Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
15 Callistemon Close
Warabrook NSW 2304
PO Box 324
Hunter Region Mail Centre NSW 2310
Phone (02) 4960 9600
Fax (02) 4960 9601

Graph Building (NSW) Pty Ltd
PO Box 205
Adamstown NSW 2289

Project 81229.06
21 June 2019
R.002.Rev1
PH:kd

Attention: Anthony Williams

Email: Anthony.Williams@graph.com.au

Dear Anthony

Acid Sulfate Soil Assessment
Proposed Aged Care and Residential Development
309 King Street, Newcastle West

1. Introduction

This report provides the results of acid sulfate soil testing undertaken for the proposed mixed use development (Wests Newcastle) at 309 King Street Newcastle. The assessment was conducted at the request of Graph Building Pty Ltd.

The aim of the assessment was to assess potential acid sulfate soil conditions within the footprint of a proposed two-level basement within the site and to confirm treatment requirements (if any) and classification of underlying natural soils to be excavated as part of the proposed development.

It is understood that the proposed development includes demolition of existing structures, subdivision of Lot 1 DP826956 from one into two lots, construction of two towers over 14 levels incorporating residential aged care facility (RACF) and independent living units (ILUs), serviced apartments and residential apartments as well as associated two basement level parking.

The lowest basement slab level (RL -2.4 AHD) is approximately 8 to 10 m below existing ground level. Construction of the basement will therefore involve substantial excavation and dewatering.

DP has previously conducted geotechnical and contamination assessment at the site, with the results reported in the DP report 81229.06.R.001.Rev0 dated 2 August 2018 (Ref 1).

2. Scope of Works

The scope of work for the acid sulfate soil assessment comprised the following:

- Brief review of published information for the site (geological and acid sulfate soil maps);

- Collection of soil samples for acid sulfate soil testing from boreholes drilled as part of the detailed site investigation for contamination (Ref 1);
- Logging of the subsurface profile by an experienced DP engineer;
- Acid sulfate soil screening tests on 15 soil samples from selected boreholes within the site;
- Chromium suite testing (detailed ASS testing) on four soil samples, with samples chosen based on screening results, subsurface conditions and the depths of the samples;
- Preparation of this report.

3. Regional Geology

Reference to the Newcastle Coalfields Surface Geology Sheet, published by BHP, indicates that the site is underlain by alluvial soils which overlie strata of the Newcastle Coal Measures. The latter are of Permian age and typically comprise sandstone, siltstone, claystone and multiple coal seams.

Reference to the Acid Sulfate Soil Risk Map prepared by the Department of Land & Water Conservation indicates that there is a low risk of acid sulfate soil materials and, if present, such soils would be at depths greater than 3 m. Accordingly, the occurrence of acid sulfate soils may only be an issue for deep excavations (e.g. basement or deep services) and / or dewatering below 3 m depth (i.e. as per the proposed development), subject to the results of this assessment.

4. Field Work

The field work was undertaken on 14 June 2018 and comprised the following:

- Drilling of seven boreholes to depths of ranging from 1.55 m to 10.4 m below the ground surface using a truck-mounted drilling rig fitted with solid flight augers. Three boreholes (Bores 3, 4 and part of Bore 7) were drilled using a 4WD-mounted push tube rig;
- Logging of the subsurface profile, including visual and olfactory assessment of potential contaminants in filling;
- Collection of soil samples for identification and testing purposes from the test locations;
- Installation, development, purging, gauging and sampling of three groundwater wells for contamination testing purposes; and
- Levelling of groundwater wells.

An engineer from DP logged the subsurface profile and collected samples for identification and testing purposes.

The subsurface conditions are presented in detail in the borehole logs and CPT logs, in Appendix A of Reference 1 and summarised below in Table 1. These should be read in conjunction with the general notes preceding them, which explain definitions of the classification methods and descriptive terms.

Table 1: Summary of the Subsurface Profile

Unit	Description	Range at Base of Stratum	
		Depth (m)	RL (AHD)
1	Filling – pavement materials, concrete, possible slag/ash (Bores 4 and 7)	0.5 to 3.5	7.5 to 1.4
2.1	SAND / Silty SAND / Sandy SILT – loose to medium dense	4.0 to 8.0	3.2 to -2.7
2.2	SAND – medium dense to very dense	7.5 to 13.0	-3.7 to -6.4
2.3	SAND – dense to very dense	10 to 16.5	-7.95 to -8.90
3.1	CLAY – stiff to very stiff	15 to 21	-12.7 to -13.4
3.2	Silty SAND / Sandy SILT and SAND – loose to medium dense	23.6#	-15.3#
3.3	CLAY / CLAY with some Silty CLAY/ Clayey – very stiff to hard	21 to 34	-19.2 to -27.4
4.1	CLAY / Silty SAND / Sandy SILT and CLAY – hard / medium dense, possible weathered rock	27 to 34	-22.2 to -28.4
4.2	SANDSTONE / SILTSTONE – variable medium strength to high strength	39 (LOI)	-37 (LOI)

Notes to Table 1:
Unit 3.2 was encountered only in CPT 1
LOI – Limit of Investigation

Groundwater parameters measured during purging of monitoring wells are provided in Table 2 below.

Table 2: Groundwater Field Parameters Measured During Purging and Sampling on 28 June 2018

Location ID	PID (sample headspace) (ppm)	Thickness of Product (mm)	pH	EC (µS/cm)	ORP (mV)	DO (ppm)	Turbidity (NTU)	Temp (°C)
5W	<1	ND	5.1	338	207	2.62	>1000	21.9
6W	<1	ND	6.2	236	193	3.56	>1000	23.1
7W	<1	ND	5.9	229	200	2.91	572	22.6

Notes to Table 2:
EC – Electrical Conductivity
ORP – Oxidation Reduction Potential
DO – Dissolved Oxygen
ND – Not detected (i.e. < 1.2 mm)

5. Analytical Results

The results of ASS testing are summarised in Table 3.

Table 3: Results of Acid Sulfate Soil Testing

Sample ID	Sample Depth [a] (m)	Sample RL (AHD)	Sample Description	Screening Test Results				Laboratory Results							
				pH			Strength of Reaction [b]	pH_{KCL}	S_{KCL}	Scr %S	s-TAA %S	S_{NAS} %S	s-ANC_{BT} %S	Net Acidity [c] %S	Exisiting and Potential Acidity %S
				pH_F	pH_{FOX}	pH_F - pH_{FOX}									
2	1.0-1.45	5.75-6.2	Filling - Sand	8.3	8.1	0.2	4	NT	NT	NT	NT	NT	NT	NT	NT
2	2.5-2.95	4.25-4.7	Sand	8.3	6.2	**2.1**	-	5.1	<0.005	<0.005	0.01	<0.005	<0.05	0.01	0.01
2	4.0-4.45	2.75-3.2	Sand	8.1	6.1	**2.0**	-	NT	NT	NT	NT	NT	NT	NT	NT
2	5.5-5.95	1.25-1.7	Sand	7.9	5.8	**2.1**	-	5.3	<0.005	<0.005	<0.01	<0.005	<0.05	0.006	0.006
3	2	6	Filling - Gravelly Sand	8.7	7.3	**1.4**	3	NT	NT	NT	NT	NT	NT	NT	NT
5W	4.0-4.45	1.15-1.6	Sand	5.3	4.7	0.6	-	NT	NT	NT	NT	NT	NT	NT	NT
5W	5.5-5.95	-0.35-0.1	Sand	6.8	6.1	0.7	-	NT	NT	NT	NT	NT	NT	NT	NT
6W	2	3	Sand	6.4	4.2	**2.2**	2	4.7	<0.005	<0.005	0.04	<0.005	<0.05	0.042	0.042
6W	2.5-2.95	2.05-2.5	Sand	6.4	5.4	**1.0**	-	NT	NT	NT	NT	NT	NT	NT	NT
6W	4.0-4.45	0.55-1.0	Sand	5.7	5.2	0.5	-	NT	NT	NT	NT	NT	NT	NT	NT
6W	5.5-5.95	-0.95 - (-0.5)	Sand	7.1	5.8	**1.3**	-	5.5	<0.005	<0.005	<0.01	<0.005	<0.05	<0.005	<0.005
7W	2	7.2	Sand	7.1	6.6	0.5	2	NT	NT	NT	NT	NT	NT	NT	NT
7W	2.5-2.95	6.25-6.7	Sand	7.4	7.4	0.0	-	NT	NT	NT	NT	NT	NT	NT	NT
7W	4	5.2	Sand	7.4	7.4	0.0	-	NT	NT	NT	NT	NT	NT	NT	NT
7W	6	3.2	Sand	7.4	6.6	0.8	-	NT	NT	NT	NT	NT	NT	NT	NT
Guideline		Coarse sands, poorly buffered		<4[d]	<3.5[e]	≥1[e]	-	Coarse sands, poorly buffered							0.01
		Coarse sands to loamy sands and peats						Coarse sands to loamy sands and peats							0.03
		Medium sandy loams to light clays						Medium sandy loams to light clays							0.06[f]/0.03[g]
		Fine medium to heavy clays & silty clays						Fine medium to heavy clays & silty clays							0.1[f]/0.03[g]

Notes to Table 3:

a Depth below ground surface

b Strength of Reaction

- 1 denotes no or slight reaction
- 2 denotes moderate reaction
- 3 denotes high reaction
- 4 denotes very vigorous reaction
- F denotes bubbling/frothy reaction indicative of organics
- H denotes heat generated

c Calculated by the laboratory based on the ABA equation in ASS Laboratory Methods Guidelines (Ref 4)

d For actual acid sulphate soils (ASS)

e Indicative value only for Potential Acid Sulphate Soils (PASS)

f QASSIT Action Criteria for disturbance of 1-1000 tonnes of material

g QASSIT Action Criteria for disturbance of more than 1000 tonnes of material

Bold results indicative of PASS

Shaded results indicate an exceedence of QASSIT action criteria (Ref 3) (i.e. existing and potential acidity >0.01%S for coarse sands, poorly buffered)

pH_F - Soil pH Test (1:5 soil:distilled water)

pH_{FOX} - Soil Peroxide pH Test (1:4 soil:distilled water following oxidation of soil with 30% hydrogen peroxide (H_2O_2))

The Acid Sulfate Soil Management Advisory Committee (ASSMAC) guidelines (Ref 2) suggest that a soil pH<4 in water is an indicator of actual ASS. The results of screening tests therefore suggest the absence of actual ASS at the locations and depths tested.

The ASSMAC guidelines also suggest that indicators of potential acid sulfate soils (PASS) include the following:

- Soil pH <3.5 following oxidation with H_2O_2 (i.e. pH_{FOX});
- Drop of 1 pH unit or more between pH_F and pH_{FOX}.

The results of screening tests indicated that seven of 15 samples tested exhibited a pH drop equal to or greater than one unit. No samples exhibited a soil pH following oxidation below 3.5.

It is noted that ASS screening tests are a qualitative method only and give an indication of the intensity of total acidification (pH). The guidelines indicate that peroxide may also oxidise organic matter (in addition to pyrite) to produce acids which are unlikely to form under natural conditions, thus giving falsely high indication of acid sulfate potential.

Based on the results of the screening tests, four soil samples were selected for detailed laboratory testing, comprising the Full Chromium Suite in accordance with QASSIT guidelines (Ref 3). The results of detailed laboratory testing are provided in the attached laboratory report sheets and summarised in Table 3.

The results of detailed laboratory testing indicate the Potential and Existing Acidity values are above the QASSIT action criteria for coarse sands / poorly buffered soils for samples from Bore 6W/2.0.

With reference to the QASSIT guidelines (Ref 3), an assessment of possible acidic soils (i.e. where the source of acidity is unclear) has been made for the above results. Acidic soils can be identified by satisfying the following four criteria:

- Contained within an ASS terrain;
- Low soluble sulfur (e.g. S_{KCl} <0.03%);
- No reportable oxidisable sulfur (using S_{CR} or S_{POS});
- No visual or reportable jarosite (or similar acid-producing iron or aluminium hydroxysulfate minerals using S_{RAS} or S_{NAS}).

Then if:

- pH_{KCl} > 5.5, no treatment required, other than general environmental duty (GED);
- pH_{KCl} ≤ 5.5, manage with a neutralising agent (generally agricultural lime).

With reference to the above criteria, based on the absence of oxidisable sulphur (i.e. Scr <0.03%S), soluble sulphur (i.e. S_{KCL} <0.03%S) and jarosite (or similar acid producing iron or aluminium hydroxy sulfate minerals) (i.e. S_{NAS}<0.03%S)), the soils analysed above are acidic rather than acid sulfate soils with reference to the QASSIT guidelines (Ref 3). The pH_{KCl} ≤ 5.5 measurements in all samples indicates that some precautionary management with a neutralising agent (i.e. agricultural lime) should be conducted during excavation or alternatively during loading (where materials are taken off site). Liming rates in the order of 2 kg lime per tonne of soil should be considered.

Confirmatory testing, comprising detailed acid sulfate testing (chromium suite), should be conducted on lime-treated soils to confirm the absence of existing and potential acidity and to confirm that appropriate treatment and liming rates have been applied prior to reuse.

6. Comments

Based on the observations made and the results of laboratory testing from the current and previous assessments, the following is noted:

- Contamination concentrations within the soil samples tested were within the acceptance criteria for classification as Virgin Excavated Natural Materials (VENM);
- ASS testing indicated that the soil samples tested were acidic soils and not ASS. On this basis the soil samples tested could be considered for classification as VENM from an ASS perspective.

Based on the results of preliminary contamination testing and the acid sulfate assessment as provided in this report, natural soils encountered at the site are likely to be classified as Virgin Excavated Natural Material (VENM), subject to appropriate segregation of upper filling and subsequent validation.

VENM could be considered for re-use on another site subject to appropriate lime treatment and confirmation testing as discussed above. The use of VENM is also subject to the receiving site having appropriate development consent and planning approvals.

In addition, the natural soils assessed at the site could be disposed to an appropriately licensed landfill as 'General Solid Waste' without the requirement for lime treatment subject to the confirmation of VENM classification as noted above.

Reference should be made to the previous report prepared by DP (Ref 1) for details of subsurface profiles, fill depths and details of the proposed development.

7. References

1. Douglas Partners Pty Ltd, "Report on Geotechnical Investigation and Targeted Site Investigation (Contamination), Wests Newcastle, 309 King Street Newcastle West, Prepared for Graph Building (NSW) Pty Ltd, Project 81229.06, August 2018".
2. ASSMAC, "ASSMAC Acid Sulfate Soil Manual", New South Wales Acid Sulfate Soil Management Advisory Committee, August 1998.
3. Queensland Acid Sulfate Soil Technical Manual - Soil Management Guidelines v4.0, Department of Science, Information Technology, Innovation and the Arts, 2014
4. Ahern CR, Sullivan LA, McElnea AE 'Acid Sulfate Soils, Laboratory Methods Guidelines Version 2.1 - June 2004', Department of Natural Resources, Mines and Energy, June 2004.

8. Limitations

Douglas Partners (DP) has prepared this report for this project at 309 King Street Newcastle with reference to DP's proposal dated 20 August 2018 and acceptance received from Anthony Williams of Graph Building (NSW) Pty Ltd dated 20 August 2018. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Graph Building (NSW) Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and the previously prepared Geotechnical Investigation and Targeted Site Investigation (Contamination) (Ref 1) and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the environmental components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Please contact the undersigned if you have any questions on this matter.

Yours faithfully
Douglas Partners Pty Ltd

Reviewed by

Patrick Heads

Patrick Heads
Associate

Matthew Blackert
Senior Associate

Attachments:
About this Report
Sampling Methods
Soil Descriptions
Symbols and Abbreviations
Laboratory Test Results
Drawing 1 – Test Location Plan

About this Report

Douglas Partners

Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this 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, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

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

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils 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 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726-1993, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

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

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

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

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

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

Cohesive Soils

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

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

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

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

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

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

Transported soils may be further subdivided into:

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

Symbols & Abbreviations

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

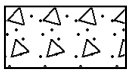
Symbols & Abbreviations

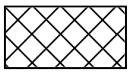
Graphic Symbols for Soil and Rock

General

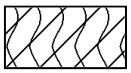

Asphalt

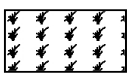

Road base

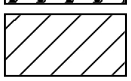

Concrete


Filling

Soils


Topsoil

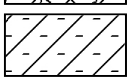

Peat


Clay


Silty clay

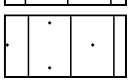

Sandy clay

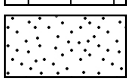

Gravelly clay

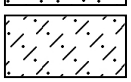

Shaly clay

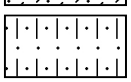

Silt


Clayey silt


Sandy silt

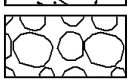

Sand


Clayey sand


Silty sand


Gravel

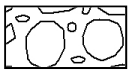

Sandy gravel


Cobbles, boulders

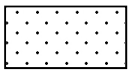

Talus

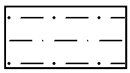
Sedimentary Rocks

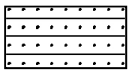

Boulder conglomerate

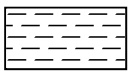

Conglomerate


Conglomeratic sandstone

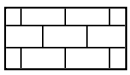

Sandstone


Siltstone

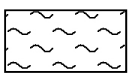

Laminite

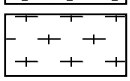

Mudstone, claystone, shale

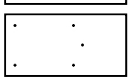

Coal


Limestone

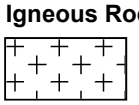
Metamorphic Rocks

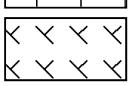

Slate, phyllite, schist

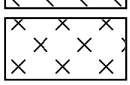

Gneiss

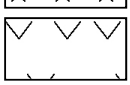

Quartzite

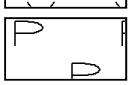
Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

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

CERTIFICATE OF ANALYSIS 198126

Client Details

Client	Douglas Partners Newcastle
Attention	Patrick Heads
Address	Box 324 Hunter Region Mail Centre, Newcastle, NSW, 2310

Sample Details

Your Reference	**81229.06, Newcastle West**
Number of Samples	4 Soil
Date samples received	10/08/2018
Date completed instructions received	10/08/2018

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	17/08/2018
Date of Issue	16/08/2018

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

Results Approved By
Nick Sarlamis, Inorganics Supervisor

Authorised By

Jacinta Hurst, Laboratory Manager

Chromium Suite					
Our Reference		198126-1	198126-2	198126-3	198126-4
Your Reference	UNITS	2	2	6w	6w
Depth		2.5-2.95	5.5-5.95	2.0	5.5-5.95
Date Sampled		14/06/2018	14/06/2018	14/06/2018	14/06/2018
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	13/08/2018	13/08/2018	13/08/2018	13/08/2018
Date analysed	-	13/08/2018	13/08/2018	13/08/2018	13/08/2018
pH $_{kcl}$	pH units	5.1	5.3	4.7	5.5
s-TAA pH 6.5	%w/w S	0.01	<0.01	0.04	<0.01
TAA pH 6.5	moles H^+ /t	6	<5	26	<5
Chromium Reducible Sulfur	%w/w	<0.005	<0.005	<0.005	<0.005
a-Chromium Reducible Sulfur	moles H^+ /t	<3	<3	<3	<3
S_{HCl}	%w/w S	<0.005	<0.005	<0.005	<0.005
S_{KCl}	%w/w S	<0.005	<0.005	<0.005	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	<0.05	<0.05	<0.05	<0.05
s-ANC_{BT}	%w/w S	<0.05	<0.05	<0.05	<0.05
s-Net Acidity	%w/w S	0.010	0.0060	0.042	<0.005
a-Net Acidity	moles H^+ /t	6.2	<5	26	<5
Liming rate	kg $CaCO_3$ /t	<0.75	<0.75	2.0	<0.75
a-Net Acidity without ANCE	moles H^+ /t	6.2	<5	26	<5
Liming rate without ANCE	kg $CaCO_3$ /t	<0.75	<0.75	2.0	<0.75
s-Net Acidity without ANCE	%w/w S	0.010	0.0060	0.042	<0.005

Method ID	Methodology Summary
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

QUALITY CONTROL: Chromium Suite						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			13/08/2018	1	13/08/2018	13/08/2018		13/08/2018	[NT]
Date analysed	-			13/08/2018	1	13/08/2018	13/08/2018		13/08/2018	[NT]
pH $_{kcl}$	pH units		Inorg-068	[NT]	1	5.1	5.1	0	93	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01	1	0.01	0.01	0	[NT]	[NT]
TAA pH 6.5	moles H^+ /t	5	Inorg-068	<5	1	6	6	0	95	[NT]
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
a-Chromium Reducible Sulfur	moles H^+ /t	3	Inorg-068	<3	1	<3	<3	0	95	[NT]
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005	1	<0.005	<0.005	0	[NT]	[NT]
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05	1	<0.05	<0.05	0	[NT]	[NT]
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05	1	<0.05	<0.05	0	[NT]	[NT]
s-Net Acidity	%w/w S	0.005	Inorg-068	<0.005	1	0.010	0.010	0	[NT]	[NT]
a-Net Acidity	moles H^+ /t	5	Inorg-068	<5	1	6.2	6.2	0	[NT]	[NT]
Liming rate	kg $CaCO_3$ /t	0.75	Inorg-068	<0.75	1	<0.75	<0.75	0	[NT]	[NT]
a-Net Acidity without ANCE	moles H^+ /t	5	Inorg-068	<5	1	6.2	6.2	0	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$ /t	0.75	Inorg-068	<0.75	1	<0.75	<0.75	0	[NT]	[NT]
s-Net Acidity without ANCE	%w/w S	0.005	Inorg-068	<0.005	1	0.010	0.010	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: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

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.

Douglas Partners
Geotechnics | Environment | Groundwater

CHAIN OF CUSTODY DESPATCH SHEET (2)

Project No: 81229.06	**Suburb/Town:** NEWCASTLE WEST	**To:** ENVIROLAB CHATSWOOD	
DP Order No: 137838	**DP Contact Person:** HARUN HEARS		
Prior Storage: Esky ☐ Fridge ☑ Shelved ☐ FREEZER		**Ph:** 0299106200	**Attn:** SIMON SONG

Do samples contain 'potential' HBM? Yes ☐ No ☑ (If YES, then handle, transport and store in accordance with FPM HAZID)

Sample				Analytes										Notes
DP ID	Date Sampled	Type S-soil W-water	Lab ID	Full Chromium Suite										
2/2.5-2.95	14/6/18	S	1	✓										
2/5.5-5.95			2	✓										
GW/7.0			3	✓										
GW/5.5-5.95			4	✓										
PQL (S) mg/kg														
PQL (W) mg/L	ANZECC PQLs req'd for all water analytes ☐													

Environmental Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 198126
Date Received: 10/8/18
Time Received: 10.00
Received By:
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

PQL = practical quantitation limit. If none given, default to Laboratory Method Detection Limit

*Metals to Analyse (Please circle) As, Cd, Cr, Cu, Pb, Zn, Hg, Ni, Mn, Fe

Total number of samples in container: 4

Date relinquished: 9/8/18 By: .....

Results required by: 17/8/18

☐ Same day ☐ 24 hours ☐ 48 hours ☐ 72 hours ☑ Standard

SAMPLES RECEIVED BY LAB
Please sign and date to acknowledge receipt of samples and return by email

Signature: .....

Date: 10.8.18

Lab Ref: 198126

Send results to:
Douglas Partners Pty Ltd
Address: .....
.....
.....
.....
Email: .....

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	Douglas Partners Newcastle
Attention	Patrick Heads

Sample Login Details

Your reference	81229.06, Newcastle West
Envirolab Reference	198126
Date Sample Received	10/08/2018
Date Instructions Received	10/08/2018
Date Results Expected to be Reported	17/08/2018

Sample Condition

Samples received in appropriate condition for analysis	YES
No. of Samples Provided	4 Soil
Turnaround Time Requested	Standard
Temperature on Receipt (°C)	10.0
Cooling Method	Ice Pack
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:

Document Set ID: 6157146
Version: 1, Version Date: 29/10/2019

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	Chromium Suite
2-2.5-2.95	✓
2-5.5-5.95	✓
6w-2.0	✓
6w-5.5-5.95	✓

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.

Document Set ID: 6157146
Version: 1, Version Date: 29/10/2019

Locality Plan

NOTE: Base drawing from Nearmap Aerial Photo Image dated 30.01.2014

0 10 20 30 40 50 75 100m

1:1000 @ A3

LEGEND

- Approximate CPT Location
- Approximate Borehole Location
- W Approximate Groundwater Well Location
- Approximate Previous Borehole Test Location (1990)
- Approximate Previous CPT Test Location (1990)
- Approximate Previous CPT Test Location (1984)
- Approximate Lot Boundary

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Graph Building (NSW) Pty Ltd		TITLE: **Site Plan**
OFFICE: Newcastle	DRAWN BY: PLH	**Acid Sulphate Soil Assessment**
SCALE: 1:1000@A3 sheet	DATE: 02.08.2018	**309 King Street , Newcastle West**

N

PROJECT No:81229.06.R002
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