ENVIRONMENTAL INVESTIGATION SERVICES

29 March 2018
Ref: E30910Klet2-ASS

Meriden School
c/- Allen Jack and Cottier

Attention: Mr Mark Louw

ACID SULFATE SOIL
PROPOSED ALTERATIONS AND ADDITIONS – MERIDEN SCHOOL
16 MARGARET STREET, STRATHFIELD

1 INTRODUCTION

Environmental Investigation Services (EIS)[1] recently completed a Preliminary Environmental Site Assessment for Meriden School (Ref: E30901KG rpt dated 6 November 2017).

The purpose of this letter to undertake an acid sulfate soil (ASS) assessment for the proposed alterations and additions at development at 16 Margaret Street, Strathfield. The site is identified as Lot 1 in DP723946. The site location is shown on Figure 1.

The aims of the assessment were to establish whether actual ASS or potential ASS (PASS) may be disturbed during the proposed development works, and to assess whether an Acid Sulfate Soil Management Plan (ASSMP) is required.

1.1 Assessment Guidelines

The ASS assessment and preparation of this report were undertaken with reference to the Acid Sulfate Soil Management Advisory Committee (ASSMAC) Acid Sulfate Soil Manual (1998)[2]. Background information on ASS and the assessment process is provided in the appendices.

1.2 Proposed Development Details

The proposed development includes demolition of number of existing buildings and construction of new buildings. Details of the proposed development were not available to EIS at the time of the preparation of this letter.

[1] Environmental consulting division of Jeffery & Katauskas Pty Ltd (J&K)

[2] Acid Sulfate Soils Management Advisory Committee (ASSMAC), (1998). *Acid Sulfate Soils Manual* (ASS Manual 1998)

2 SITE INFORMATION

2.1 Site Description

The site is located in a predominantly residential area of Strathfield. The site is located approximately 385m to the south of a stormwater channel that runs into Powells Creek and eventually into Homebush Bay. The site is situated within gently undulating topography on a hillside that gently slopes down to the north-east at approximately 3° to 4°. The site has a northern frontage on Margaret Street.

At the time of the initial investigation (October 2017), the southern half of the site was generally occupied by a number of single storey brick, sandstone block, weatherboard clad and demountable buildings and fibro clad sheds with concrete and brick paved surrounds.

The northern half of the site comprised grass surfaced areas and planter beds (containing a number of medium to large sized trees) and asphaltic concrete (AC) paved access roads. A gravel surfaced parking area and synthetic grass surfaced play area were located over the western and south-eastern portions of the site, respectively. The northern and western sides of the synthetic grass surfaced play area were supported by 0.5m high segmental concrete block retaining walls.

2.2 Regional Geology

The geological map of Sydney (1983/)[3] indicates the site to be underlain by Ashfield Shale of the Wianamatta Group, which typically consists of black to dark grey shale and laminite.

2.3 Strathfield Council Local Environmental Plan (LEP) 2012

A review of the Strathfield council LEP indicates that the site is located in a Class 5 risk Area (refer to appendices for further details on each risk class). An extract from the Plan is reproduced below.

The closest Class 1, 2, 3, and 4 areas shown on the Strathfield Local Environmental Plan are:

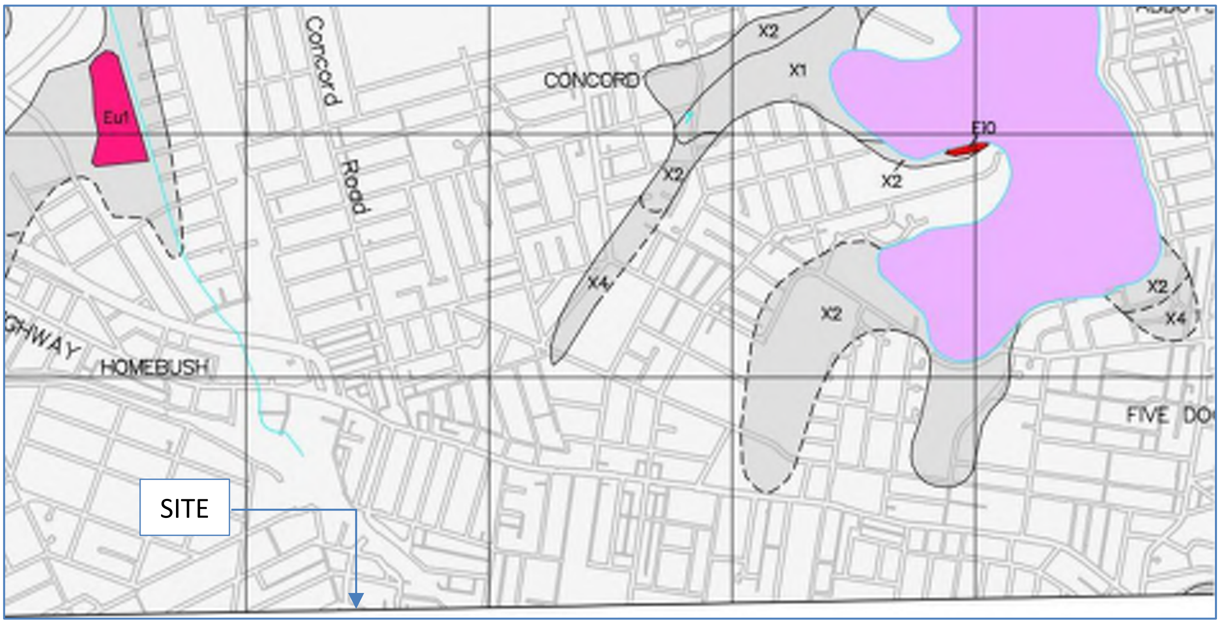
- A creek associated with Airey Park located approximately 1.7km to the north-west and classed as Class 3.

[3] Department of Mineral Resources, (1983). *1:100,000 Geological Map of Sydney (Series 9130)*

- Ismay Reserve located approximately 1.6km to the north and classed as Class 2; and
- A zone around the Cooks River located approximately 2.8km to the south and classed as Class 2.

2.4 Acid Sulfate Soil Risk Map

A review of the ASS risk maps prepared by Department of Land and Water Conservation (1997)[4] indicates that the site is located in an area classed as no known occurrence of acid sulfate soil. A section of the map is reproduced below. EIS note that the initial report stated that the site was located in a low risk area.



Based on the risk maps there do not appear to be any risk areas within 500m of the site. There is a creek source (Powells Creek) approximately 550m to the north of the site. The acid sulfate soil risk map does include a notation that river and creek sediments may contain acid sulfate soil. However EIS note that the sections of creek closest to the site are concrete lined. This area does not show up as Class 1, 2, 3, or 4 area on the Strathfield LEP 2012.

3 RESULTS OF THE INVESTIGATION

3.1 Subsurface Conditions

The subsurface conditions encountered generally consisted of fill material to a depth of approximately 0.5m. This was underlain by silty clay that was assessed to be residual (ie derived from weather bedrock). Shale bedrock was encountered at approximately 1.1 to 2.8m below ground level. No groundwater was encountered during drilling to a maximum depth of 6m. Reference should be made to the borehole logs attached in the appendices for further details on sub-surface conditions.

[4] Department of Land and Water Conservation, (1997). *1:25,000 Acid Sulfate Soil Risk Map (Series 9130N3, Ed 2).*

4 CONCLUSIONS

Based on the information reviewed for this assessment, EIS are of the opinion that there is negligible potential for ASS or PASS to be disturbed during the proposed development works described in Section 1.2 of this report. This conclusion is based on the following:

- The ASS risk map for the site indicates that the site is located within an area of no known occurrence of ASS;
- The boreholes encountered residual silty clay over shallow shale bedrock. Acid sulfate soils are associated with alluvial soils;
- No organic material that may be indicative of potential acid sulfate soil was encountered
- The geological map for the area indicates that the site underlain by Ashfield Shale. This was confirmed by the boreholes;
- The site is located at approximately 19m Australian Heights Datum (AHD). ASS are not usually associated with soil horizons above 5m AHD;
- There are no potential acid sulfate areas with 500m of the site marked on the ASS soil risk map.

The risk of any site works lowering the water table on adjacent Class 1,2,3,4 land below 1m AHD is considered to be negligible for the following reasons:

- The Strathfield Council Local Environmental Plan (LEP) 2012 does not show any Class 1,2,3 or 4 land within 500m of the site;
- The investigation did not encounter groundwater (to a maximum depth of 6m); and
- The permeability of Ashfield shale is very low. Therefore the risk of changing water levels within the site having any impact on water levels in areas more than 500m away is considered to be very low.

Based on this information, an ASSMP is not considered necessary for the proposed development. With regard to potential acid sulfate soil the site is considered suitable for the proposed development.

5 LIMITATIONS

The report limitations are outlined below:

- EIS accepts no responsibility for any unidentified ASS or PASS issues at the site. Any unexpected problems/subsurface features that may be encountered during development works should be inspected by an environmental consultant as soon as possible;
- This report has been prepared based on site conditions which existed at the time of the investigation; scope of work and limitation outlined in the EIS proposal; and terms of contract between EIS and the client (as applicable);
- The conclusions presented in this report are based on investigation of conditions at specific locations, chosen to be as representative as possible under the given circumstances, visual observations of the site and immediate surrounds and documents reviewed as described in the report;
- Subsurface soil and rock conditions encountered between investigation locations may be found to be different from those expected. Groundwater conditions may also vary, especially after climatic changes;

- The investigation and preparation of this report have been undertaken in accordance with accepted practice for environmental consultants, with reference to applicable environmental regulatory authority and industry standards, guidelines and the assessment criteria outlined in the report;
- Where information has been provided by third parties, EIS has not undertaken any verification process, except where specifically stated in the report;
- EIS accept no responsibility for potentially asbestos containing materials that may exist at the site. These materials may be associated with demolition of pre-1990 constructed buildings or fill material at the site;
- EIS have not and will not make any determination regarding finances associated with the site;
- Additional investigation work may be required in the event of changes to the proposed development or landuse. EIS should be contacted immediately in such circumstances;
- Material considered to be suitable from a geotechnical point of view may be unsatisfactory from a soil contamination viewpoint, and vice versa;
- 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;
- Copyright in this report is the property of EIS. EIS has used a degree of care, skill and diligence normally exercised by consulting professionals 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;
- If the client, or any person, provides a copy of this report to any third party, such third party must not rely on this report except with the express written consent of EIS; and
- Any third party who seeks to rely on this report without the express written consent of EIS does so entirely at their own risk and to the fullest extent permitted by law, EIS accepts no liability whatsoever, in respect of any loss or damage suffered by any such third party.

If you have any questions concerning the contents of this letter please do not hesitate to contact us.

Kind Regards

Adrian Kingswell
Principal

Attachments:

1) Report Figure
2) Appendices –
    a. Information on Acid Sulfate Soils
    b. Borehole Logs

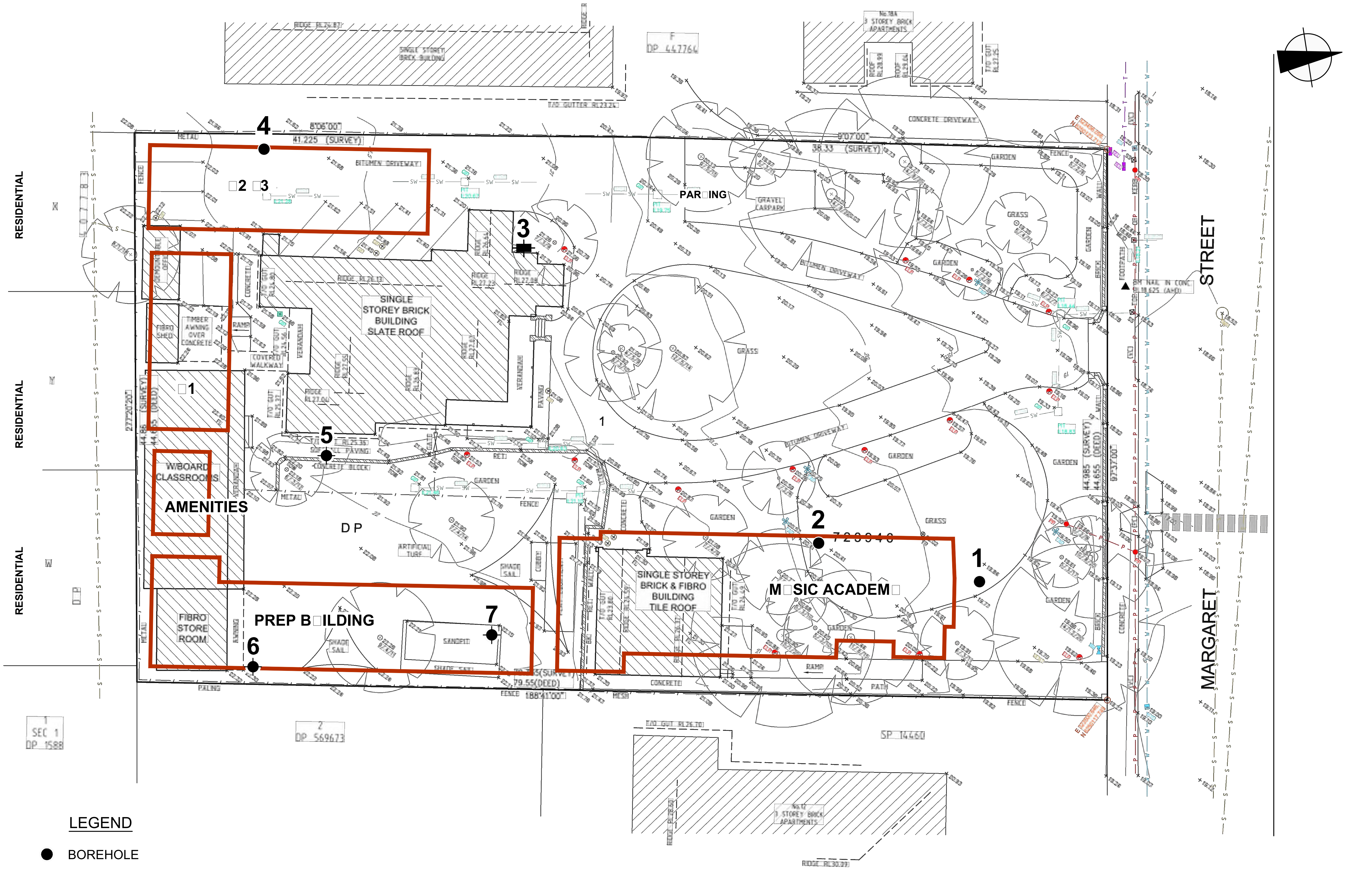
REPORT FIGURES

AERIAL IMAGE SO□RCE: GOOGLE EARTH PRO 7.1.5.1557
AERIAL IMAGE ©: 2015 GOOGLE INC.

This plan should □e read in con□unction with the J□ Geotechnics report.

Title:	**SITE L□CATI□N PLAN**
Location:	16 MARGARET STREET STRATHFIELD□NSW
Report No: 30□10□R	Figure No: 1
	JK **Geotec□nics**

PLOT DATE: 16/10/2017 3:15:37 PM DWG FILE: S:\6 GEOTECHNICAL\JOBS\30000'S\30□10□R STRATHFIELD\CAD\30□10□R.DWG



LEGEND

- BOREHOLE
- BOREHOLE AND DCP TEST (HAND A□GER AND DCP TEST)
- TEST PIT AND DCP TEST
- APPRO□IMATE O□TLINE OF PROPOSED B□ILDINGS

0 3 6 □ 12 15

SCALE 1:300 @A3 METRES

This plan should □e read in con□unction with the J□ Geotechnics report.

Title: **TEST L□CATI□N PLAN**

Location: 16 MARGARET STREET STRATHFIELD□NSW

Report No: 30□10□R

Figure No: 2

J K **Geotec□nics**

PLOT DATE: 20/10/2017 12:13:56 PM DWG FILE: S:\6 GEOTECHNICAL JOBS\30000's\30□10□R STRATHFIELD\CAD\30□10□R.DWG

Appendix A: Information on Acid Sulfate Soils

INFORMATION ON ACID SULFATE SOILS

Background

Acid Sulfate Soil (ASS) is formed from iron rich alluvial sediments and sulfate (found in seawater) in the presence of sulfate reducing bacteria and plentiful organic matter. These conditions are generally found in mangroves, salt marsh vegetation or tidal areas and at the bottom of coastal rivers and lakes. These soils include those that are producing acid (termed actual ASS) and those that can become acid producing (termed potential ASS or 'PASS'). PASS are naturally occurring soils and sediment that contain iron sulfides (pyrite) which, when exposed to oxygen generate sulfuric acid.

The ASS Management Advisory Committee (ASSMAC)

The NSW government in 1994 formed the ASSMAC to coordinate a response to ASS issues. In 1998 this group released the Acid Sulfate Soil Manual[5] providing best practice advice for planning, assessment, management, laboratory methods, drainage, groundwater and the preparation of ASS management plans (ASSMP).

In 1997 the Department of Land and Soil Conservation (now part of the Office of Environment and Heritage[6]) developed two series of maps with respect to ASS for use by council and technical staff implementing the ASS Manual 1998:

- ASS Planning Maps – issued to councils and government units; and
- ASS Risk Maps – issued to interested parties.

The ASS Planning Maps

The ASS planning maps provide an indication of the relative potential for disturbance of ASS to occur at locations within the council area. These maps do not provide an indication of the actual occurrence of ASS at a site or the likely severity of the conditions.

The maps are divided into five classes dependent upon the type of activities/works that if undertaken, may represent an environmental risk through the development of acidic conditions associated with ASS:

Table 1: Risk Classes

Risk Class	Description
Class 1	All works.
Class 2	All works below existing ground level and works by which the water table is likely to be lowered.

[5] Acid Sulfate Soils Management Advisory Committee (ASSMAC), (1998). *Acid Sulfate Soils Manual* (ASS Manual 1998)

[6] http://www.environment.nsw.gov.au/acidsulfatesoil/index.htm

Risk Class	Description
Class 3	Works at depths beyond 1m below existing ground level or works by which the water table is likely to be lowered beyond 1m below existing ground level.
Class 4	Works at depths beyond 2m below existing ground level or works by which the water table is likely to be lowered beyond 2m below existing ground level.
Class 5	Works within 500m of adjacent Class 1,2,3,4 land which are likely to lower the water table below 1m AHD on the adjacent land.

The ASS Risk Maps

The ASS risk maps provide an indication of the probability of occurrence of PASS at a particular location based on interpretation from geological and soil landscape maps. The maps provide classes based on high probability, low probability, no known occurrence and areas of disturbed terrain (site specific assessment necessary) and the likely depth at which ASS are likely to be encountered.

Investigation and Laboratory Testing for ASS

The ASS Manual 1998 includes information on assessment of the likelihood of PASS, the need for an ASSMP, and the development of mitigation measures for a proposed development located in PASS risk areas.

The ASS Manual 1998 recommends a minimum of four sampling locations for a site with an area up to 1ha. For sites greater than 4ha, the manual recommends the use of a reduced density of two locations per hectare subject to the proposed development. For lineal investigations, the manual recommends sampling every 50-100m.

The sampling locations should include all areas where significant disturbance of soils will occur and/or areas with a high environmental sensitivity. In some instances a varied sampling plan may be more suitable, particularly for sites less than 1,000m^2 in area.

The depth of investigation should extend to at least 1m beyond the depth of proposed excavation/disturbance or estimated drop in water table height, or to a minimum of 2m below existing ground level, whichever is greatest.

Standard methods for the laboratory analysis of samples are presented in the Australian Standard AS4969-2008/09[7] (part 1 to 14). The principal analytical method is suspension Peroxide Oxidation Combined Acidity and Sulfur (sPOCAS).

[7] Standards Australia, (2008/2009). *Analysis of acid sulfate soil – Dried samples – Methods of test, Parts 1 to 14.* (AS4969-2008/09)

The sPOCAS method specified in AS4969-2008/09 supersedes the POCAS method specified in the ASS Manual 1998. When S_{POS} (peroxide oxidisable sulfur) values are close to the action criteria confirmation of the result can be undertaken by the chromium reducible sulfur (S_{CR}) method.

The endpoint for the pH titration in AS4969-2008/09 is pH6.5 as opposed to pH5.5 adopted in the ASS Manual. Therefore the values for Total Actual Acidity (TAA), Total Sulfide Acidity (TSA) and Total Potential Acidity (TPA) will more conservative when analysed using the sPOCAS method specified in AS4969-2008/09.

Appendix B: Borehole Logs

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BOREHOLE LOG

Borehole No.
1
1/1

Client: MERIDEN SCHOOL
Project: PROPOSED ALTERATIONS AND ADDITIONS
Location: 16 MARGARET STREET, STRATHFIELD, NSW

Job No. 30910ZR
Date: 27-9-17
Method: SPIRAL AUGER JK308
Logged/Checked by: A.F./P.R.
R.L. Surface: ≈ 19.8m
Datum: AHD

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		0		TOPSOIL: Silty clay, low to medium plasticity, brown, trace of roots and root fibres, ash and fine to medium grained sand.	MC>PL			GRASS COVER
	N = 8 3,3,5		CH	SILTY CLAY: high plasticity, orange brown, trace of ironstone gravel.	MC>PL	VSt	250 280 300	RESIDUAL
	N = 18 5,8,10	1				H	420 420 420	
		2	-	SHALE: grey brown, with iron indurated bands and clay bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
		3			DW	VL		VERY LOW TO LOW 'TC' BIT RESISTANCE
		4		as above, but without iron indurated bands, dark grey.		L-M		LOW TO MODERATE RESISTANCE
		5			SW	M		MODERATE RESISTANCE
		6		END OF BOREHOLE AT 6.0m				
		7						

Samples: ES, U50, DB, DS

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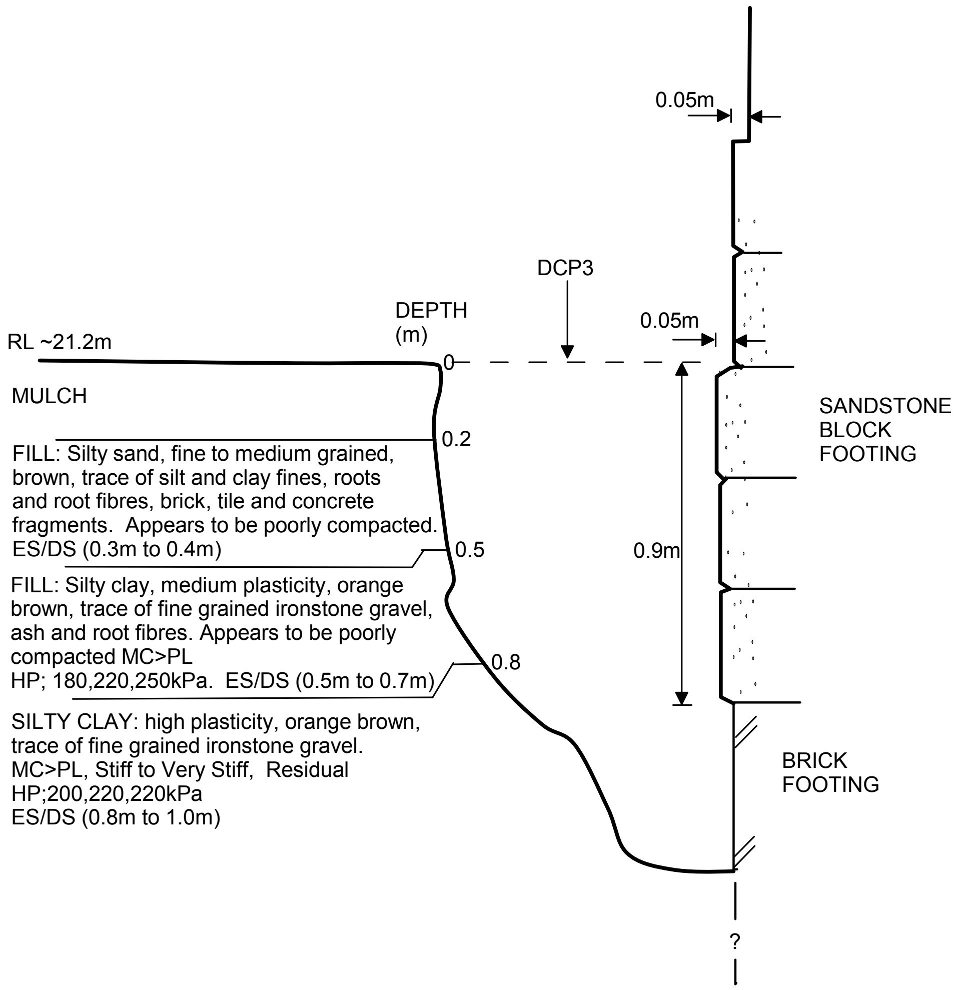
BOREHOLE LOG

Borehole No.
2
1/1

Client: MERIDEN SCHOOL
Project: PROPOSED ALTERATIONS AND ADDITIONS
Location: 16 MARGARET STREET, STRATHFIELD, NSW

Job No. 30910ZR **Method:** SPIRAL AUGER JK308 **R.L. Surface:** ≈ 20.4m
Date: 27-9-17 **Datum:** AHD
Logged/Checked by: A.F./P.R.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 1 HR			0			TOPSOIL: Silty clay, low to medium plasticity, brown, trace of fine grained sand and root fibres.	MC<PL			GRASS COVER
		N = 12 4,6,6			CH	SILTY CLAY: high plasticity, orange brown, trace of fine grained ironstone gravel.	MC≈PL	H	400 >600 >600	RESIDUAL
			1							
		N = 22 7,11,11			-	SHALE: grey brown, with iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
			2							
						as above, but without iron indurated bands.	DW	L-M		LOW RESISTANCE
			3							
							SW	M		MODERATE RESISTANCE
			4							
						END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							



END OF TEST PIT AT 1.35m
DRY ON COMPLETION

TEST PIT 3
CROSS SECTIONAL SKETCH
LOOKING EAST

0 1.0
Scale 1:20 @A4 Metres

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Report No. 30910ZR Figure No. 3

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BOREHOLE LOG

Borehole No. 4

1/1

Client: MERIDEN SCHOOL

Project: PROPOSED ALTERATIONS AND ADDITIONS

Location: 16 MARGARET STREET, STRATHFIELD, NSW

Job No. 30910ZR **Method:** SPIRAL AUGER JK308 **R.L. Surface:** ≈ 21.9m

Date: 27-9-17 **Datum:** AHD

Logged/Checked by: A.F./P.R.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Silty sandy gravel, fine to medium grained, angular igneous gravel, light brown, fine to medium grained sand.	D			
					CH	SILTY CLAY: high plasticity, brown, trace of fine grained ironstone gravel.	MC≈PL	H		RESIDUAL
		N = 15 6,8,7							400 500 470	
			1							
		N = 15 5,7,8					MC>PL	VSt	310 260 300	
			2							
			3		-	SHALE: orange brown and grey brown, with iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
			4			as above, but dark grey.	DW	L-M		LOW TO MODERATE RESISTANCE
			5				SW	M-H		MODERATE TO HIGH RESISTANCE
			6			END OF BOREHOLE AT 6.0m				
			7							

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BOREHOLE LOG

Borehole No.
5
1/1

Client: MERIDEN SCHOOL
Project: PROPOSED ALTERATIONS AND ADDITIONS
Location: 16 MARGARET STREET, STRATHFIELD, NSW

Job No. 30910ZR **Method:** HAND AUGER **R.L. Surface:** ≈ 22.2m
Date: 27-9-17 **Datum:** AHD
Logged/Checked by: A.F./P.R

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		REFER TO DCP TEST RESULTS	0			MULCH: 100mm.t				
						FILL: Silty clay, medium to high plasticity, brown, trace of fine grained igneous and ironstone gravel, fine grained sand and root fibres.	MC≈PL			APPEARS MODERATELY COMPACTED
					CH	SILTY CLAY: high plasticity, orange brown, trace of fine grained ironstone gravel.	MC>PL	VSt	300 280 270	RESIDUAL
			1			as above, but light grey.	MC<PL	(H)		TOO FRIABLE FOR HP TESTING
						END OF BOREHOLE AT 1.5m				HAND AUGER REFUSAL
			2							
			3							
			4							
			5							
			6							
			7							

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BOREHOLE LOG

Borehole No.
6
1/1

Client: MERIDEN SCHOOL
Project: PROPOSED ALTERATIONS AND ADDITIONS
Location: 16 MARGARET STREET, STRATHFIELD, NSW

Job No. 30910ZR **Method:** HAND AUGER **R.L. Surface:** ≈ 22.2m
Date: 29-9-17 **Datum:** AHD
Logged/Checked by: A.F./P.R.

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLET-ION		REFER TO DCP TEST RESULTS	0			FILL: Silty sand, fine to medium grained, brown, with root fibres and clay fines.	D			GARDEN BED COVER APPEARS POORLY COMPACTED
					CH	SILTY CLAY: high plasticity, mottled red brown and light grey, trace of fine to medium grained ironstone gravel.	MC>PL	F-St	100 50	RESIDUAL
								St-VSt	80	
			1			as above, but light grey, with ironstone gravel.			180 160	
					-	SHALE: light grey, with L-M strength iron indurated bands.	XW	EL	180 250 200 210	HAND AUGER REFUSAL ON INFERRED IRONSTONE BAND
						END OF BOREHOLE AT 1.2m				
			2							
			3							
			4							
			5							
			6							
			7							

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
7
1/1

Client: MERIDEN SCHOOL
Project: PROPOSED ALTERATIONS AND ADDITIONS
Location: 16 MARGARET STREET, STRATHFIELD, NSW

Job No. 30910ZR | **Method:** HAND AUGER | **R.L. Surface:** ≈ 22.0m
Date: 29-9-17 | **Datum:** AHD
Logged/Checked by: A.F./P.R.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION					REFER TO DCP TEST RESULTS	0			FILL: Sand, fine to medium grained, yellow brown.	D			SAND PIT APPEARS POORLY COMPACTED
								CH	SILTY CLAY: high plasticity, orange grey brown, trace of medium grained ironstone gravel.	MC>PL	St	150 170 160	RESIDUAL
						1			as above, but light grey.	MC≈PL	H		TOO FRIABLE FOR HP TESTING
									END OF BOREHOLE AT 1.5m				
						2							
						3							
						4							
						5							
						6							
						7							

EXPLANATORY NOTES – ENVIRONMENTAL LOGS

INTRODUCTION

These notes have been provided to supplement the environmental report with regards to drilling and field logging. Not all notes are necessarily relevant to all reports. Where geotechnical borehole logs are utilised for environmental purpose, reference should also be made to the explanatory notes included in the geotechnical report. Environmental logs are not suitable for geotechnical purposes.

The ground is a product of continuing natural and manmade processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Environmental studies involve gathering and assimilating limited facts about these characteristics and properties in order to understand the ground on a particular site under certain conditions. These conditions are directly relevant only to the ground at the place where, and time when, the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (e.g. sandy clay) as set out below (note that unless stated in the report, the soil classification is based on a qualitative field assessment, not laboratory testing):

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as shown in the following table:

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'Shale' is used to describe thinly bedded to laminated siltstone.

DRILLING OR EXCAVATION METHODS

The following is a brief summary of drilling and excavation methods currently adopted by the Company, and some comments on their use and application. All except test pits and hand auger drilling require the use of a mechanical drilling rig.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descend into the pit. The depth of penetration is limited to approximately 3m for a backhoe and up to 6m for an excavator. Limitations of test pits include problems associated with disturbance and difficulty of reinstatement; and the consequent effects on nearby structures. Care must be taken if construction is to be carried out near test pit locations to either properly re-compact the backfill during construction, or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as fill, hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water 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 "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (e.g. from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The locations of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm 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 150mm of, say, 4, 6 and 7 blows, as: N = 13 (4, 6, 7)
- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as: N>30 (15, 30/40mm)

The results of the test can be related empirically to the engineering properties of the soil. Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60 tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "Nc" on the borehole logs, together with the number of blows per 150mm penetration.

LOGS

The borehole or test pit logs presented herein are an interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it 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 and may not be the same at the time of construction; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or 'reverted' chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising at intervals ranging from several days to 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 perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (e.g. bricks, concrete, plastic, slag/ash, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes

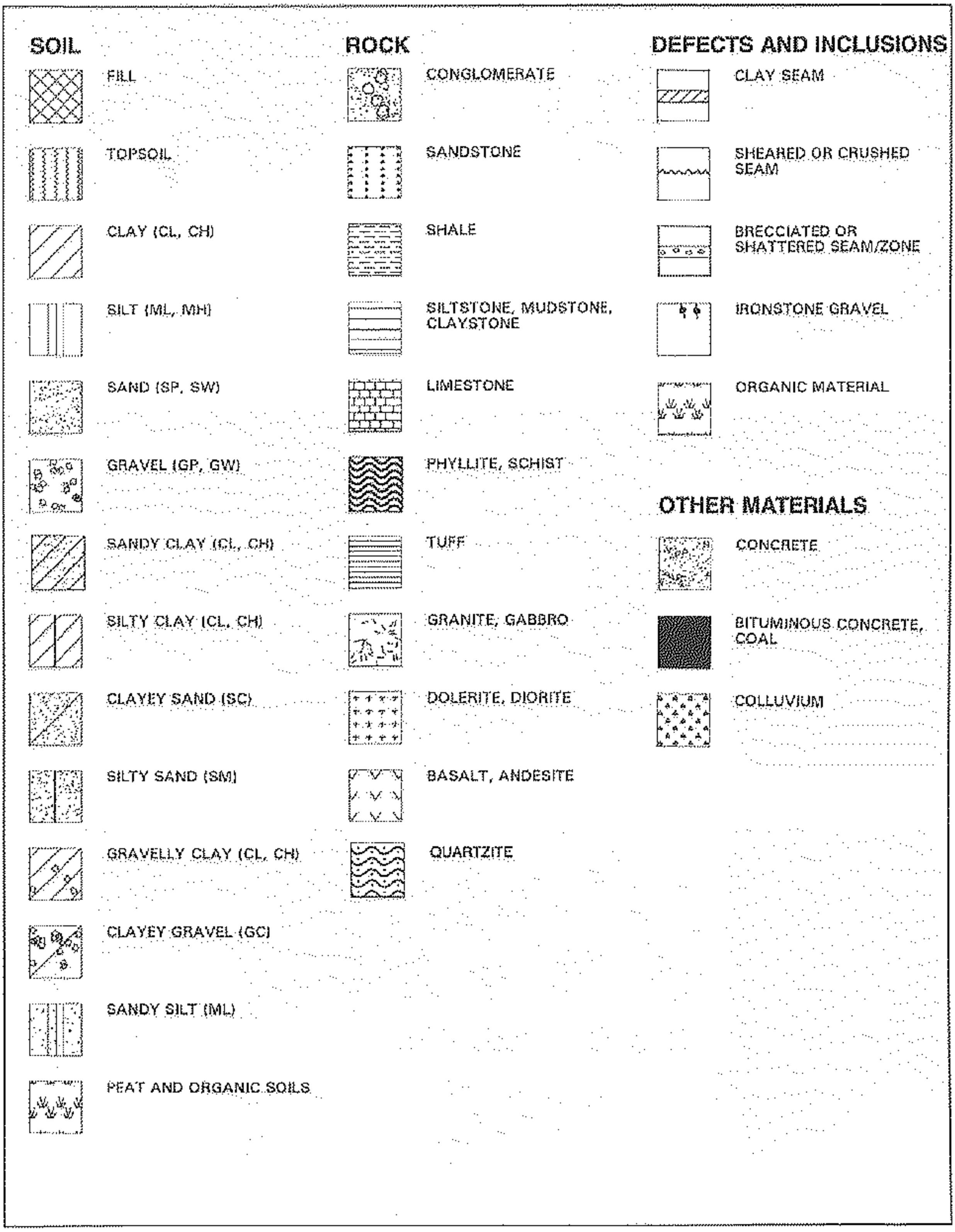
LABORATORY TESTING

Laboratory testing has not been undertaken to confirm the soil classifications and rocks strengths indicated on the environmental logs unless noted in the report.

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, EIS should be notified immediately.

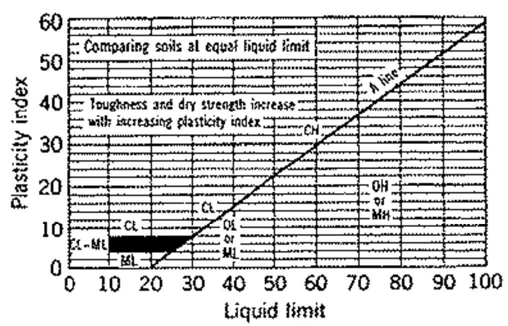
GRAPHIC LOG SYMBOLS FOR SOIL AND ROCKS



Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)				Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria	
Coarse-grained soils More than half of material is *larger* than 75 μm sieve size[b]	Gravels More than half of coarse fraction is larger than 4 mm sieve size	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; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation 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	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases 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 coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation 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 requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7	

Laboratory Classification Criteria (coarse-grained soils): 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 75 μm 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 symbols.

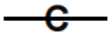
Fine-grained soils More than half of material is *smaller* than 75 μm sieve size (The 75 μm sieve size is about the smallest particle visible to naked eye)	Identification Procedures on Fraction Smaller than 380 μm Sieve Size: Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate 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
	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	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
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, elastic silts	
	High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example:
	Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	*Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
Highly Organic Soils	Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



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.

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record	  	Standing water level. Time delay following completion of drilling may be shown. Extent of borehole collapse shortly after drilling. Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES U50 DB DS ASB ASS SAL	Soil sample taken over depth indicated, for environmental analysis. Undisturbed 50mm diameter tube sample taken over depth indicated. Bulk disturbed sample taken over depth indicated. Small disturbed bag sample taken over depth indicated. Soil sample taken over depth indicated, for asbestos screening. Soil sample taken over depth indicated, for acid sulfate soil analysis. Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3 R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25 PID = 100	Vane shear reading in kPa of Undrained Shear Strength. Photoionisation detector reading in ppm (Soil sample heads pace test).
Moisture (Cohesive Soils) (Cohesionless)	MC>PL MC≈PL MC<PL D M W	Moisture content estimated to be greater than plastic limit. Moisture content estimated to be approximately equal to plastic limit. Moisture content estimated to be less than plastic limit. DRY – Runs freely through fingers. MOIST – Does not run freely but no free water visible on soil surface. WET – Free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS S F St VSt H ( )	VERY SOFT – Unconfined compressive strength less than 25kPa SOFT – Unconfined compressive strength 25-5 0kPa FIRM – Unconfined compressive strength 50-1 00kPa STIFF – Unconfined compressive strength 100- 200kPa VERY STIFF – Unconfined compressive strength 200- 400kPa HARD – Unconfined compressive strength greater than 400kPa Bracketed symbol indicates estimated consistency based o n tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)	 VL L MD D VD ( )	**Density Index (ID) Range (%)** — **SPT ' N' Value Range (Blows/300mm)** Very Loose <15 — 0-4 Loose 15-35 — 4-10 Medium Dense 35-65 — 10-30 Dense 65-85 — 30-50 Very Dense >85 — >50 Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise
Remarks	'V' bit 'TC' bit $\mathbf{T}_{60}$	Hardened steel 'V' shaped bit. Tungsten carbide wing bit. Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

LOG SYMBOLS CONTINUED

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining and Geomechanics Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
		0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is “sugary” and friable.
		0.1	
Low:	L		A piece of core 150 mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
		0.3	
Medium Strength:	M		A piece of core 150 mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
		1	
High:	H		A piece of core 150 mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
		3	
Very High:	VH		A piece of core 150 mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
		10	
Extremely High:	EH		A piece of core 150 mm long x 50mm dia. is very difficult to break with h and-held hammer . Rings when struck with a hammer.

ROCK STRENGTH

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to (i.e. relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Iron stained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	