ENVIRONMENTAL INVESTIGATION SERVICES

5 November 2018
Ref: E28092KPlet-ASS

Warren and Mahoney Architects Australia Pty Ltd
(ABN: 15 607 221 198)
Level 13
95 Pitt Street
Sydney NSW 2000

Attention: Mr Andrew Walsh

PRELIMINARY ACID SULFATE SOIL ASSESSMENT
PROPOSED ALTERATIONS AND ADDITIONS
MONA VALE SLSC, SURFVIEW ROAD, MONA VALE, NSW

1 INTRODUCTION

Warren and Mahoney Architects Australia Pty Ltd ('the client') commissioned Environmental Investigation Services (EIS)[1] to undertake a preliminary acid sulfate soil (ASS) assessment for the proposed alterations and additions at Mona Vale Surf Life Saving Club (SLSC), Surfview Road, Mona Vale, NSW. The site location is shown on Figure 1 and the investigation was confined to the borehole locations as shown on Figure 2. The borehole locations were selected based on access limitations and are considered to be representative of the soil conditions beneath the site.

The investigation was undertaken generally in accordance with an EIS proposal (Ref: EP48202KG Rev1) of 22 October 2018 and written acceptance from Warren and Mahoney Architects Australia dated the same. A preliminary geotechnical investigation was undertaken previously to the ASS assessment by JK Geotechnics[2] and the results are presented in a separate report (Ref: 28092ZRrpt) dated 13 February 2015.

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

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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)[3]. Background information on ASS and the assessment process is provided in the appendices.

1.2 Proposed Development Details

Based on the details provided, it is understood that the proposed development includes alterations and additions to the existing SLSC. Significant soil disturbance/excavation is not proposed, however it is anticipated that minor soil disturbance will occur for the construction of strip/pad footings or for the installation of piles to a maximum depth of approximately 2.5m. The preliminary ASS assessment has assessed the soil conditions down to a maximum depth of 6m to allow for potential minor variations to this design.

2 SITE INFORMATION

2.1 Summary of Previous Investigations

The preliminary geotechnical investigation included the drilling of two boreholes. One of these boreholes (BH1) was positioned immediately to the south of the SLSC building. The other borehole (BH2) was located in an alternative development location further to the east/north-east. BH1 generally encountered light brown sand to a depth of approximately 4m, underlain by dark grey and grey sand and clayey sand to approximately 10m, then grey and orange brown silty clay to the termination depth of the borehole at approximately 18m. Groundwater was observed in the borehole at a depth of approximately 5.4m on completion.

2.2 Site Description

Mona Vale SLSC is located on the eastern side of Surfview Road, to the west of Mona Vale Beach. At the time of the investigation the existing SLSC was a single storey structure constructed approximately at the existing grade.

2.3 Regional Geology

The geological map of Sydney (1983)[4] indicates the site to be underlain by Quaternary aged deposits of alluvial and estuarine sands, silts and clays, and marine sands overlying the interbedded shale, laminate and sandstone of the Triassic aged Newport Formation.

2.4 Pittwater Local Environmental Plan (LEP) 2014

A review of the Pittwater LEP indicates that the site is located in a Class 4 (refer to appendices for further details on each risk class).

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

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

2.5 Acid Sulfate Soil Risk Map

A review of the ASS risk maps prepared by Department of Land and Water Conservation (1997)[5] indicates that the site is located in an area mapped as having a "low probability" of ASS occurrence in the soil profile at depths of greater than 3m below the ground surface.

3 INVESTIGATION REQUIREMENTS AND ASSESSMENT CRITERIA

3.1 Investigation Requirements

The ASS Manual 1998 recommends a minimum of four sampling locations for a site with an area up to 1ha (10,000m^2). 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.

3.2 Action Criteria

The ASS Manual 1998 presents 'action criteria' for the interpretation of laboratory results. The 'action criteria' define the need to prepare an ASSMP and are based on soil pH, potential acidity and the percentage of oxidisable sulfur for broad categories of soil types. Where disturbance of greater than 1,000 tonnes of ASS is proposed, the action criteria for 'coarse textured soils' apply to all soil types. The following action criteria are presented in the ASS Manual:

Table 3-1: ASS Action Criteria

Category	Description	Criteria
Coarse Textured Soils	Sands to loamy sands	• pH - less than 5; • Total Actual Acidity (TAA)/Total Sulfide Acidity (TSA)/ Total Potential Acidity (TPA) (pH5.5) – greater than 18mol H^+/tonne; and • S_{pos} – greater than 0.03% sulfur oxidisable.

[5] Department of Land and Water Conservation, (1997). *1:25,000 Acid Sulfate Soil Risk Map (Series 9130S1, Ed 2).*

Category	Description	Criteria
Medium Textured Soils	Sandy loams to light clays	• pH - less than 5; • TAA/TSA/TPA (pH5.5) – greater than 36mol H^+/tonne; and • S_{pos} – greater than 0.06% sulfur oxidisable.
Fine Textured Soils	Medium to heavy clays and silty clays	• pH - less than 5; • TAA/TSA/TPA (pH5.5) – greater than 62mol H^+/tonne; and • S_{pos} – greater than 0.1% sulfur oxidisable.

3.3 Site Specific Action Criteria

The action criteria for coarse textured soils has been adopted for this assessment for all samples except one collected from BH102 (5.9-6.0m). The BH102 (5.9-6.0m) sample was clayey sand, therefore the medium textured soil criteria have been adopted for this sample. These criteria are considered most appropriate as the proposed development works will not disturb greater than 1,000 tonnes of soil.

4 INVESTIGATION PROCEDURE

4.1 Subsurface Investigation and Soil Sampling Methods

Field work for this investigation was undertaken on 25 October 2018. Soil samples were collected from two locations (BH101 and BH102), to a maximum borehole depth of 6m. Based on the proposed development details provided at the time of reporting (see Section 1.2), the depth of sampling meets/exceeds the minimum requirement outlined in the ASS Manual 1998. It is noted that the number of sampling locations is below the recommended density of four locations for sites up to 1ha, however, EIS are of the opinion that the reduced sampling density is adequate considering the site/area of proposed excavation is limited and the extent of soil disturbance is minimal. The sampling locations are shown on the attached Figure 2.

The sample locations were drilled using a track mounted hydraulically operated drill rig equipped with spiral flight augers. Soil samples were obtained from a Standard Penetration Test (SPT) sampler or directly from the auger. Soil samples were obtained at various depths, based on observations made during the field investigation. All samples were placed in plastic bags and sealed with plastic ties with minimal headspace. Each sample was labelled with a unique job number, the sampling location, sampling depth and date. All samples were recorded on the borehole logs attached in the appendices.

The samples were preserved by immediate storage in an insulated sample container with ice. Samples were subsequently delivered in the insulated sample container (on ice or with ice packs) to a NATA registered laboratory for analysis under standard chain of custody (COC) procedures.

4.2 Laboratory Analysis

Six selected natural soil samples obtained from the site were analysed for ASS/PASS using the suspension Peroxide Combined Acidity and Sulfur (sPOCAS) analytical methods detailed in AS4969-2008/09[6]. The laboratory testing was undertaken by Envirolab Services (NATA Accreditation Number – 2901). Reference should be made to the laboratory reports (Ref: 203941) attached in the appendices for further information.

5 RESULTS OF THE INVESTIGATION

5.1 Subsurface Conditions

The subsurface conditions encountered generally consisted of a thin layer of clayey fill, underlain by brown, natural sand. Yellow brown and dark grey clayey sand was encountered in BH102 between 5.4 and 6m deep. Both boreholes were terminated at 6m below ground level. Groundwater (standing water level) was observed on completion of drilling at a depths of approximately 5.4-5.6m.

5.2 Laboratory Results

The soil laboratory results were assessed against the action criteria adopted for the assessment. The results are presented in the attached report Table A and are summarised below:

Table 5-1: Summary of ASS Results

Analyte	Results Compared to ASS Guidelines
pH_{kcl} and pH_{ox}	The pH_{KCl} results ranged from pH 7.3 to 9.7. None of the pH_{KCl} results exceeded (i.e. were below) the action criterion of pH 5. Following oxidation, the pH_{ox} results for the samples ranged from pH to 2.6 to 10.2. The pH_{KCl} result for sample BH102 (5.9-6.0m) exceeded (i.e. was below) the action criterion of pH 5. The pH of the BH102 (5.9-6.0m) sample dropped by more than 4 pH units following oxidation.
Acid Trail	• TAA results were all less than the practical quantitation limit (PQL) of 5mol H^+/tonne; • TPA results for all sand samples were less than the PQL. The TPA result for the clayey sand sample from BH102 (5.9-6.0m) was 90mol H^+/tonne and exceeded the action criterion of 36mol H^+/tonne; and • TSA results for all sand samples were less than the PQL. The TSA result for the clayey sand sample from BH102 (5.9-6.0m) was 90mol H^+/tonne and exceeded the action criterion of 36mol H^+/tonne.

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

Analyte	Results Compared to ASS Guidelines
Sulfur Trail	The S_{pos}% results for all sand samples were less than the PQL. The S_{pos}% result for the clayey sand sample from BH102 (5.9-6.0m) was 0.26% w/w and exceeded the action criterion of 0.06%.
Liming Rate	The liming rate required for neutralisation of the material sampled from BH102 (5.9-6.0m) was 8.6kg$CaCO_3$/tonne.

6 CONCLUSIONS

With the exception of one clayey sand sample collected from BH102 (5.9-6.0m), all sPOCAS results were below the action criteria. The dark grey clayey sand encountered in BH102 at a depth of 5.8m below ground level at that location is PASS. A sample of the overlying, yellow brown clayey sand at this location that was encountered between 5.4m and 5.8m was not analysed. However, based on the limited data obtained for the preliminary assessment, it would be reasonable to assume that this soil may also be PASS.

Based on the proposed development details provided (see Section 1.2), the PASS is not expected to be disturbed during the proposed development work and on this basis an ASSMP is not considered to be required. Potential environmental risks posed by PASS present at depth are negligible in the proposed development scenario where the PASS remains undisturbed.

In the event that the proposed development details change and soils are to be disturbed (e.g. during piling) from a depth of 5m (or greater) below ground level, an ASSMP must be prepared. The 5m depth has been established to provide a reasonable buffer between the PASS and the overlying sand that is not ASS or PASS.

7 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

B Page

Brendan Page
Principal Associate Environmental Scientist

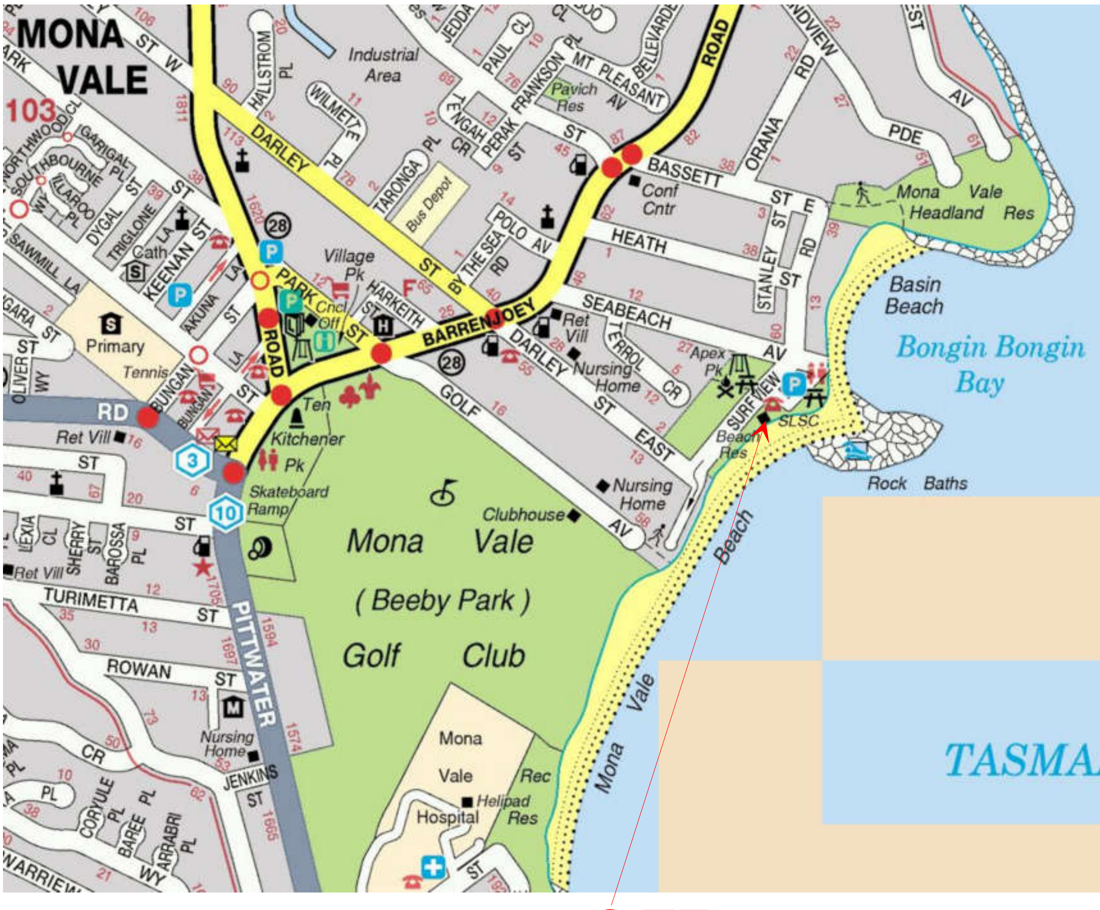
AS Kingswell

Adrian Kingswell
Principal

Attachments:

1) Report Figures 1 and 2
2) Report Table A
3) Appendices –
    a. Information on Acid Sulfate Soils
    b. Borehole Logs
    c. Laboratory Analysis Report and Chain of Custody Documentation

REPORT FIGURES



SITE

Note: Reference should be made to the report for a full understanding of this plan.

Image Sources:
https://maps.six.nsw.gov.au/
UBD on disk v7.0.0

Title: **SITE LOCATION PLAN**

Location: MONA VALE SLSC, SURFVIEW ROAD, MONA VALE, NSW

Report No: E28092KP

Figure No: 1

ENVIRONMENTAL INVESTIGATION SERVICES

EIS

LEGEND:

● BH101 BOREHOLE LOCATION AND NUMBER (EIS 2018)

● BH1 BOREHOLE LOCATION AND NUMBER (JK 2015)

Scale 0 – 25 Metres

Notes: Scale is approximate. Reference should be made to the report for a full understanding of this plan.

Title:	**BOREHOLE LOCATION PLAN**
Location:	MONA VALE SLSC, SURFVIEW ROAD MONA VALE, NSW
Report No:	E28092KP
Figure No:	2

ENVIRONMENTAL INVESTIGATION SERVICES

REPORT TABLE A

EIS

TABLE A

SUMMARY OF LABORATORY RESULTS - ACID SULFATE SOIL ANALYSIS (sPOCAS)

		Analysis	pH_{KCL}	TAA pH 6.5	pH_{ox}	TPA pH 6.5	TSA pH 6.5	S_{POS} %w/w	Liming Rate kg $CaCO_3$/tonne
Acid Sulfate Soil Manual (1998) -Action Criteria		Coarse Textured Soil	pH 5.0	18molH+/ tonne	pH 5.0	18molH+/ tonne	18molH+/ tonne	0.03% w/w	
Acid Sulfate Soil Manual (1998) -Action Criteria		Medium Textured Soil	pH 5.0	36molH+/ tonne	pH 5.0	36molH+/ tonne	36molH+/ tonne	0.06% w/w	
Sample Reference	**Sample Depth (m)**	**Sample Description**							
BH101	0.85-0.95	Sand	9.4	<5	9.4	<5	<5	<0.005	<0.75
BH101	1.6-1.95	Sand	9.7	<5	9.7	<5	<5	<0.005	<0.75
BH102	0.6-0.95	Sand	9.7	<5	10.2	<5	<5	<0.005	<0.75
BH102	1.5-1.95	Sand	9.6	<5	9.9	<5	<5	<0.005	<0.75
BH102	3.2-3.45	Sand	9.6	<5	10.0	<5	<5	<0.005	<0.75
BH102	5.9-6.0	Clayey sand	7.3	<5	2.6	90	90	0.26	8.6
Total Number of Samples			6	6	6	6	6	6	6
Minimum Value			7.3	<5	2.6	90	90	0.26	8.6
Maximum Value			9.7	<5	10.2	90	90	0.26	8.6

Values Exceeding Action Criteria **VALUE**

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[7] 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[8]) 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.

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

[8] 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[9] (part 1 to 14). The principal analytical method is suspension Peroxide Oxidation Combined Acidity and Sulfur (sPOCAS).

[9] 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

ENVIRONMENTAL INVESTIGATION SERVICES
CONSULTING ENVIRONMENTAL ENGINEERS

ENVIRONMENTAL LOG

Borehole No. **101**

1/1

Environmental logs are not to be used for geotechnical purposes

Client: WARREN AND MAHONEY ARCHITECTS AUSTRALIA
Project: PROPOSED ALTERATEIONS AND ADDITIONS
Location: MONA VALE SLSC, SURFVIEW ROAD, MONA VALE, NSW

Job No. E28092KP | **Method:** SPIRAL AUGER JK305 | **R.L. Surface:** N/A
Date: 25/10/18 | **Datum:**
Logged/Checked by: A.M./B.P.

Groundwater Record	SAMPLES (ES, ASS, ASB, SAL, DB)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty clay, low to medium plasticity, brown, trace of root fibres.	w<PL			
					SP	SAND: fine to medium grained, brown.	M			
		N = 15 8,8,7								
			1							
		N = 10 6,4,6								
			2							
		N = 20 10,9,11	3							
			4							
▶		N = 18 8,9,9				SAND: fine to medium grained, yellow brown.		W		
			5							
▼						SAND: fine to medium grained, grey.		W		
			6			END OF BOREHOLE AT 6.0m				
			7							

ENVIRONMENTAL INVESTIGATION SERVICES

CONSULTING ENVIRONMENTAL ENGINEERS

ENVIRONMENTAL LOG

Borehole No.
102
1/1

Environmental logs are not to be used for geotechnical purposes

Client: WARREN AND MAHONEY ARCHITECTS AUSTRALIA

Project: PROPOSED ALTERATEIONS AND ADDITIONS

Location: MONA VALE SLSC, SURFVIEW ROAD, MONA VALE, NSW

Job No. E28092KP

Method: SPIRAL AUGER
JK305

R.L. Surface: N/A

Date: 25/10/18

Datum:

Logged/Checked by: A.M./B.P.

Groundwater Record	SAMPLES (ES, ASS, ASB, SAL, DB)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty clay, low to medium plasticity, brown, fine to medium grained sand, trace of ironstone gravel and root fibres.	w>PL			GRASS COVER
					SP		D			
		N = 20 7,10,10				SAND: fine to medium grained, red brown, trace of ironstone gravel.	M			
			1			SAND: fine to medium grained, brown, trace of clay fines.				
		N = 13 5,6,7								
			2							
			3							
▶		N = 8 4,4,4					W			
			4							
		N = 6 4,4,2								
			5							
▼						Clayey SAND: fine to medium grained, yellow brown.	W			
						Clayey SAND: fine to medium grained, dark grey mottled yellow brown.				
			6			END OF BOREHOLE AT 6.0m				
			7							

ENVIRONMENTAL LOGS EXPLANATORY NOTES

INTRODUCTION

These notes have been provided to amplify the environmental report in regard to classification methods, field procedures and certain matters relating to the logging of soil and rock. 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 man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Environmental studies include gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they 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 1726:2017 *'Geotechnical Site Investigations'*. 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 geoenvironmental practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached soil classification table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	< 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2.36mm
Gravel	2.36 to 63mm
Cobbles	63 to 200mm
Boulders	> 200mm

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 (VL)	< 4
Loose (L)	4 to 10
Medium dense (MD)	10 to 30
Dense (D)	30 to 50
Very Dense (VD)	> 50

Cohesive soils are classified on the basis of strength (consistency) either by use of a hand penetrometer, vane shear, laboratory testing and/or tactile engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength (kPa)	Indicative Undrained Shear Strength (kPa)
Very Soft (VS)	≤ 25	≤ 12
Soft (S)	> 25 and ≤ 50	> 12 and ≤ 25
Firm (F)	> 50 and ≤ 100	> 25 and ≤ 50
Stiff (St)	> 100 and ≤ 200	> 50 and ≤ 100
Very Stiff (VSt)	> 200 and ≤ 400	> 100 and ≤ 200
Hard (Hd)	> 400	> 200
Friable (Fr)	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 fissile mudstone, with a weakness parallel to bedding. Rocks with alternating inter-laminations of different grain size (eg. siltstone/claystone and siltstone/fine grained sandstone) are referred to as 'laminite'.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All methods except test pits, hand auger drilling and portable Dynamic Cone Penetrometers require the use of a mechanical rig which is commonly mounted on a truck chassis or track base.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and 'weaker' bedrock if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for a large excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact 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. Refusal of the hand auger can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, 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 insitu 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 limited 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 cuttings. 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 assessed 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. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg. 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, NMLC or HQ triple tube core barrels, which give a core of about 50mm and 61mm diameter, respectively, 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 NO CORE. The location of NO CORE recovery is determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the bottom 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 1289.6.3.1–2004 (R2016) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – Standard Penetration Test (SPT)'*.

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 63.5kg 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.

A modification to the SPT 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 'N_c' 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 terms and symbols used in preparation of the logs are defined in the following pages.

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.
- 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 reliable water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after the groundwater level has stabilised 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 (eg. bricks, 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 assess the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse environmental characteristics or behaviour. If the volume and nature 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 classification and rock strengths indicated on the environmental logs unless noted in the report.

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SYMBOL LEGENDS

SOIL

- FILL
- TOPSOIL
- CLAY (CL, CI, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CI, CH)
- SILTY CLAY (CL, CI, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CI, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML, MH)
- PEAT AND HIGHLY ORGANIC SOILS (Pt)

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE/MUDSTONE
- SILTSTONE
- CLAYSTONE
- COAL
- LAMINITE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

OTHER MATERIALS

- BRICKS OR PAVERS
- CONCRETE
- ASPHALTIC CONCRETE

CLASSIFICATION OF COARSE AND FINE GRAINED SOILS

Major Divisions		Group Symbol	Typical Names	Field Classification of Sand and Gravel	Laboratory Classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND (more than half of coarse fraction is smaller than 2.36mm)	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	N/A
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	

Major Divisions		Group Symbol	Typical Names	Field Classification of Silt and Clay			Laboratory Classification
				Dry Strength	Dilatancy	Toughness	% < 0.075mm
ine grained soils (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Laboratory Classification Criteria

A well graded coarse grained soil is one for which the coefficient of uniformity $Cu > 4$ and the coefficient of curvature $1 < C_c < 3$. Otherwise, the soil is poorly graded. These coefficients are given by:

$$C_u = \frac{D_{60}}{D_{10}} \quad \text{and} \quad C_c = \frac{(D_{30})^2}{D_{10}\ D_{60}}$$

Where D_{10}, D_{30} and D_{60} are those grain sizes for which 10%, 30% and 60% of the soil grains, respectively, are smaller.

NOTES:

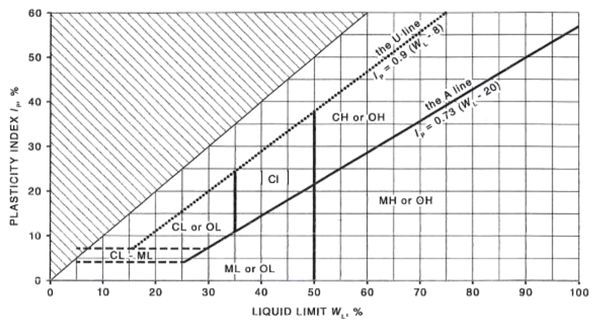
1 For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.

2 Where the grading is determined from laboratory tests, it is defined by coefficients of curvature (C_c) and uniformity (C_u) derived from the particle size distribution curve.

3 Clay soils with liquid limits > 35% and ≤ 50% may be classified as being of medium plasticity.

4 The U line on the Modified Casagrande Chart is an approximate upper bound for most natural soils.

Modified Casagrande Chart for Classifying Silts and Clays according to their Behaviour



LOG SYMBOLS

Log Column	Symbol	Definition
Groundwater Record		Standing water level. Time delay following completion of drilling/excavation may be shown.
	C	Extent of borehole/test pit collapse shortly after drilling/excavation.
		Groundwater seepage into borehole or test pit noted during drilling or excavation.
Samples	ES	Sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos analysis.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	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 figures show blows per 150mm penetration. 'Refusal' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60° solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of undrained shear strength.
	PID = 100	Photoionisation detector reading in ppm (soil sample headspace test).
Moisture Condition (Fine Grained Soils)	w > PL	Moisture content estimated to be greater than plastic limit.
	$w \approx$ PL	Moisture content estimated to be approximately equal to plastic limit.
	w < PL	Moisture content estimated to be less than plastic limit.
	$w \approx$ LL	Moisture content estimated to be near liquid limit.
	w > LL	Moisture content estimated to be wet of liquid limit.
(Coarse Grained Soils)	D	DRY – runs freely through fingers.
	M	MOIST – does not run freely but no free water visible on soil surface.
	W	WET – free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – unconfined compressive strength ≤ 25kPa.
	S	SOFT – unconfined compressive strength > 25kPa and ≤ 50kPa.
	F	FIRM – unconfined compressive strength > 50kPa and ≤ 100kPa.
	St	STIFF – unconfined compressive strength > 100kPa and ≤ 200kPa.
	VSt	VERY STIFF – unconfined compressive strength > 200kPa and ≤ 400kPa.
	Hd	HARD – unconfined compressive strength > 400kPa.
	Fr	FRIABLE – strength not attainable, soil crumbles.
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other assessment.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** — **SPT 'N' Value Range (Blows/300mm)**
	VL	VERY LOOSE — ≤ 15 — 0 – 4
	L	LOOSE — > 15 and ≤ 35 — 4 – 10
	MD	MEDIUM DENSE — > 35 and ≤ 65 — 10 – 30
	D	DENSE — > 65 and ≤ 85 — 30 – 50
	VD	VERY DENSE — > 85 — > 50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other assessment.
Hand Penetrometer Readings	300 250	Measures reading in kPa of unconfined compressive strength. Numbers indicate individual test results on representative undisturbed material unless noted otherwise.

Log Column	Symbol	Definition
Remarks	‘V’ bit	Hardened steel ‘V’ shaped bit.
	‘TC’ bit	Twin pronged tungsten carbide bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.
	Soil Origin	The geological origin of the soil can generally be described as:
		RESIDUAL – soil formed directly from insitu weathering of the underlying rock. No visible structure or fabric of the parent rock.
		EXTREMELY WEATHERED – soil formed directly from insitu weathering of the underlying rock. Material is of soil strength but retains the structure and/or fabric of the parent rock.
		ALLUVIAL – soil deposited by creeks and rivers.
		ESTUARINE – soil deposited in coastal estuaries, including sediments caused by inflowing creeks and rivers, and tidal currents.
		MARINE – soil deposited in a marine environment.
		AEOLIAN – soil carried and deposited by wind.
		COLLUVIAL – soil and rock debris transported downslope by gravity, with or without the assistance of flowing water. Colluvium is usually a thick deposit formed from a landslide. The description ‘slopewash’ is used for thinner surficial deposits.
		LITTORAL – beach deposited soil.

Classification of Material Weathering

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.</td></tr>
<tr><td colspan="2">Extremely Weathered</td><td colspan="2">XW</td><td>Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered (Note 1)</td><td>HW</td><td rowspan="2">DW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition of individual minerals or colour changes.</td></tr>
</table>

NOTE 1: The term ‘Distinctly Weathered’ is used where it is not practicable to distinguish between ‘Highly Weathered’ and ‘Moderately Weathered’ rock. ‘Distinctly Weathered’ is defined as follows: *‘Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores’*. There is some change in rock strength.

Rock Material Strength Classification

Term	Abbreviation	Uniaxial Compressive Strength (MPa)	Guide to Strength	
			Point Load Strength Index $Is_{(50)}$ (MPa)	Field Assessment
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	6 to 20	0.3 to 1	Scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Appendix C: Laboratory Report and Chain of Custody Documentation

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CERTIFICATE OF ANALYSIS 203941

Client Details

Client	Environmental Investigation Services
Attention	Brendan Page
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**E28092KP**
Number of Samples	11 SOIL
Date samples received	25/10/2018
Date completed instructions received	25/10/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	01/11/2018
Date of Issue	01/11/2018

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Jacinta Hurst, Laboratory Manager

sPOCAS + %S w/w						
Our Reference		203941-1	203941-2	203941-6	203941-7	203941-8
Your Reference	UNITS	BH101	BH101	BH102	BH102	BH102
Depth		0.85-0.95	1.6-1.95	0.6-0.95	1.5-1.95	3.2-3.45
Date Sampled		25/10/2018	25/10/2018	25/10/2018	25/10/2018	25/10/2018
Type of sample		SOIL	SOIL	SOIL	SOIL	SOIL
Date prepared	-	29/10/2018	29/10/2018	29/10/2018	29/10/2018	29/10/2018
Date analysed	-	29/10/2018	29/10/2018	29/10/2018	29/10/2018	29/10/2018
pH_{kcl}	pH units	9.4	9.7	9.7	9.6	9.6
TAA pH 6.5	moles H^+/t	<5	<5	<5	<5	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
pH_{Ox}	pH units	9.4	9.7	10.2	9.9	10.0
TPA pH 6.5	moles H^+/t	<5	<5	<5	<5	<5
s-TPA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
TSA pH 6.5	moles H^+/t	<5	<5	<5	<5	<5
s-TSA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
ANC_E	% $CaCO_3$	1.3	1.6	1.7	1.6	1.5
a-ANC_E	moles H^+/t	260	320	340	310	300
s-ANC_E	%w/w S	0.42	0.52	0.54	0.50	0.48
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
S_P	%w/w	<0.005	0.005	<0.005	0.005	<0.005
S_{POS}	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
a-S_{POS}	moles H^+/t	<5	<5	<5	<5	<5
Ca_{KCl}	%w/w	0.43	0.50	0.40	0.30	0.34
Ca_P	%w/w	0.62	0.75	0.59	0.49	0.46
Ca_A	%w/w	0.19	0.25	0.20	0.20	0.12
Mg_{KCl}	%w/w	0.026	0.029	0.022	0.016	0.021
Mg_P	%w/w	0.024	0.032	0.025	0.016	0.018
Mg_A	%w/w	<0.005	<0.005	<0.005	<0.005	<0.005
S_{HCl}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	<0.005	<0.005	<0.005
a-S_{NAS}	moles H^+/t	<5	<5	<5	<5	<5
s-S_{NAS}	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
Fineness Factor	-	1.5	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+/t	<5	<5	<5	<5	<5
s-Net Acidity	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
Liming rate	kg $CaCO_3$/t	<0.75	<0.75	<0.75	<0.75	<0.75
s-Net Acidity without -ANCE	%w/w S	<0.01	<0.01	<0.01	<0.01	<0.01
a-Net Acidity without ANCE	moles H^+/t	<5	<5	<5	<5	<5
Liming rate without ANCE	kg $CaCO_3$/t	<0.75	<0.75	<0.75	<0.75	<0.75

sPOCAS + %S w/w		
Our Reference		203941-11
Your Reference	UNITS	BH102
Depth		5.9-6.0
Date Sampled		25/10/2018
Type of sample		SOIL
Date prepared	-	29/10/2018
Date analysed	-	29/10/2018
pH_{kcl}	pH units	7.3
TAA pH 6.5	moles H^+/t	<5
s-TAA pH 6.5	%w/w S	<0.01
pH_{Ox}	pH units	2.6
TPA pH 6.5	moles H^+/t	90
s-TPA pH 6.5	%w/w S	0.14
TSA pH 6.5	moles H^+/t	90
s-TSA pH 6.5	%w/w S	0.14
ANC_E	% $CaCO_3$	<0.05
a-ANC_E	moles H^+/t	<5
s-ANC_E	%w/w S	<0.05
S_{KCl}	%w/w S	0.04
S_P	%w/w	0.30
S_{POS}	%w/w	0.26
a-S_{POS}	moles H^+/t	160
Ca_{KCl}	%w/w	0.10
Ca_P	%w/w	0.13
Ca_A	%w/w	0.028
Mg_{KCl}	%w/w	0.007
Mg_P	%w/w	0.009
Mg_A	%w/w	<0.005
S_{HCl}	%w/w S	<0.005
S_{NAS}	%w/w S	<0.005
a-S_{NAS}	moles H^+/t	<5
s-S_{NAS}	%w/w S	<0.01
Fineness Factor	-	1.5
a-Net Acidity	moles H^+/t	110
s-Net Acidity	%w/w S	0.18
Liming rate	kg $CaCO_3$/t	8.6
s-Net Acidity without -ANCE	%w/w S	0.18
a-Net Acidity without ANCE	moles H^+/t	110
Liming rate without ANCE	kg $CaCO_3$/t	8.6

Method ID	Methodology Summary
Inorg-064	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL: sPOCAS + %S w/w					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			29/10/2018	1	29/10/2018	29/10/2018		29/10/2018	[NT]
Date analysed	-			29/10/2018	1	29/10/2018	29/10/2018		29/10/2018	[NT]
pH $_{kcl}$	pH units		Inorg-064	[NT]	1	9.4	9.6	2	90	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	115	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
pH $_{Ox}$	pH units		Inorg-064	[NT]	1	9.4	9.7	3	100	[NT]
TPA pH 6.5	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	85	[NT]
s-TPA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
TSA pH 6.5	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	[NT]	[NT]
s-TSA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
ANC_E	% $CaCO_3$	0.05	Inorg-064	<0.05	1	1.3	1.3	0	[NT]	[NT]
a-ANC_E	moles H^+/t	5	Inorg-064	<5	1	260	260	0	[NT]	[NT]
s-ANC_E	%w/w S	0.05	Inorg-064	<0.05	1	0.42	0.42	0	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-064	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
S_P	%w/w	0.005	Inorg-064	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
S_{POS}	%w/w	0.005	Inorg-064	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
a-S_{POS}	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	[NT]	[NT]
Ca_{KCl}	%w/w	0.005	Inorg-064	<0.005	1	0.43	0.41	5	[NT]	[NT]
Ca_P	%w/w	0.005	Inorg-064	<0.005	1	0.62	0.62	0	[NT]	[NT]
Ca_A	%w/w	0.005	Inorg-064	<0.005	1	0.19	0.21	10	[NT]	[NT]
Mg_{KCl}	%w/w	0.005	Inorg-064	<0.005	1	0.026	0.023	12	[NT]	[NT]
Mg_P	%w/w	0.005	Inorg-064	<0.005	1	0.024	0.025	4	[NT]	[NT]
Mg_A	%w/w	0.005	Inorg-064	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-064	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-064	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
a-S_{NAS}	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	[NT]	[NT]
s-S_{NAS}	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
Fineness Factor	-	1.5	Inorg-064	<1.5	1	1.5	1.5	0	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	[NT]	[NT]
s-Net Acidity	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	1	<0.75	<0.75	0	[NT]	[NT]
s-Net Acidity without -ANCE	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	[NT]	[NT]

QUALITY CONTROL: sPOCAS + %S w/w					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	1	<0.75	<0.75	0	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

SAMPLE RECEIPT ADVICE

Client Details	
Client	Environmental Investigation Services
Attention	Brendan Page

Sample Login Details	
Your reference	E28092KP
Envirolab Reference	203941
Date Sample Received	25/10/2018
Date Instructions Received	25/10/2018
Date Results Expected to be Reported	01/11/2018

Sample Condition	
Samples received in appropriate condition for analysis	YES
No. of Samples Provided	11 SOIL
Turnaround Time Requested	Standard
Temperature on Receipt (°C)	12.1
Cooling Method	Ice
Sampling Date Provided	YES

Comments

Nil

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

Sample ID	sPOCAS + %S w/w	On Hold
BH101-0.85-0.95	✓	
BH101-1.6-1.95	✓	
BH101-3.1-3.4		✓
BH101-4.6-4.95		✓
BH101-5.9-6.0		✓
BH102-0.6-0.95	✓	
BH102-1.5-1.95	✓	
BH102-3.2-3.45	✓	
BH102-4.7-4.95		✓
BH102-5.4-5.5		✓
BH102-5.9-6.0	✓	

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info
Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.
Requests for longer term sample storage must be received in writing.

SAMPLE AND CHAIN OF CUSTODY FORM

TO: **ENVIROLAB SERVICES PTY LTD** **12 ASHLEY STREET** **CHATSWOOD NSW 2067** **P: (02) 99106200** **F: (02) 99106201** **Attention: Aileen**	**EIS Job Number:** E28092KP **Date Results Required:** STANDARD **Page:** 1/1	**FROM:** **ENVIRONMENTAL INVESTIGATION SERVICES** **REAR OF 115 WICKS ROAD** **MACQUARIE PARK, NSW 2113** **P: 02-9888 5000 F: 02-9888 5001** **Attention:** Brendan Page

Location:

Sampler:

Sample Preserved in Esky on Ice

Tests Required

Date Sampled	Lab Ref:	Sample Number	Depth (m)	Sample Container	PID	Sample Description	Combo 2	Combo 3a	Combo 6	Combo 6a	8 Metals	PAHs	TRH/BTEX	BTEX	Asbestos	sPOCA		
25/10/18	1	BH101	0.85-0.95	G,A P	-	Sand										X		
	2		1.6-1.95		-											X		
	3		3.1-3.4		-													
	4		4.6-4.95		-													
	5		5.9-6.0		-													
	6	BH102	0.6-0.95		-											X		
	7		1.5-1.95		-											X		
	8		3.2-3.45		-											X		
	9		4.7-4.95		-													
	10		5.4-5.5		-	Clayey Sand												
	11		5.9-6.0		-											X		

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 203941
Date Received: 25/10/18
Time Received: 11:55
Received By: MT
Temp: Cool/Ambient 12
Cooling: Ice/Icepack
Security: Intact/Broken/None

Remarks (comments/detection limits required):

Sample Containers:
G - 250mg Glass Jar
A - Ziplock Asbestos Bag
P - Plastic Bag

Relinquished By:	Date:	Time:	Received By:	Date:
[signature]	25/10/18		Ming Yan To	25/10/18 11:55