAPHS**	Page: 1 of 1
	Client: Developer Entity Pty Limited		
	Date: 17 December 2021		

Subject Site

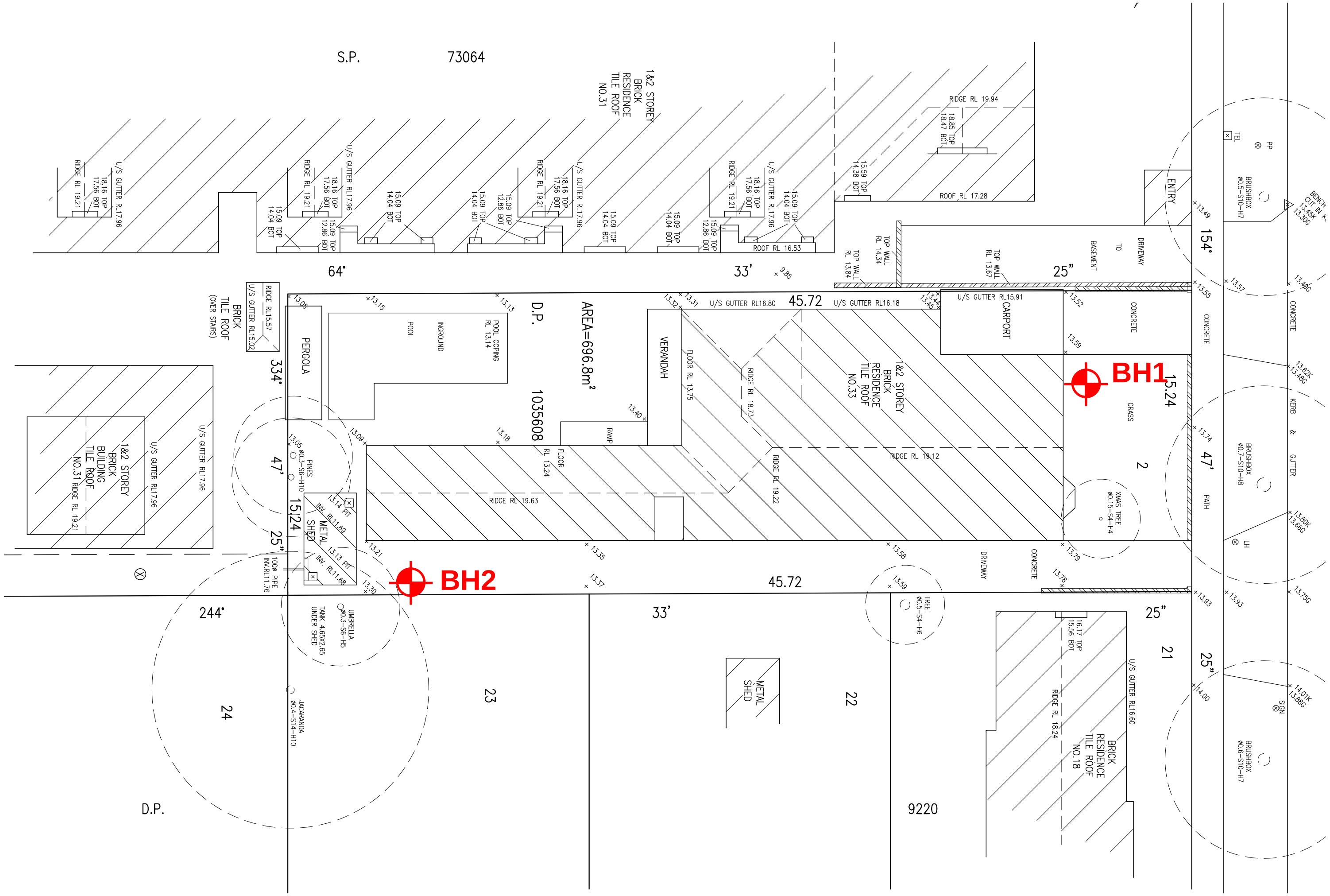
GREEN GEOTECHNICS	Project No: GG10455.001	Geotechnical Investigation 33 Mackenzie Street, Homebush	Figure No: GG10455.001A
	Client: Developer Entity Pty Limited		Drawn By: MG
	Date: 17 December 2021	**SITE LOCATION PLAN**	Scale: Unknown

Legend:

= Borehole

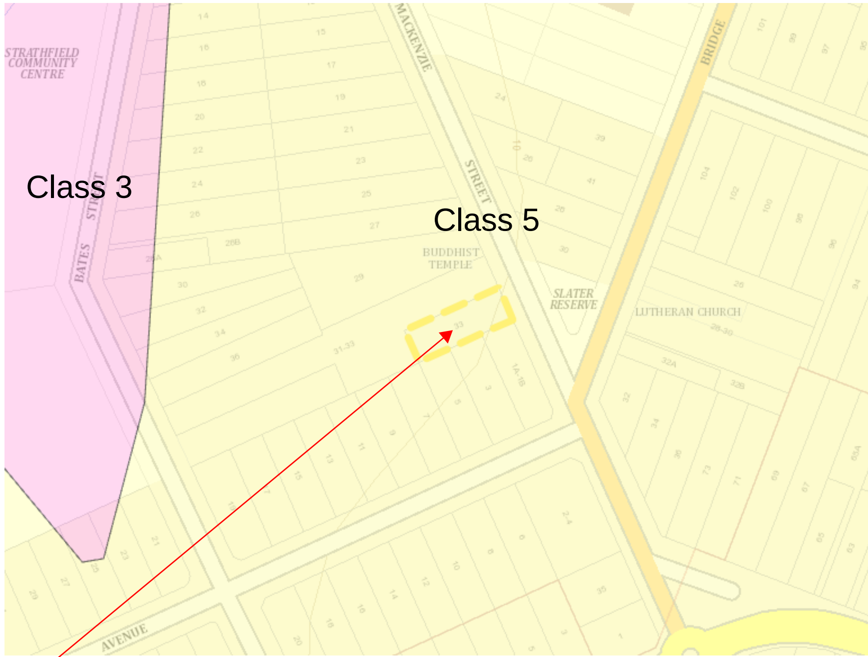
= DCP

= Test Pit



GREEN GEOTECHNICS	Project No: GG10455.001	Geotechnical Investigation 33 Mackenzie Street, Homebush	Figure No: GG10455.001B
	Client: Developer Entity Pty Limited		Drawn By: MG
	Date: 17 December 2021	**TEST LOCATION PLAN**	Scale: Unknown

Prospect - Parrmatta Acid Sulfate Soils Risk Map



Acid Sulfate Soils Classification Mapping (Source ePlanning Spatial Viewer)

Subject Site

GREEN GEOTECHNICS	Project No: GG10455.001	Geotechnical Investigation 33 Mackenzie Street, Homebush	Figure No: GG10455.001D
	Client: Developer Entity Pty Limited		Drawn By: MG
	Date: 17 December 2021	**ACID SULFATE SOILS MAPPING**	Scale: Unknown

APPENDIX A – BOREHOLE LOGS

GEOTECHNICAL LOG - NON CORED BOREHOLE

GREEN GEOTECHNICS

Project No: GG10455	Surface RL: 13.6m AHD	Date Logged : 14/12/2021	**BOREHOLE NO.: BH 1**
Address: 33 Mackenzie Street, Homebush		Logged By: JK	
Client: Developer Entity Pty Limited		Checked By: MG	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (M)	DESCRIPTION (Soil type, colour, grain size, plasticity, minor components, observations)	USC SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			TOPSOIL: Silty CLAY: Dark brown, medium plasticity.	CL		M
			Silty CLAY: Orange brown with light grey, high plasticity.	CH	FIRM FIRM TO STIFF STIFF	M
		1.0				
			Silty CLAY: Red brown with light grey and orange brown, medium to high plasticity.	CI-CH	VERY STIFF	M
		2.0				
			Silty CLAY: Light grey with orange brown, medium to high plasticity, trace if shale gravel.	CI-CH	HARD	M
		3.0	Gravelly Silty CLAY: Orange brown and dark brown with light grey, medium plasticity, some shale gravel (completely weathered shale).	CI	HARD	M/D
		4.0				
		5.0				
			SHALE: Dark grey with light grey and clay seams (Class 5)			D
			AUGER REFUSAL AT 5.6m ON WEATHERED SHALE.			

D - Disturbed sample	U - Undisturbed tube sample	B - Bulk sample	Contractor: Green Geotechnics
S - Chemical Sample	SPT - Standard Penetration Test		Equipment: Christie
WT - Standing Water Table	SP - Water Seepage Level		Hole Diameter (mm): 105
NOTES:	See explanation sheets for meaning of all descriptive terms and symbols		Angle from Vertical (^{o}): 0°
			Drill Bit: Spiral TC

GEOTECHNICAL LOG - NON CORED BOREHOLE

GREEN GEOTECHNICS

Project No: GG10455	Surface RL: 13.3m AHD	Date Logged : 14/12/2021	BOREHOLE NO.: BH 2
Address: 33 Mackenzie Street, Homebush		Logged By: JK	
Client: Developer Entity Pty Limited		Checked By: MG	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (M)	DESCRIPTION (Soil type, colour, grain size, plasticity, minor components, observations)	USCS SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: Silty CLAY: Dark brown with orange brown, medium plasticity, trace of concrete gravel.	CI		M
		1.0	Silty CLAY: Orange brown with light grey, high plasticity.	CH	FIRM FIRM TO STIFF	M
			Silty CLAY: Light grey with orange brown and red brown, high plasticity.	CH	STIFF	M
			Silty CLAY: Orange brown with light grey, medium to high plasticity, trace of shale gravel, (completely weathered shale).	CI-CH	HARD	M
		2.0	HAND AUGER REFUSAL AT 1.7m ON SILTY CLAY/COMPLETLEY WEATHERED SHALE.			
		3.0				
		4.0				
		5.0				

D - Disturbed sample	U - Undisturbed tube sample	B - Bulk sample	Contractor: Green Geotechnics
S - Chemical Sample	SPT - Standard Penetration Test		Equipment: Hand Auger
WT - Standing Water Table	SP - Water Seepage Level		Hole Diameter (mm): 65
NOTES:	See explanation sheets for meaning of all descriptive terms and symbols		Angle from Vertical (^{o}): 0°
			Drill Bit: Mild Steel

Dynamic Cone Penetrometer Test Report

Project Number: GG10455
Site Address: 33 Mackenzie Street, Homebush
Test Date: 14/12/2021

Test Method: **AS1289.6.3.2**

Technician: JK

Test No	BH1	BH2				
Starting Level	Surface	Surface				
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	*	*				
0.15 - 0.30	*	1				
0.30 - 0.45	2	2				
0.45 - 0.60	3	2				
0.60 - 0.75	3	3				
0.75 - 0.90	5	4				
0.90 - 1.05	5	4				
1.05 - 1.20	8	4				
1.20 - 1.35	13	4				
1.35 - 1.50	13	4				
1.50 - 1.65	12	8				
1.65 - 1.80	14	22				
1.80 - 1.95	16	Refusal				
1.95 - 2.10	22					
2.10 - 2.25	Refusal					
2.25 - 2.40						
2.40 - 2.55						
2.55 - 2.70						
2.70 - 2.85						
2.85 - 3.00						

Remarks: * Pre drilled prior to testing

SAMPLING & IN-SITU TESTING

GREEN GEOTECHNICS

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock. Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure. Undisturbed samples are taken by pushing a thin walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator.

Large Diameter Augers

Boreholes can be drilled using a large diameter auger, typically up to 300 mm or larger in diameter mounted on a standard drilling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration.

Diamond Core Rock Drilling

A continuous core sample of can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter (NMLC). The borehole is advanced using a water or mud flush to lubricate the bit and removed cuttings.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1. The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable, and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as: 15, 30/40 mm.

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.

- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

SOIL DESCRIPTIONS

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle Size (mm)
Boulder >200	Boulder >200
Cobble 63 - 200	Cobble 63 - 200
Gravel 2.36 - 63	Gravel 2.36 - 63
Sand 0.075 - 2.36	Sand 0.075 - 2.36
Silt 0.002 - 0.075	Silt 0.002 - 0.075
Clay <0.002	Clay <0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle Size (mm)
Coarse Gravel	20 – 63
Medium Gravel	6 – 20
Fine Sand	2.36 – 6
Coarse Sand	0.6 – 2.36
Medium Sand	0.2 – 0.6
Fine Sand	0.075 – 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion
And	Specify
Adjective	20 - 35%
Slightly	12 - 20%
With some	5 - 12%
With a trace of	0 - 5%

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained Shear Strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	ST	50 - 100
Very stiff	VST	100 - 200
Hard	H	200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (DCP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N Value	CPT qc value (MPa)
Very loose	VL	<4	<2
Loose	L	4 - 10	2 -5
Medium Dense	MD	10-30	5-15
Dense	D	30-50	15-25
Very Dense	VD	>50	>25

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

ROCK DESCRIPTIONS

GREEN GEOTECHNICS

Rock Strength

The Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $IS_{(50)}$ MPa	Approximate Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200

* Assumes a ration of 20:1 for UCS to $IS_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable.
Moderately weathered	MW	Staining and discolouration of rock substance has taken Place.
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh stained	FS	Rock substance unaffected by weathering but staining visible along defects.
Fresh	FR	No signs of decomposition or staining.

Degree of Fracturing

The following classification applies to the spacing of natural fractures in core samples (bedding plane partings, joints and other defects, excluding drilling breaks

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured Core	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Unbroken Core lengths mostly > 1000 mm

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	2 m

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$RQD\ \% = \frac{\text{cumulative length of 'sound' core sections} \geq 100\text{ mm long}}{\text{total drilled length of section being assessed}}$$

'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling/handling, then the broken pieces are fitted back together and are not included in the calculation of RQD.

ABBREVIATIONS

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

Z	Water seep
V	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
S	Chemical sample
U50	Undisturbed tube sample (50mm)
W	Water sample
PP	Pocket Penetrometer (kPa)
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

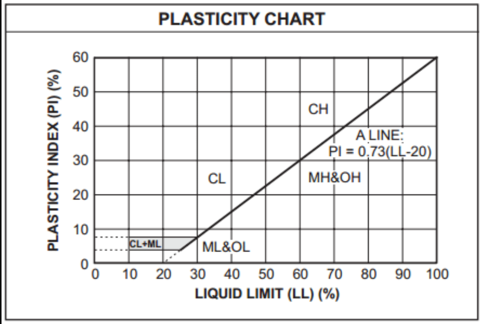
Other

fg	fragmented
bnd	band
qtz	quartz

UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75um and basing fractions on estimated weights)						Group Symbols	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria		
Coarse-grained soils More than half of the material is large that 75um sieve size[b]	Gravels More than half of the coarse fraction is larger than a 4mm sieve	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes			*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name: indicative approximate percentages of sand and gravel; maximum size; angularity; surface condition, and hardness of the coarse grains; local of geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty Sand*, gravelly; about 20% hard, angular gravel particles 12mm maximum size; rounded and subangular sand grains, coarse to fine, about 15% non-plastic fines low dry strength; well compacted and moist in place; alluvial sand; *(SM)*	Use grain size curve in identifying the fractions as given under field identification	Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than 75um sieve size) coarse grained soils are classified as follows Less than 5% GW, GP, SW, SP More than 12% GM, GC, SM, SC 5 to 12% Borderline cases requiring use of dual symbol	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or range of sizes with some intermediate sizes missing			*GP*	Poorly graded gravels, grave-sand mixtures, little or no fines				Not meeting all graduation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)			*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures				Atterberg limits below "A" line or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are borderline cases of requiring use of dual symbols
			Plastic fines (for identification procedures see *CL* below)			*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures				Atterberg limits above "A" line with *PI* greater than 7
	Sands More than half of the coarse fraction is smaller than a 4mm sieve	Clean sands (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes			*SW*	Well graded sands, gravelly sands, little or no fines				$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or range of sizes with some intermediate sizes missing			*SP*	Poorly graded sands, gravelly sands, little or no fines				Not meeting all graduation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)			*SM*	Silty sands, poorly graded sand-silt mixtures				Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are borderline cases of requiring use of dual symbols
			Plastic fines (for identification procedures see *CL* below)			*SC*	Clayey sands, poorly graded sand-clay mixtures				Atterberg limits above "A" line with *PI* greater than 7
Find-grained soils More than half of the material is smaller than 75um sieve size	Identification Procedures of Fractions Smaller than 380 um Sieve Size										
	Silts and clays liquid limit less than 50		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)						
			None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slit plasticity	Give typical name: indicative degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey Silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; *(ML)*			
			Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays				
			Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity				
	Silts and clays liquid limit greater than 50		Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, clastic silts				
			High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays				
			Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity				
Highly Organic Soils			Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils				

The 75um sieve size is about the particle visible to the naked eye



Plasticity Chart
For laboratory classification of fine-grained soils

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines
2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity