GEOTECHNIQUE® PTY LTD

ABN 64 002 841 063

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Knowles Group
P O Box 2250
MOORABBIN VIC 3189
Email: janelle.pirone@knowlesgroup.com.au

Attention: Ms J Pirone

Dear Madam

re: **Proposed Development**
25-27 Warriewood Road, Warriewood
Geotechnical Investigation Report

This geotechnical investigation report is prepared for the proposed development at 25-27 Warriewood Road, Warriewood, hereafter referred to as the proposed development site.

We understand that the proposed residential aged care facility (RACF) development at the above site includes construction of two residential apartment buildings (designated as North and South Building) in the western portion and two to three storey semi-detached dwellings (designated as DW01 to DW11) in the eastern portion. The attached site plan showing the footprints of the proposed buildings/dwellings was provided for preparation of this report. We also understand that the residential apartment buildings will have one level of basement car park with base at RL2.90m AHD.

Geotechnique Pty Ltd carried out a geotechnical investigation for proposed aged care facility development at 23-27 Warriewood Road, Warriewood, and submitted Report Nos 13787/1-AA dated 3 August 2016 (Reference 1), 13787/2-AA dated 27 November 2017 (Reference 2) and 13787/3-AA dated 10 January 2018 (Reference 3).

Proposed residential aged care facility development site 25-27 Warriewood Road, Warriewood, forms the northern portion of 23-27 Warriewood Road, Warriewood, for which References 1, 2 and 3 were prepared. Therefore, this report for the proposed development at 25-27 Warriewood Road, Warriewood, is based on results of field and laboratory works completed for preparation of References 1, 2 and 3. However, this report can be read independently, as all relevant information in References 1, 2 and 3 are reproduced in this report.

Background Information

Review of Geological Map of Sydney (scale 1:100,000) indicates that the subsurface profile in most portions of the site belongs to the Narrabeen Group comprising interbedded laminite, shale and sandstone with minor clays. The subsurface profile in the western portion of the site may include stream alluvium and/or estuarine deposit, comprising silty to peaty quartz sand, silt and clay, ferruginous and humic at places, with shell layers.

Review of the Soil Landscape Map of Sydney (scale 1:100,000) indicates the following:

- The landscape in most portions of the site belongs to the Watagan Group, which is characterised by rolling to very steep hills on fine grained Narrabeen Group sediments, with local relief of 60m to 120m, ground slopes in excess of 25%, narrow crests and ridges, steep colluvial side slopes and occasional sandstone boulders and benches. There is likely to be occasional rock outcrops with sandy soils on sandstone and clayey soils on shale. The group is susceptible to mass movement and erosion hazard.
- The landscape in the western portion of the site belongs to the Warriewood Group, which is characterised by level to gently undulating swales, depressions and in filled lagoons on Quaternary sand, with local relief of less than 10m, ground slopes of less than 3%, depth to water table of less than 2.0m. Soils in this group comprise sandy humus, sand and peat, with thickness exceeding 1.5m. This landscape has a high water table and is subjected to flooding.

Review of the Acid Sulphate Soil Risk Map (Edition 2, scale 1:25,000) of Hornsby/Mona Vale prepared by the Department of Land and Water Conservation the following:

- There are no known occurrences of acid sulphate soil materials within the soil profiles in most portions of the site, and acid sulphate soil materials are not expected in most portions of the site.
- In the western portion of the site, adjacent to Narrabeen Creek, there is low probability of occurrence of acid sulphate soil materials within the soil profile at depths exceeding 3.0m.

Field Works

Field works for preparation of References 1, 2 and 3 were carried out in July 2016 and December 2017, and consisted of the following:

- A walkover survey to assess general site conditions.
- Reviewing services plans obtained from “Dial Before You Dig” to ascertain the locations of underground services across the site.
- Scanning proposed borehole locations for underground services to ensure that the investigation works would not damage existing underground services. We engaged a specialist services locator for this purpose.
- Drilling twenty one boreholes using a truck mounted drilling rig fully equipped for geotechnical investigation. Boreholes BH1 to BH8 were drilled in July 2016 and BH208 to BH220 were drilled in December 2018. Fifteen of these boreholes are located within the proposed development site. Boreholes were uniformly distributed in accessible portions of the site. Boreholes were initially drilled using V-bit or TC-bit refusal in bedrock at depths of 6.0m to 11.2m from existing ground surface. Then most boreholes were continued into bedrock to depths of about 10.5m to 14.6m using rock coring techniques. Approximate locations of all boreholes are indicated on the attached Drawing No 13787/3-AA1. Logs and core photographs for boreholes located within the proposed development site are attached along with explanatory notes.
- Carry out Standard Penetration Tests (SPT) in boreholes at regular depth intervals to assess the strength characteristics of the sub-surface soils. SPT test results are included in borehole logs.
- Recover representative soil samples and rock cores from the boreholes for visual classification and laboratory tests.
- Measure depths to groundwater level in boreholes, if encountered.

Field work was supervised by a team of two Field Engineers from this company, who were responsible for nominating the borehole locations, supervising SPT tests, sampling, and preparation of field logs.

Site Conditions

The proposed development site is of irregular shape, measuring approximately 8183.0m^2 in area. The site is bound by Warriewood Road to the east, Narrabeen Creek to the west, a vacant residential lot to the north, and part of residential aged care facility (RACF) to the south. The natural ground surface across the site dips from east to west at about 3 to 4 degrees.

Sub-surface profiles encountered in the boreholes drilled within the proposed development site are detailed in the attached borehole logs, and summarised below in Table 1.

Table 1 – Sub-surface Profiles at Borehole Locations

Borehole No	Ground Surface RL* (m, AHD)	Termination Depth* (m)	Depth Range for Topsoil/Fill (m)	Depth Range for Alluvium (m)	Depth to Bedrock (m)	Depth to Groundwater (m)
BH3	4.6	10.3	0.0-0.2	0.2-10.3	10.3	7.9
BH4	4.0	8.9	0.0-0.3	0.3-7.0	7.0	>8.9
BH5	12.0	11.7	0.0-0.2	0.2-7.0	7.0	>11.7
BH6	8.8	11.9	0.0-0.5	0.5-6.6	6.6	4.4
BH7	6.5	14.4	0.0-0.3	0.3-7.2	7.2	4.4
BH201	9.8	10.4	0.0-0.2	0.2-8.8	8.8	3.0
BH202	12.7	11.1	0.0-0.1	0.1-7.2	7.2	4.0
BH203	5.2	13.0	0.0-0.1	0.1-8.7	8.7	3.0
BH208	11.9	10.5	0.0-0.2	0.2-8.6	8.6	>5.0
BH209	9.8	11.75	0.0-0.2	0.2-9.5	9.5	>6.0
BH210	8.2	11.85	0.0-0.2	0.2-8.9	8.9	7.5
BH211	8.8	13.0	0.0-0.2	0.2-9.5	9.5	8.0
BH212	10.8	14.5	0.0-0.2	0.2-10.0	10.0	7.5
BH218	6.4	13.1	0.0-0.2	0.2-10.3	10.3	8.3

*RL and depths are approximate only.

Table 1 indicates that the sub-surface profile across the site comprises a sequence of topsoil/fill and alluvial soils underlain by bedrock. The thickness of topsoil/fill, alluvium, and depth to bedrock vary across the site. Topsoil/fill included silty sand of fine to medium grained, sandy silt and clayey silt of low plasticity with some roots. Alluvial soils included layers of fine to medium grained sand, clayey sand and silty sand and low to high plasticity silty clay, silty sandy clay, and sandy clay with ironstone. Bedrock to borehole termination depth was predominantly sandstone, with localised layers of ironstone.

Groundwater Conditions

During borehole drilling, groundwater was encountered in all boreholes except BH4, BH5, BH208, and BH209. The depths to groundwater level encountered in boreholes are presented above in Table 1. It is noted that the depth to groundwater level across the site varies from about 3.0m to 11.7m from existing ground surface. These measurements indicate that the groundwater levels are about RL -4.9m AHD to 8.7m AHD.

Measurements during drilling indicated that the groundwater level in some portions of the proposed development site could be higher than the proposed basement level at RL2.90m AHD. However, borehole drilling was carried out during rainy periods which would have affected the groundwater level. Therefore, a test pit was excavated within the footprint of the proposed residential flat buildings on 28 February 2019. The test pit did not encounter groundwater even at RL-0.4m AHD. Therefore, it is our assessment that the depth to groundwater level across the proposed flat buildings is lower than the proposed basement level under normal climatic conditions. However, it should be noted that the fluctuations in the level of groundwater might occur due to variations in rainfall and/or other factors not evident during field works.

Laboratory Testing

Representative soil samples recovered from the boreholes were tested in the NATA accredited laboratory of SGS Environmental Services to determine the chemical properties to assess the following:

- Salinity of soil in terms of Electrical Conductivity (EC)
- Aggressivity of soil in terms of pH, chloride, sulphate and resistivity
- Acid sulphate soils in terms of pH_{KCl}, pH_{ox}(pH after oxidation), TPA (Total Potential Acidity), TAA (Total Actual Acidity), TSA (Total Sulphidic Acidity), S_{POS}% (Percent Peroxide Oxidisable Sulfur) and S_{cr} (Chromium Reducible Sulphur).

Detailed laboratory test results are attached and summaries are presented in the following Tables 2 to 4.

Table 2 – Results of Electrical Conductivity Tests

Borehole No	Depth (m)	EC (µS/cm)
BH4	1.0-1.45	74
BH4	3.0-3.45	65
BH4	5.0-5.45	160
BH4	6.5-6.95	86
BH6	0.5-0.95	220
BH6	1.5-1.95	140
BH6	3.0-3.45	76
BH6	4.5-4.95	94
BH6	6.0-6.45	120
BH6	7.5-7.95	85

Table 3 – Results of Soil Aggressivity Tests

Borehole No	Depth (m)	pH	Chloride (mg/kg)	Sulphate (mg/kg)	Resistivity (ohm-cm)
BH6	1.5-1.95	4.8	61	100	5000
BH6	3.0-3.45	4.9	21	100	8200
BH6	4.5-4.95	4.9	19	100	6900
BH6	6.0-6.45	4.7	22	140	6000
BH6	7.5-7.95	5.1	24	89	7800

Table 4 – Results of Acid Sulphate Soil Tests

Borehole No	Depth (m)	pH_{KCl}	pH_{ox}	TPA (pH6.5)	TAA (pH6.5)	TSA (pH6.5)	S_{POS} (% w/w)	Scr (% w/w)
BH3	0.5-0.95	5.9	6.0	<5	6	<5	<0.005	<0.005
BH3	2.5-2.95	4.0	5.1	57	57	<5	<0.005	<0.005
BH3	5.5-5.95	3.8	4.9	87	82	<5	<0.005	<0.005
BH3	8.0-8.45	3.8	5.1	90	87	<5	<0.005	<0.005

Notes

pH_{KCl} = pH of filtered 1:20, 1M K_{Cl} extract, overnight shake
pH_{ox} = pH of filtered 1:20, 1M K_{Cl} after peroxide digestion
TPA = Total Potential Acidity (mol H^+/tonne)
TAA = Total Actual Acidity (mol H^+/tonne)
TSA = Total Sulphidic Acidity (mol H^+/tonne)
S_{POS} = Peroxide Oxidisable Sulphur (%w/w)
S_{cr} = Chromium Reducible Sulphur (% w/w)
Limit of Reporting for TAA, TPA and TSA is 5 moles H^+/tonne, and for S_{POS} is 0.005% w/w.

Rock cores obtained from boreholes were photographed and tested at regular depth intervals for determination of Point Load Strength Index (I_{s50}). The point load strength indices for the rock cores and the assessed rock strengths, in accordance with Australian Standard AS1726-2017 (Reference 4), are summarised in the following Table 5.

Table 5 – Results of Point Load Strength Index Tests

Borehole No	Depth (m)	Diametral $I_{s(50)}$ (MPa)	Axial $I_{s(50)}$ (MPa)	Assessed Diametral Strength	Assessed Axial Strength
BH4	7.27	0.79	1.53	Medium	High
	7.70	0.11	0.04	Low	Very Low
	8.50	0.21	0.25	Low	Low
	8.85	1.02	1.00	High	High
BH5	10.40	0.13	0.14	Low	Low
	11.70	0.20	1.19	Low	High
BH6	11.90	1.78	1.60	High	High
	12.80	1.47	1.21	High	High
	13.60	0.53	0.83	Medium	Medium
B208	8.90	0.15	0.20	Low	Low
	9.70	0.05	0.09	Very low	Very low
	10.40	0.03	0.07	Very low	Very low
BH209	9.70	0.75	1.06	Medium	High
	10.60	1.11	1.26	High	High
	11.70	1.45	1.77	High	High
BH210	8.90	0.03	0.22	Very low	Low
	10.20	1.01	1.93	High	High
	11.20	0.14	0.57	Low	Medium
	11.60	1.64	2.34	High	High

Borehole No	Depth (m)	Diametral $I_{s(50)}$ (MPa)	Axial $I_{s(50)}$ (MPa)	Assessed Diametral Strength	Assessed Axial Strength
BH211	10.35	0.96	1.16	Medium	High
	11.20	1.14	1.70	High	High
	12.35	0.21	0.12	Low	Low
	12.65	1.29	1.03	High	High
BH212	10.70	3.55	1.99	Very high	High
	11.90	1.37	2.07	High	High
	12.50	0.97	1.61	Medium	High
	14.20	0.79	1.18	Medium	High
BH218	10.40	0.92	1.99	Medium	High
	11.20	0.29	0.76	Low	Medium
	12.50	1.00	1.32	High	High
	13.00	1.49	1.49	High	High

It should be noted that Point Load Strength tests could only be carried out on intact (stronger) portions of rock cores. Therefore, strength assessments presented in Table 5 indicate the upper limits of rock strengths.

Based on rock strengths (Table 5) and rock discontinuities shown in the borehole logs, bedrock from the proposed development site is classified for foundation design in accordance with Pells et al (Reference 5) in the following Table 6.

Table 6 – Rock Classification for Foundation Design

Borehole No	Depth Ranges for Various Rock Classes (m)		
	Sandstone Class V	Sandstone Class IV	Sandstone Class III
BH3	>7.0	Not Encountered	Not Encountered
BH4	7.0-8.0	Not Encountered	>8.0
BH5	>10.3	Not Encountered	Not Encountered
BH6	6.6-10.5	10.5-11.5	>11.5
BH7	7.2->11.5	Not Encountered	Not Encountered
BH201	Not Encountered	8.8->10.4	Not Encountered
BH202	7.2-8.1 (Shale)	8.1-9.9 (Shale)	9.8->11.1 (Shale)
BH203	8.7-10.0	10.0->13.0	Not Encountered
BH208	9.6	>11.0	Not Encountered
BH209	9.6	10.2	11.2
BH210	8.9	11.4	>11.4
BH211	10.3	10.7	>13.0
BH212	10.0	11.6	13.2
BH218	10.3	11.2	12.2

DISCUSSION AND RECOMMENDATIONS

Soil Salinity

Salinity refers to the presence of excess salt in the environment, either in soil or water. Salinity is a serious problem for any development due to the many environmental, economic and social impacts. Soil salinity is generally assessed by measuring EC of a soil sample made up of 1:5 soil water suspension. Thus, determined EC is multiplied by a factor varying from 6 to 23, based on the texture of the soil sample to obtain Corrected Electrical Conductivity designated as ECe (Reference 5). Alternatively, ECe may be directly measured in soil saturation extracts. Soils are classified as saline if ECe of the saturated extracts exceed 4.0dS/m. The criteria for assessment of soil salinity classes are shown in the following Table 7 (Reference 6).

Table 7 – Criteria for Soil Salinity Classification

Classification	EC_e (dS/m)	Comments
Non-saline	<2	Salinity effects mostly negligible
Slightly saline	2 – 4	Yields of very sensitive crops may be affected
Moderately saline	4 – 8	Yields of many crops affected
Very saline	8 – 16	Only tolerant crops yield satisfactorily
Highly saline	>16	Only a few tolerant crops yield satisfactorily

EC values for 10 representative soil samples are summarised in Table 2. For sandy soils encountered across the site, multiplying factors of 12 to 14 are considered appropriate. Even if the multiplying factor is 14, estimates of ECe values for representative samples vary from about 0.9dS/m to 3.1dS/m.

Therefore, it is our assessment that the soils likely to be disturbed or excavated during proposed development works are non-saline. That also means that the excavation and disturbance of the soils during proposed development works can be carried out without a specific saline soil management plan.

Soil Aggressivity

Aqueous solution of chlorides causes corrosion of iron and steel, including steel reinforcements in concrete. The aggressivity classifications of soil and groundwater applicable to iron and steel, in accordance with Australian Standard AS2159 (Reference 7), are given below in Table 8.

Table 8 – Soil Aggressivity Classification for Steel/Iron

Chloride		pH	Resistivity (ohm cm)	Soil Condition A*	Soil Condition B#
In Soil (ppm)	In Water (ppm)				
<5000	<1000	>5.0	>5000	Non-aggressive	Non-aggressive
5000-20000	1000-10000	4.0-5.0	2000-5000	Mild	Non-aggressive
20000-50000	10000-20000	3.0-4.0	1000-2000	Moderate	Mild
>50000	>20000	<3.0	<1000	Severe	Moderate

*Soil Condition A = high permeability soils (e.g. sands and gravels) which are below groundwater
#Soil Condition B = low permeability soils (e.g. silts and clays) and all soils above groundwater

The aggressivity classifications of soil and groundwater applicable to concrete, in accordance with Reference 7 are given below in Table 9.

Table 9 – Soil Aggressivity Classification for Concrete

Sulphate expressed as SO_4		pH	Chloride in Water (ppm)	Soil Condition A	Soil Condition B
In Soil (ppm)	In Groundwater (ppm)				
<5000	<1000	>5.5	<6000	Mild	Non-aggressive
5000-10000	1000-3000	4.5-5.5	6000-12000	Moderate	Mild
10000-20000	3000-1000	4.0-4.5	12000-30000	Severe	Moderate
>20000	>10000	<4.0	>30000	Very Severe	Severe

Approximately 100ppm of SO_4 = 80ppm of SO_3

Results of aggressivity tests on 5 representative soil samples are summarised in Table 3. The soils likely to be encountered during proposed development works are assessed to be predominantly sandy with high permeability. Therefore, results of the aggressivity tests indicate the following:

- The pH value of soils vary from 4.7 to 5.1, indicating that the site is non-aggressive to mildly aggressive to steel/iron but moderately aggressive to concrete.
- Chloride contents in soils vary from 19.0 to 61.0ppm, indicating the site is non-aggressive to steel but mildly aggressive to concrete.
- Sulphate contents in soils vary from 89.0 to 140.0 ppm, indicating the site is mildly aggressive to concrete.
- Resistivity of soil varies from 5000 to 8200 ohm-cm, indicating the site is non-aggressive to mildly aggressive to steel/iron.

Based on the laboratory test results and the assumption that soils are predominantly sandy, the site is assessed to be mildly aggressive towards steel/iron and moderately aggressive towards concrete. Therefore, we recommend use of construction materials, such as concrete and steel that are appropriate to assessed aggressivity.

Acid Sulphate Soil Assessment

Review of existing information and site assessment indicated the following:

- The Acid Sulphate Soil Risk Map of Hornsby/Mona Vale indicates there are no known occurrences of acid sulphate soil materials in most portions of the site. However, there is a low probability of occurrence of acid sulphate soil materials in the western portion of the site, adjacent to the Narrabeen Creek.
- Buildings for the proposed development will be constructed at least 50.0m away from the Narrabeen Creek (buffer zone), where ground surface elevation is at 5.0m AHD or higher. The ground surface within the proposed building area dips gently (2 to 3 degrees) towards the west. Therefore, ground surface elevation and geomorphology of the site indicate that acid sulphate or potentially acid sulphate soils are unlikely to be encountered across the site.
- The sub-surface profile across the site comprises a sequence of topsoil/fill and alluvial soil underlain by sandstone. Topsoil/fill as well as alluvial soils likely to be disturbed or excavated during construction of the proposed residence could be acid sulphate or potentially acid sulphate soils.
- Groundwater level is likely to be deeper than the base of the proposed excavation. Although the level of groundwater might fluctuate due to variations in rainfall and/or other factors not evident during drilling, it is unlikely that the proposed development works will lower the groundwater level to expose the acid sulphate or potentially acid sulphate soils to atmosphere.

The above assessments indicated that acid sulphate or potentially acid sulphate soils are unlikely to be encountered at the proposed development site. Despite that, representative soil samples obtained from various depths were tested for acid sulphate or potentially acid sulphate soils. The laboratory test results summarised in Table 4 indicate the following:

- The pH_{kcl} (field pH) values are in range of 3.8 to 5.9, indicating actual acid sulphate soils are absent at the site, but does not give an indication whether potential acid sulphate soils are present or not.
- The pH_{ox} values (pH after oxidation) of samples range from 4.9 to 6.1. The pH_{ox} values of all samples are higher than the pH_{kcl} values, indicating that oxidation of soils is unlikely to produce any acid.
- Peroxide Oxidisable Sulphur content in the soil samples is lower than 0.03% and hence oxidation of soils is unlikely to produce any significant acid.
- Chromium Reducible Sulphur content in the soil samples is lower than 0.03% and hence oxidation of soils is unlikely to produce any significant acid.

Assessments of laboratory test results indicate soils across the site are unlikely to be acid sulphate or potentially acid sulphate soils.

Acid sulphate soils are a problem because they produce significant acid (sulphuric acid) by oxidation when exposed to oxygen, which might occur during excavation or disturbance of soils containing iron sulphides/oxidisable sulphur. Lowering the groundwater level might also encourage oxidation. The New South Wales Acid Sulphate Soils Management Advisory Committee (Reference 8) recommends "Action Criteria" (Table 10) based on results of acid sulphate soils analysis for three broad texture categories. Works in soils that exceed these "Action Criteria" must be carried out in accordance with an approved Acid Sulphate Soils Management Plan.

Table 10 – Action Criteria for Acid Sulphate Soils

Type of Material		**Action Criteria 1-1000 tonnes of soil is disturbed**		**Action Criteria More than 1000 tonnes of soil is disturbed**	
Texture Range	**Approximate Clay Content <0.002mm** (%)	**Sulphur Trail** % S oxidisable (S_{TOS} or S_{POS})	**Acid Sulphate Trail** mol H^+/tonne (TPA or TSA)	**Sulphur Trail** % S oxidisable (S_{TOS} or S_{POS})	**Acid Sulphate Trail** mol H^+/tonne (TPA or TSA)
Coarse Texture Sands to loamy sands	≤5	0.03	18	0.03	18
Medium Texture Sandy loams to light clays	5-40	0.06	36	0.03	18
Fine Texture Medium to heavy clays and silty clays	≥40	0.10	62	0.03	18

The borehole logs indicate sandy soils and some clayey soils likely to be disturbed or excavated during the proposed development. Therefore, appropriate texture is assessed to be "Fine to Medium".
Laboratory test results presented in Table 4 shows that the oxidisable sulphur (S_{POS}) for all samples are less than the instrument detectable limit of 0.005%. Likewise, Total Sulphidic Acidity (TSA) for all

samples is lower than the instrument detectable limit of 5.0mol H^+/tonne. Therefore, even if volume of soils to be disturbed or excavated during the proposed development works is more than 1000 tonnes, the Action Criteria for both Sulphur Trail and Acid Trail presented in Table 10 show that the excavations and disturbance of soils during the proposed development works may be carried out without an approved "Acid Sulphate Soils Management Plan".

Excavation Condition

Proposed development will include basement excavation to RL2.9m AHD. Therefore, it is anticipated that the proposed development will involve about 2.5m to 4.5m deep excavation. The materials to be excavated are anticipated to comprise topsoil, fill, and alluvial soils. No rock excavation is anticipated. It is our assessment that excavation of topsoil, fill, and alluvial soils can be achieved using conventional earthmoving equipment such as excavators and dozers.

Although fluctuations in the level of groundwater and/or seepage might occur due to variations in rainfall and/or other factors not observed during field work day, it is our assessment that the proposed basement excavation to RL2.90m AHD is unlikely to encounter groundwater inflow. Minor groundwater inflow that might be encountered during rainy periods could be managed by a conventional sump and pump method.

Fill Placement

We anticipate site preparation for the proposed development works will involve removal of weak alluvial soils and replacement with controlled fill. The following procedures are recommended for placement of controlled fill, where required:

- Strip topsoil and existing fill materials and stockpile separately for possible future uses or dispose off the site. Topsoils may be used in landscaping and fill materials may be selectively used in controlled fill.
- Undertake proof rolling (using an 8 to 10 tonnes roller) of the exposed alluvial soils to detect potentially weak spots (ground heave). Excavate areas of localised heaving to depths of about 300mm and replace with crushed sandstone, compacted as described below.
- Undertake proof rolling of soft spots backfilled with crushed sandstone, as described above. If the backfilled area shows movement during further proof rolling, this office should be contacted for further recommendations. The additional works may include removal of additional alluvial soils or construction of a Geogrid reinforced bridging layer.
- Place controlled fill over compacted surface of alluvial soil or Geogrid reinforced bridging layer. The controlled fill should comprise at least 0.5m thick crushed sandstone layer overlain by crushed sandstone and/or a mixture of crushed sandstone and alluvial soils obtained from excavations within the site. Particle size of crushed sandstone should not exceed 75mm.
- Controlled fill should be placed in horizontal layers of 200mm to 250mm maximum loose thickness and compacted to a Minimum Dry Density Ratio (MDDR) of 98% Standard at moisture content within 2% of Optimum Moisture Content (OMC) for cohesive soils or Minimum Density Index of 75% for sandy soils.
- Fill placement should be supervised to ensure that material quality, layer thickness, testing frequency and compaction criteria conform to the specifications. We recommend "Level 1" supervision, in accordance with Australian Standard AS3798- (Reference 9). It should be noted that a Geotechnical Inspection and Testing Authority will generally only provide certification on quality of compacted fill if Level 1 supervision and testing is carried out.

Batter Slopes and Retaining Structures

It is anticipated that the proposed development works will involve 2.5m to 4.5m deep excavation. The excavation will occur predominantly within alluvial soils. Some minor fill placement might also be required. Cut and fill slopes during and after development works should be battered for stability or retained by engineered retaining structures. If battering is the preferred option, we recommended the following batter slopes:

- For short term stability = 1 vertical to 2 horizontal
- For long term stability = 1 vertical to 4 horizontal

Surface protection of the batter slopes can be provided by shotcreting. It is also recommended that batter slopes are provided with adequate surface and sub-surface drainage, and the crest of the batter slope is at least 1.5m away from the site boundaries and any existing structure.

As the materials in the excavation faces are anticipated to comprise predominantly sandy soils, it is unlikely that steep slopes could be maintained in these materials. This is especially the case if groundwater is encountered during basement excavation. Therefore, excavation faces may preferably be retained by engineered retaining structures.

Appropriate retaining structures for the proposed excavation would comprise contiguous bored pier walls or cantilever walls or gravity. Secant pile walls may be required if groundwater level is shallower than the base of the excavation, unless a pumping system is installed to maintain the groundwater level below the base of the excavation permanently. The pressure distribution on such walls is assumed to be triangular in shape and estimated as follows:

$$p_h = \gamma k H$$

If the retaining walls are anchored or strutted, the active pressure distribution on such retaining structures is assumed to be rectangular and estimated as follows:

$$p_h = 0.3\gamma H$$

Where,

p_h = Horizontal active pressure (kN/m^2)
γ = Total density of materials to be retained (say 18.0kN/m^3)
k = Coefficient of earth pressure (k_a or k_o)
H = Retained height (m)

Distribution of passive pressure, if retaining walls are embedded below the base of excavation, may also be assumed triangular and estimated as follows:

$$p_p = \gamma_1 k_p h$$

Where,

p_p = Horizontal passive pressure (kN/m^2)
γ_1 = Total density of materials below base of excavation (say 18.0kN/m^3)
k_p = Coefficient of passive earth pressure
h = Wall embedment depth below base of excavation (m)

For the design of flexible retaining structures, where some lateral movement is acceptable, an active earth pressure coefficient (k_a=0.45) is recommended. If it is critical to limit the horizontal deformation of a retaining structure, use of an earth pressure coefficient at rest (k_0=0.60) should be considered. To estimate passive resistance, we recommend use of k_p= 2.8. These coefficients are based on the assumption that ground level behind the retaining structure is horizontal, and the retained material is effectively drained. Additional earth pressures resulting from surcharge loads (existing structures, traffic, etc) and groundwater pressure should also be considered in designing the retaining structures.

The design of any retaining structure should also be checked for bearing capacity, overturning, sliding and overall stability of the slope.

Floor Slabs and Footings

Floor slabs for the proposed buildings may be designed as suspended slabs supported by footings founded in appropriate foundation materials, or ground bearing slabs bearing on controlled fill placed in accordance with the recommendations presented in this report. For design of floor slabs bearing on controlled fill, we recommend a Modulus of Subgrade Reaction Value of 15kPa/mm.

We are not aware of the exact loadings from the proposed structures at this stage. However, we understand that the design intention is to support the proposed buildings by piers founded in bedrock with an allowable bearing pressure of 1000kPa. The depths to bedrock with recommended allowable bearing pressure of 1000kPa and RL at the top of bedrock with an allowable bearing pressure of 1000kPa in each borehole location presented in Table 1 are presented below in Table 11.

Table 11 – Depths to Bedrocks with Recommended Allowable Bearing Pressure of 1000kPa

Borehole No	Depth to Sandstone with Allowable Bearing Pressure of 1000kPa (m)	RL at the Top of Sandstone with Allowable Bearing Pressure of 1000kPa (m, AHD)
BH3	10.9	-6.3
BH4	8.0	-4.0
BH5	11.5	0.5
BH6	10.5	-1.7
BH7	11.5	-5.0
BH201	8.8	1.0
BH202	8.2	4.5
BH203	10.0	-4.8
BH208	9.6	2.3
BH209	9.6	0.2
BH210	8.9	-0.7
BH211	10.3	-1.5
BH212	10.6	0.2
BH218	10.3	-3.9

Piers should be socketed into bedrock at least 300mm below the depths provided in Table 11 to achieve an allowable bearing pressure of 1000kPa. For piers socketed 300mm into bedrock, total settlements under the recommended allowable bearing pressure are estimated to be about 1.0% of pier diameter. The differential settlements are estimated to be about halves of the estimated total settlements.

It is possible that shallow footings (pad or strip footings) founded on controlled fill or alluvial soils at shallower depths may be required for ancillary structures. For design of such footings, recommended allowable bearing pressures are presented below in Table 12.

Table 12 – Recommended Allowable Bearing Pressures

Founding Materials	Founding Depth from Ground Surface* (m)	Allowable End Bearing Pressure (kPa)	Allowable Shaft Adhesion (kPa)
Controlled Fill/ Alluvial Soils	0.5-1.5	100.0	Ignore
Alluvial Soils	3.0-5.0	200.0	Ignore
Alluvial Soils	5.0-11.5	350.0	5.0

*Approximate only.

For footings founded in controlled fill and alluvial soils, total settlement is anticipated to be 2.5% of minimum footing dimension. The differential settlements are estimated to be about halves of the estimated total settlements.

We recommend that a Geotechnical Engineer inspect footing excavations and/or pier hole drilling to confirm that the footings and piers are founded or socketed adequately into the founding materials that satisfy the design allowable bearing pressures.

Risk of Slope Instability to Property Loss- Existing Conditions

Site factors such as slope angles, depth of insitu soils, strength of sub-surface material and concentrations of water generally govern the stability of a site. Practice Note Guidelines for Landslide Risk Management, prepared by Australian Geomechanics Society (Reference 10), recommends that the landslide/slope failure risk of a site is assessed on the basis of the likelihood of a landslide/slope failure event and the consequences of that event.

The ground surface across the site is dipping gently and no significant landslides or slope failures are anticipated across the site. However, if a slope failure is to occur, the critical slope failure across the site is anticipated to be global instability resulting in sliding of soils. Applying the Australian Geomechanics Society guidelines, the site for the proposed development, as it exists, is assessed as follows:

- **Qualitative Measures of Likelihood** - It is our assessment that a landslide/slope failure event is conceivable within the site but only under very exceptional circumstances (with indicative annual probability $\approx 10^{-5}$), i.e.: Landslide is “Rare”.
- **Qualitative Measures of Consequences to Property** - It is our assessment that the consequences of a landslide/slope failure event to the property would be “Minor”, resulting in limited damage to part of structure or part of the site requiring some stabilisation works.
- **Qualitative Risk Analysis** – Based on the above Qualitative Measures, the site for the proposed development, as it exists, is assessed to have a “Very Low Risk Level”. Definitions of the risk levels are provided by The Australian Geomechanics Society (Reference 10) and reproduced below.

Risk Level		Implication
VH	**Very High Risk**	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low, may be too expensive and not practical. Works likely to cost more than the value of the property.
H	**High Risk**	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Works would cost a substantial sum in relation to the value of the property.
M	**Moderate Risk**	May be tolerable in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as possible.
L	**Low Risk**	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, on-going maintenance is required.
VL	**Very Low Risk**	Acceptable. Manage by normal slope maintenance procedures.

The "Very Low Risk Level" is assessed to be acceptable for proposed aged care facility development at 25-27 Warriewood Road, Warriewood.

Risk of Slope Instability to Loss of Life - Existing Conditions

The annual probability of Loss of Life for the person most at risk from landslide depends on frequency of slope failures/landslides and the consequences. The individual risk, as determined by summing up the risk for the person most at risk from all the landslide hazards, is used for comparison with the tolerable risk criteria.

For Loss of Life, Australian Geomechanics Society (Reference 10) recommends that the individual risk can be calculated using the following equation:

$$R_{(LOL)} = P_{(H)} \times P_{(S;H)} \times P_{(T;S)} \times P_{(D;T)}$$

Where

$R_{(LOL)}$ = The risk (annual probability of loss of life/death of an individual)

$P_{(H)}$ = Annual probability of a slope failure/landslide

$P_{(S;H)}$ = Probability of spatial impact of the landslide impacting a building/location, taking into account the travel distance and travel direction given the event

$P_{(T;S)}$ = Temporal spatial probability (e.g. of building/location being occupied by the individual) given the spatial impact and allowing for possibility of evacuation, given there is warning of the landslide occurrence

$P_{(D;T)}$ = Vulnerability of individual (probability of loss of life of the individual) given the impact

The critical slope failure at the site is anticipated to be global instability. It is our assessment that an event of a landslide (global slope failure) across the site is "Rare". Accordingly, assessed risks to Loss of Life for the person most at risk, due to probable landslides/slope failures at its existing conditions, are presented in Table 13.

Table 13 – Qualitative Risk Assessment for Loss of Life

Landslide Hazard	$P_{(H)}$	$P_{(S;H)}$	$P_{(T;S)}$	$P_{(D;T)}$	$R_{(LOL)}$
Global Slope Failures	$1.0x10^{-5}$	1.0	0.05	0.10	$3.5x10^{-8}$
Sum of the risk for the person most at risk from landslide hazards					**$3.5x10^{-8}$**

The sum of risk to Loss of Life, from likely landslides/slope failures across the site in its existing conditions, for an individual most at risk is $3.5x10^{-8}$ per annum. Australian Geomechanics Society (Reference 10) suggests a tolerable risk level of $1.0x10^{-4}$ per annum for an existing slope or existing residence and $1.0x10^{-5}$ per annum for new slope or new residence. That means that the estimated risk for Loss of Life for an individual most at risk is tolerable for the proposed development works.

Risk of Slope Instability – During and After Proposed Development Works

In its existing condition, the risk of landslides or slope failures to Property Loss is "Very Low" and risk to Loss of Life for an individual most at risk is less than $1.0x10^{-5}$ per annum. Therefore, the site in its existing condition is assessed to be suitable for the proposed development works. However, proposed development works will involve alteration to site conditions, including basement excavation. These operations may create unstable slopes that could increase likelihood of landslides/slope failures. This in turn will increase the risk to Property Loss and Loss of Life. Therefore, site preparation and proposed development works should be carried out to ensure that the risk of landslides/slope failure does not increase to unacceptable level.

It is our assessment that the likelihood of landslides or slope failures will not increase during and after proposed development works if site preparation (including excavation and fill placement) as well as design and construction of retaining structures, floor slabs and footings are carried out in general accordance with geotechnical recommendations provided in this report. Provision of an appropriate and adequate drainage should form part of site preparation and retaining wall construction. However, the consequence of any landslide or slope failure after proposed development works could be severe due to presence of buildings occupied by people. The assessment of risk of landslides or slope failures after proposed development works should take into account the changes in consequence. Our assessments of the risk to Property Loss due to landslides or slope failures during and after completion of the proposed development works are as follows:

- Qualitative Measures of Likelihood - It is our assessment that an event of a landslide or slope failure (Local and Regional Failures) is "Rare", with high indicative annual probability of $\approx 10^{-5}$.
- Qualitative Measures of Consequences - It is our assessment that the consequences of landslides within the site to the property would vary from "Medium" resulting in moderate damage to some structures, or significant part of the site requiring large reinstatement/stabilisation works.
- Based on the above Qualitative Measures, it is our assessment that the risk to Property Loss due to landslides/slope failures during and after proposed development works is "Very Low to Low".

Our assessments of risk to Loss of Life due to landslides and slope failures during and after proposed development works are provided below in Table 14.

Table 14 – Qualitative Risk Assessment for Loss of Life

Landslide Hazard	$P_{(H)}$	$P_{(S;H)}$	$P_{(T;S)}$	$P_{(D;T)}$	$R_{(LOL)}$
Global Slope Failures	$1.0x10^{-5}$	0.7	0.50	0.20	$7.0x10^{-7}$
Sum of the risk for the person most at risk from landslide hazards					**$7.0x10^{-7}$**

The sum of risk to life, from likely landslide events for an individual most at risk is $7.0x10^{-7}$ per annum.

As risk of landslides and slope failures to Property Loss is "Very Low to Low" and risk to Loss of Life for an individual most at risk is less than $1.0x10^{-5}$ per annum during and after completion of proposed development works, it is our assessment that the risk of slope instability even after construction of proposed buildings is tolerable. Therefore, in terms of risk of slope instability, the site is assessed to be suitable for construction of buildings for the proposed aged care facility development at 25-27 Warriewood Road, Warriewood, provided site preparation as well as design and construction of retaining structures, floor slabs and footings are carried out in general accordance with geotechnical recommendations provided in this report.

General

Assessments and recommendations presented in this report are based on site observation and information from a limited number of boreholes distributed across the site. Although we believe that the sub-surface profile presented in this report is indicative of the general profile across the site, it is possible that the sub-surface profile across the site could differ from those encountered in boreholes. Likewise, comments on depths to groundwater level are based observation during field work. Therefore, we recommend that this company is contacted for further advice if actual site conditions encountered during construction differ from those presented in this report.

If you have any questions, please do not hesitate to contact the undersigned.

Yours faithfully
GEOTECHNIQUE PTY LTD

INDRA JWORCHAN
Principal Geotechnical Engineer

Attached
Plan Showing Building Footprints
Drawing No 13787/3-AA1 – Borehole Location Plan
Borehole Logs, Core Photos & Explanatory Notes
Laboratory Test Results
Forma 1 and 1A

References

1. Geotechnique Pty Ltd, Geotechnical Investigation, Proposed Development, 23-27 Warriewood Road, Warriewood, Submitted to J+G Knowles and Associates Pty Ltd, Report No 13787/1-AA, 3 August 2016.
2. Geotechnique Pty Ltd, Additional Geotechnical Investigation, Proposed Development, 23-27 Warriewood Road, Warriewood, Submitted to Knowles Group, Report No 13787/1-AA, 27 November 2017.
3. Geotechnique Pty Ltd, Additional Geotechnical Investigation, Proposed Development, 23-27 Warriewood Road, Warriewood, Submitted to Knowles Group, Report No 13787/3-AA dated 10 January 2018.
4. Australian Standard, Geotechnical Site Investigation, AS1726-2017.
5. Pells, P J N, Mostyn, E and Walker, B F, Foundations on Sandstone and Shale in the Sydney Region, Australian Geomechanics Journal, Dec 1998.
6. Lillicrap, A and McGhie, S., Site Investigation for Urban Salinity, Department of Land and Water Conservation, 2002.
7. Standard Australia- AS2159-1995, Piling – Design and Installation, 1995.
8. New South Wales, Acid sulphate Soil Management Advisory Committee, 1988 – Acid sulphate Soil Manual.
9. Australian Standard AS3798-2007, Guidelines on Earthworks for Commercial and Residential Developments, 2007.
10. Australian Geomechanics Society Landslide Taskforce, Landslide Practice Note Working Group - "Practice Note Guidelines for Landslide Risk Management", March 2007.

LEGEND

THIS DRAWING IS TO BE READ IN CONJUCTION WITH THE LANDSCAPE DOCUMENTS

- CONCRETE FOOTPATH
- STONE FOOTPATH
- GARDEN
- GRASS
- PLANTER BOX
- PERMEABLE PAVING / PARKING
- PRIVATE OPEN SPACE - BALCONY / TERRACE
- PRIVATE OPEN SPACE - GARDEN
- TREE - PROPOSED REFER TO LANDSCAPE PLAN FOR DETAILS
- RAINWATER TANK - REFER TO PLANS FOR LOCATIONS
- WINDOW WITH BI-FOLD SHUTTERS REFER TO DRAWING DA - 260

V / A
A R C H I T E C T S

LEVEL 3, 377 LONSDALE STREET MELBOURNE VIC 3000
+61 3 8678 3300 / viaarchitects.com.au

REV	DESCRIPTION	DATE	BY
DA1	ISSUE FOR CO-ORDINATION	20.03.2020	TM
DA2	UPDATED APARTMENTS AND BASEMENT	08.04.2020	TM
DA3	DRAFT ISSUE FOR DEVELOPMENT APPLICATION	20.04.2020	MH
DA4	ISSUE FOR DEVELOPMENT APPLICATION	06.05.2020	TM
DA5	ISSUE FOR STRADA REVIEW	18.05.2020	MH

PROJECT REF: C:\Users\MHondrogiannis\Documents\1510121 - ARCARE - WARRIEWOOD APT - DA PACKAGE_CENTRAL_19_MHondrogiannis.rvt
TIMESTAMP: 26/05/2020 12:19:25 PM

KEY PLAN

STATUS

DEVELOPMENT APPLICATION

NORTH POINT

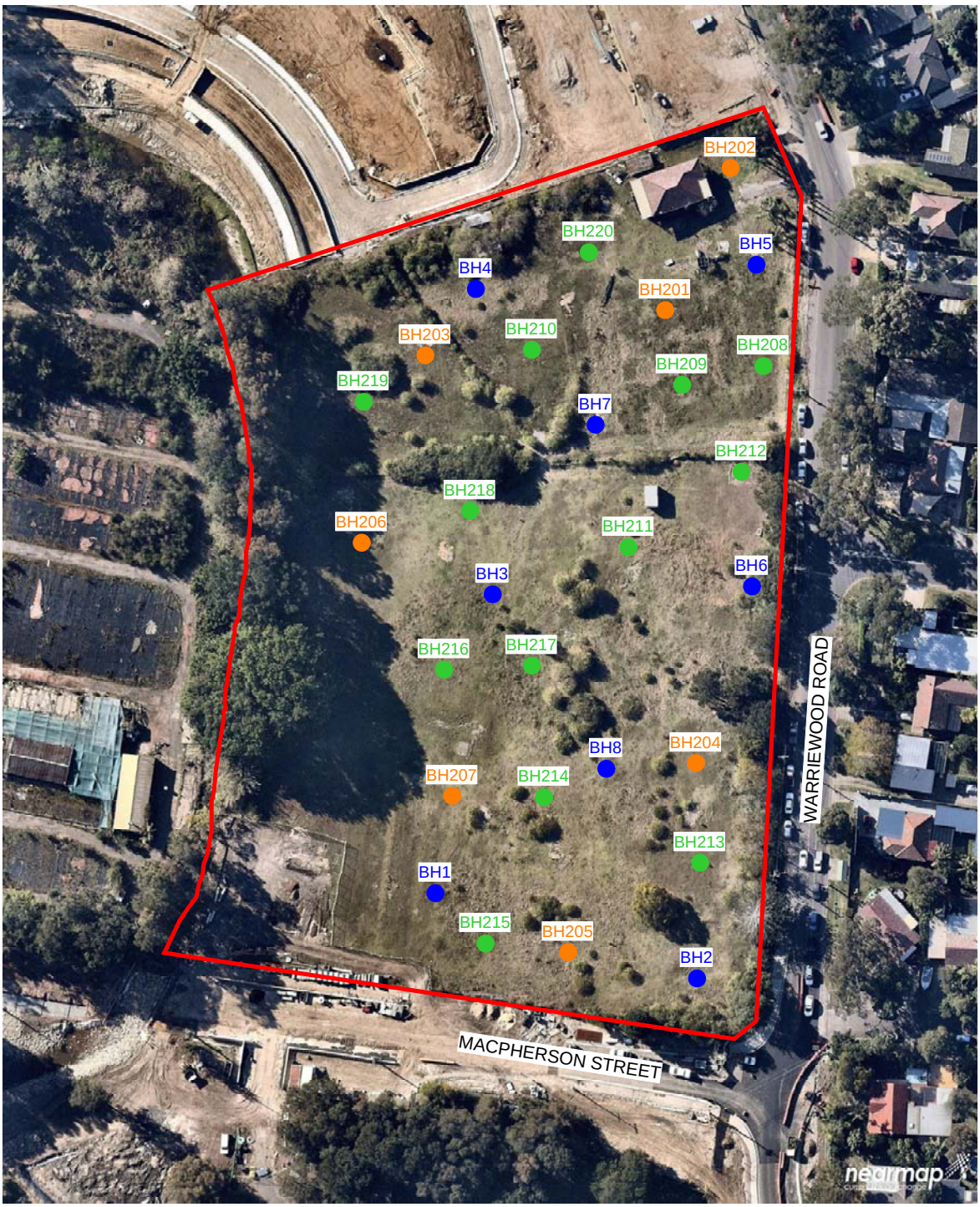
PROJECT
WARRIEWOOD RESIDENTIAL DEVELOPMENT

ADDRESS
25 - 27 WARRIEWOOD ROAD, NSW 2102

CLIENT
KNOWLES GROUP

DRAWING TITLE
PROPOSED APARTMENT GROUND FLOOR PLAN / DWELLING LOWER LEVEL FLOOR PLAN

SCALE (@A1)	DRAWN BY	CHECKED BY	PROJECT No.	DRAWING No.	REV
1 : 200	JC	MA	1510121	DA - 100	DA5



LEGEND

- Borehole (July 2016)
- Borehole (November 2017)
- Borehole (December 2017)

Imagery ©2017 NearMap.com

0 15 30 45 60 75m

Scale 1:1500

PREPARED BY:

GEOTECHNIQUE® PTY LTD

PO Box 880
Penrith NSW 2750
Tel: 02 4722 2700
Fax: 02 4722 2777
e-mail:info@geotech.com.au
www.geotech.com.au

Knowles Group
Proposed Residential Aged Care Facility
23-27 Warriewood Road
Warriewood

Borehole Locations

Drawing No: 13787/3-AA1
Job No: 13787/3
Drawn By: MH
Date: 15 December 2017
Checked By: MT

File No: 13787-3
Layers: 0, AA1

GEOTECHNIQUE
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engineering log - borehole

Client : J & G Knowles & Associates Pty Ltd
Project : Aged Care Facility
Location : 23-27 Warriewood Road, Warriewood

Job No. : 13787/1
Borehole No. : 3
Date : 15/07/2016
Logged/Checked by: AJP

drill model and mounting : Hydro-Powered Scout,Truck Mount **slope :** **deg.** **R.L. surface :** 4.6

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
V-Bit	▼					0			TOPSOIL: Silty Sand, medium grained, dark-brown, with root fibres				
								SP	Silty SAND, medium grained, pale brown	M	MD		Alluvium
				DS	N=9 2,4,5	1		CL	Sandy CLAY, low plasticity, orange-brown and grey mottled Becoming red-brown and grey mottled	M≤PL	St		
				DS	N=13 4,6,7	2		CL	Sandy CLAY, low plasticity, orange-brown, becoming grey, with ironstone bands	M≤PL	VSt		
				DS	N=14 4,6,8	3							
						4							
						5							
						6							
						7				M>PL	VSt		
				DS	N=19 6,9,10	8			Becoming red-brown mottled grey, with ironstone bands				
						9							

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engineering log - borehole

Client : J & G Knowles & Associates Pty Ltd
Project : Aged Care Facility
Location : 23-27 Warriewood Road, Warriewood

Job No. : 13787/1
Borehole No. : 3
Date : 15/07/2016
Logged/Checked by: AJP

drill model and mounting : Hydro-Powered Scout,Truck Mount **slope :** **deg.** **R.L. surface :** 4.6

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						10							
									SANDSTONE, red-brown and grey, very low strength, extremely weathered				Bedrock
						11			Borehole No. 3 terminated at 10.9m due to refusal in sandstone bedrock				
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

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engineering log - borehole

Client : J & G Knowles & Associates Pty Ltd
Project : Aged Care Facility
Location : 23-27 Warriewood Road, Warriewood

Job No. : 13787/1
Borehole No. : 4
Date : 15/07/2016
Logged/Checked by: AJP

drill model and mounting : Hydro-Powered Scout,Truck Mount **slope :** **deg.** **R.L. surface :** 4.0

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
V-Bit						0			TOPSOIL: Silty Sand, fine to medium grained, dark brown, with root fibres				
								SP	Silty SAND, medium grained, pale brown	M-W	MD		Alluvium
								CL	Sandy CLAY, low plasticity, orange-brown and grey mottled	M≤PL	VSt		
				DS	N=11 3,5,6	1							
									Becoming red-brown and grey mottled				
						2							
				DS	N=16 5,7,9	3			Presence of ironstone bands				
						4							
								CI-CH	Silty CLAY, medium to high plasticity, grey, with ironstone bands	M≤PL	VSt		
				DS	N=20 5,8,12	5							
TC-Bit								CL	Sandy CLAY, low plasticity, grey, with ironstone bands				5.8-6.2m: Ironstone band approximately 400mm thick
				DS		6							
						7			Refer to cored borehole				
						8							
						9							

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engineering log
cored borehole

Client : J & G Knowles & Associates Pty Ltd
Project : Aged Care Facility
Location : 23-27 Warriewood Road, Warriewood

Job No. : 13787/1
Borehole No. : 4
Date : 15/07/2016
Logged/Checked by : AJP

drill model and mounting : Hydra Powered Scout, truck **slope :** **deg.** **R.L. surface :** 4.0
core size: 50mm **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
		7		Commenced coring at 7.0m					
				SANDSTONE, medium to coarse grained, red-brown and grey					7.1m: Bp,Pl,Ro,sn 7.2m: Jo,Un,Ro,sn 7.25m: Jo,5°,Pl,Ro,sn 7.3m: Jo,5mm,Ro,sn 7.45m: Fr,90°,5mm,Ro,sn
		8							
									8.6m: Jo,Pl,Ro,sn 8.75m: Jo,Pl,Ro,sn 8.9m: Jo,Pl,Ro,sn
		9		Borehole No. 4 terminated at 8.95m					
		10							
		11							
		12							
		13							
		14							
		15							
		16							

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Job No 13787/1 BH4 Started Coring at 7.0m

7.0m

8.0m

8.95m

BH4 terminated at 8.95m

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engineering log - borehole

Client : J & G Knowles & Associates Pty Ltd
Project : Aged Care Facility
Location : 23-27 Warriewood Road, Warriewood

Job No. : 13787/1
Borehole No. : 5
Date : 15/07/2016
Logged/Checked by: AJP

drill model and mounting : Hydro-Powered Scout,Truck Mount **slope :** **deg.** **R.L. surface :** 12.0

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
V-Bit						0			TOPSOIL: Silty Sand, fine to medium grained, dark brown, with root fibres				
								SP	Silty SAND, fine to medium grained, grey	M	MD		Alluvium
								CL	Silty CLAY, low plasticity, yellow-brown and grey mottled	M≤PL	St		
				DS		1			Becoming red-brown mottled yellow-brown				
				DS	N=17 4,7,10	2				M≤PL	VSt		
				DS		3			Becoming red-brown mottled grey				
				DS	N=16 5,7,9	5			Becoming grey, with ironstone bands				
				DS		7							
						8							
						9							

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engineering log - borehole

Client : J & G Knowles & Associates Pty Ltd
Project : Aged Care Facility
Location : 23-27 Warriewood Road, Warriewood

Job No. : 13787/1
Borehole No. : 5
Date : 15/07/2016
Logged/Checked by: AJP

drill model and mounting : Hydro-Powered Scout,Truck Mount **slope :** **deg.** **R.L. surface :** 12.0

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						10							
						11							
TC-Bit									SANDSTONE, medium to coarse grained, red-brown and grey, extremely low to low strength, extremely to distinctly weathered				Bedrock
									Borehole No. 5 terminated at 11.7m due to refusal				
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

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engineering log - borehole

Client : J & G Knowles & Associates Pty Ltd
Project : Aged Care Facility
Location : 23-27 Warriewood Road, Warriewood

Job No. : 13787/1
Borehole No. : 6
Date : 19/07/2016
Logged/Checked by: SM

drill model and mounting : Geoprobe 6600 **slope :** **deg.** **R.L. surface :** 8.8

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
TC-Bit	▼					0			FILL: Silty Sand, fine to medium grained, brown, with brick pieces	M	VL		
								SM	Silty SAND, fine grained, grey	M	L		Alluvium
				DS				CI	Sandy CLAY, medium plasticity, red-brown, yellow-brown	M≥PL	F		
						1							
				DS	N=12 4,5,7				Becoming red-brown	M<PL	VSt		
						2							
									Introduction of ironstone bands				
				DS	N=16 6,9,7	3							
									Becoming more grey				
						4							
				DS	N=21 6,8,13				Becoming more sandy	M>PL	VSt-H		Extremely weathered sandstone?
						5							
									Becoming red				Residual?
				DS	N=23 5,9,14	6							
									SANDSTONE, fine to medium grained, grey, extremely weathered				Bedrock
				DS	N=20 5,9,11	7							
						8							
						9							
									Refer to cored borehole				

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : J & G Knowles & Associates Pty Ltd
Project : Aged Care Facility
Location : 23-27 Warriewood Road, Warriewood

Job No. : 13787/1
Borehole No. : 6
Date : 19/07/2016
Logged/Checked by : SM

drill model and mounting : Geoprobe 6600 **slope :** **deg.** **R.L. surface :** 8.8

core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Commenced coring at 9.3m CORE LOSS					
		10		CLAYSTONE, grey, red, with siltstone bands	EW	L			10.23m: Cs,2mm,Pl,Sl 10.75m: Cs,5mm,Pl,Sl
		11		SANDSTONE, fine to medium grained, grey-red	SW	M-H			11.16m: Bp,Ir,Ro,sn 11.45m: Jo,Ir,Ro,sn 11.67m: Jo,5°,Pl,Ro
		12		Borehole No. 6 terminated at 11.9m					
		13							
		14							
		15							
		16							
		17							
		18							

GEOTECHNIQUE
PTY LTD

Job No 13787/1 BH6 Started Coring at 9.3m

9.0m	9.3m	Core Loss
10.0m	Core Loss	
11.0m		11.9m

BH6 terminated at 11.9m

IJ.mh/03.08.2016

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road
Warriewood

Job No. : 13787/2
Borehole No. : BH201
Date : 22/11/2017
Logged/Checked by: SS

drill model and mounting : Edson 100, Truck Mounted **slope :** **deg.** **R.L. surface :** 9.83

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
TC Bit	▼					0			TOPSOIL: Clayey Silt, low plasticity, brown, with root fibres				
								CH	Sandy CLAY, high plasticity, mottled grey, red and yellow brown	M<PL	St-VSt		Alluvial
				DS	N=18 5,8,10	1							
								CH	Silty CLAY, high plasticity, red mottled grey, with fine grained ironstone gravel	M<PL	VSt		
				DS	N=17 4,7,10	2							
								CH	Silty CLAY, high plasticity, grey mottled red, with ironstone gravel	M≥PL			
				DS	N=18 4,8,10	3							
						4							
				DS	N=21 5,10,11	5					H		
						6							
				DS	N=23 6,10,13	7							
						8							
						9			Started coring at 8.8m				

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/2
Borehole No. : BH201
Date : 22/11/2017
Logged/Checked by : SS

drill model and mounting : Edson 100, Truck Mounted **slope :** **deg.** **R.L. surface :** 9.83
core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
		8		Started coring at 8.8m					
		9		SANDSTONE, fine to medium grained, grey	DW	M-H			8.97m, Bp=30° 9.02m, Bp=30° 9.05m, Bp=30° 9.11m, Bp=0° 9.26m, Bp=30°
		10							9.85m, clay band=270mm
				Borehole No 201 terminated at 10.4m					10.4m, start of clay band
		11							
		12							
		13							
		14							
		15							
		16							
		17							

GEOTECHNIQUE
PTY LTD

Job No 13787/2 BH201 Started Coring at 8.8m

9.0m

10.0m

BH201 terminated at 10.4m

Knowles Group
IJ.sf/27.11.2017

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road
Warriewood

Job No. : 13787/2
Borehole No. : BH202
Date : 22/11/2017
Logged/Checked by: SS

drill model and mounting : Edson 100, Truck Mounted **slope :** **deg.** **R.L. surface :** 12.69

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
TC Bit	▼					0			TOPSOIL: Sandy Silt, low plasticity, brown				
								ML	Sandy SILT, low plasticity, brown	M<PL	F		Alluvial
								CH	Silty Sandy CLAY, high plasticity, mottled grey, red and medium yellow-brown, with ironstone gravel	M<PL	VSt		
				DS	N=15 4,6,9	1							
						2							Regular ironstone banding
						3		CH	Silty CLAY, high plasticity, grey, with ironstone gravel	M<PL	VSt-H		
	▼			DS	N=R 10,10/80	4							
						5							
						6							
						7							
	▼								SHALE, grey, extremely weathered, low strength				Shale fragments observed in cuttings, Bedrock
						8							
									Started coring at 8.10m				
						9							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road
Warriewood

Job No. : 13787/2
Borehole No. : BH202
Date : 22/11/2017
Logged/Checked by : SS

drill model and mounting : Edson 100, Truck Mounted **slope :** **deg.** **R.L. surface :** 9.83

core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
		8		Started coring at 8.10m					
		9		SHALE, grey	DW	L-M			8.14m, Jo=45°,Pl,sn 8.35m, Jo=0°,Cu,Ir,Ro,sn 8.49m, Bp=0° 8.81m, Is(clay) 8.93m, Jo=45°,Pl,sn 9.10m, Jo=30°,Ir,Ro 9.20m, Is(clay) 9.40m, Jo,(sealed),Cu 9.45m, Jo=10°,Pl
		10			DW-SW	M-H			9.85m, Jo,Cu,Pl 10.17m, Bp=0°,Ir,Ro 10.44m, Jo=0° 10.70m, Jo=10°,Pl,Un,Sm
		11		CORELOSS					
		12		Borehole No 202 terminated at 11.1m					
		13							
		14							
		15							
		16							
		17							

GEOTECHNIQUE
PTY LTD

Job No 13787/2 BH202 Started Coring at 8.1m

Started @ 8.1m		
9.0m		
10.0m		Coreloss
11.0m	Coreloss	BH202 terminated at 11.1m

Knowles Group
IJ.sf/27.11.2017

GEOTECHNIQUE PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/2
Borehole No. : BH203
Date : 23/11/2017
Logged/Checked by: SS

drill model and mounting : Edson 100, Truck Mounted **slope :** **deg.** **R.L. surface :** 5.16

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION (soil type, plasticity or particle characteristic, colour, secondary and minor components.)	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
TC Bit	▼			DS		0		SP	TOPSOIL: Silty Sand, fine grained, brown, with fine grained gravel	D	VL-L		Alluvial
									Silty SAND, fine grained, brown				
				DS	N=9 3,3,6	1		CH	Silty Sandy CLAY, high plasticity, mottled red, grey and yellow brown	M<PL	St-VSt		
						2		CH	Silty CLAY, high plasticity, red mottled grey	M<PL	St-VSt		
						3		SP	Clayey SAND, fine to medium grained, yellow brown	M	L-MD		
	▼			DS	N=11 4,5,6	4		SP	Clayey SAND, fine to medium grained, red	M-W			
						5		CH	Silty Sandy CLAY, high plasticity, grey mottled red and yellow-brown	M<PL	St-VSt		
				DS	N=9 3,4,5	6							
						7							Ironstone bands at approximately 7.4m
						8							
						9			SANDSTONE, fine to medium grained, red-grey, extremely to distinctly weathered				Possible weathered rock Bedrock

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road
Warriewood

Job No. : 13787/2
Borehole No. : BH203
Date : 23/11/2017
Logged/Checked by: SS

drill model and mounting : Edson 100, Truck Mounted **slope :** **deg.** **R.L. surface :** 5.16

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						10			Started coring at 10.0m				
						11							
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/2
Borehole No. : BH203
Date : 23/11/2017
Logged/Checked by : SS

drill model and mounting : Edson 100, Truck Mounted **slope :** **deg.** **R.L. surface :** 5.16
core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	defect spacing (mm) 2000 1000 500 300 100 50	DEFECT DETAILS DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Started coring at 10.0m					
		10		SANDSTONE, grey	DW	M-H			10.03m, Is(clay),sn 10.18m, Is(clay),sn 10.37m, Bp=5° 10.43m, Bp=5° 10.48m, Bp=0° 10.74m, clay band=80mm
		11							11.17m, Bp=0° 11.38m, Is(clay) 11.56m, Bp=0° 11.72m, Is(clay)
		12							12.05m, Bp=0° 12.35m, Is(clay),sn 12.48m, Is(clay),sn
		13							12.86m, clay band=20mm Regularly interbedded
				Borehole No 203 terminated at 13.0m					
		14							
		15							
		16							
		17							
		18							
		19							

GEOTECHNIQUE
PTY LTD

Job No 13787/2 BH203 Started Coring at 10.0m

BH203 terminated at 13.0m

Knowles Group
IJ.sf/27.11.2017

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH208
Date : 04/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** 11.9

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			TOPSOIL: Silty Clayey Sand, fine to medium grained, brown, with grass roots				
								CI	Silty Sandy CLAY, medium plasticity, red brown	M<PL	St-VSt		Alluvial
					N=17 7,8,9	1							
						2							
						3							
					N=14 5,5,9	4		CI-CH	Silty CLAY, medium to high plasticity, grey, with trace of fine sand	M<PL	VSt-H		
						5		CI-CH	Silty CLAY, medium to high plasticity, grey red, with ironstone	M<PL	H		Getting hard to drill
						6							
						7							Hard Resistance at 7.0m
						8							
						9			Started coring at 8.6m				

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH208
Date : 04/12/2017
Logged/Checked by : MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅11.9

core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	defect spacing (mm) 2000 1000 500 300 100 50	DEFECT DETAILS DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Started coring at 8.6m					
		9		SHALE, grey, with ironstone and clay bands	EW	VL			8.70m, Infilled Seam
				SHALE, grey red, with ironstone	EW-DW	VL			9.00m, Crushed Seam 9.25m, Bp=0° planar 9.40m, Bp=0° planar 9.55m, Bp=0° planar
		10		SILTSTONE/SHALE, grey brown, with ironstone	DW	VL-L			10.05m, Bp=0° planar
				Borehole 208 terminated at 10.5m					
		11							
		12							
		13							
		14							
		15							
		16							
		17							

GEOTECHNIQUE
PTY LTD

Job No 13787/3 BH208 Started Coring at 8.6m

BH208 terminated at 10.5m

Knowles Group
IJ.sf/09.01.2018

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH209
Date : 04/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** 9.8

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			TOPSOIL: Silty Sandy Silt, low plasticity, grey, with grass roots				
								CI-CH	Silty Sandy CLAY, medium to high plasticity, red brown	M<PL	St-VSt		Alluvial
					N=16 4,6,10	1							
						2							
						3							
						4							
								CI-CH	Silty CLAY, medium to high plasticity, grey red	M<PL	VSt-H		
						5							
						6							
								CI-CH	Silty CLAY, medium to high plasticity, grey red, with ironstone	M<PL	H		Getting hard to drill
						7							
						8							
						9							
									SANDSTONE, fine to medium grained, grey				Bedrock

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH209
Date : 04/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** 9.8

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						10			brown, extremely weathered Started coring at 9.6m				
						11							
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

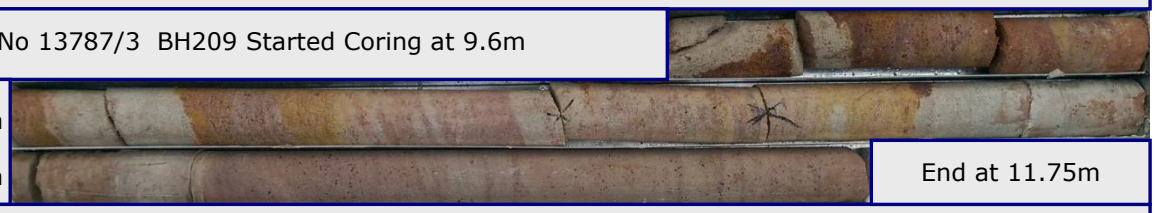
Job No. : 13787/3
Borehole No. : BH209
Date : 04/12/2017
Logged/Checked by : MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅9.8
core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Started coring at 9.6m					
		10		SANDSTONE, fine to medium grained, grey red, with iron staining and some weathered seams	DW-SW	M-H			9.70m, Bp=0° planar 9.87m, Bp=0° planar 10.10m, Bp=0° planar
		11							10.90m, Infilled Seam 11.10m, Decomposed Seam
				SANDSTONE, fine to medium grained, grey red	SW	H			
		12		Borehole No 209 terminated at 11.75m					
		13							
		14							
		15							
		16							
		17							
		18							

GEOTECHNIQUE
PTY LTD

Job No 13787/3 BH209 Started Coring at 9.6m



End at 11.75m

BH209 terminated at 11.75m

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH210
Date : 06/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅8.2

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			TOPSOIL: Sandy Silt, low plasticity, brown, with grass roots				
								SM	Silty SAND, fine to medium grained, brown	M	MD		Alluvial
								CI-CH	Silty Sandy CLAY, medium to high plasticity, brown red	M<PL	St-VSt		
						1							
								CI-CH	Silty CLAY, medium to high plasticity, red	M<PL	VSt		
						2							
						3							
						4							
						5							
								CI-CH	Silty CLAY, medium to high plasticity, red grey, with ironstone	M<PL	VSt-H		
	▼					6							
						7							Groundwater at 7.5m
						8			SANDSTONE, fine to medium grained, grey red, extremely weathered, with clay bands and ironstone				Bedrock
						9			Started coring at 8.9m				

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH210
Date : 05/12/2017
Logged/Checked by : MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅8.2

core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Started coring at 8.9m					
		9		SANDSTONE, fine to medium grained, grey, with iron staining	EW-DW	L-M			9.40m, Decomposed Seam 9.60m, Decomposed Seam 9.75m, Bp=0° planar 9.85m, Jo=45° Stepped
		10							10.25m, Decomposed Seam 10.35m, Decomposed Seam 10.45m, Decomposed Seam
		11							10.75m, Infilled Seam 10.90m, Bp=0° planar
				SANDSTONE, fine to medium grained, grey	F	H-VH			11.35m, Bp=0° planar 11.40m, Bp=0° planar
		12		Borehole 210 terminated at 11.85m					
		13							
		14							
		15							
		16							
		17							
		18							

GEOTECHNIQUE
PTY LTD

Job No 13787/3 BH210 Started Coring at 8.9m

BH210 terminated at 11.85m

Knowles Group
IJ.sf/09.01.2018

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH211
Date : 06/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅8.8

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			TOPSOIL: Silty Sand, fine to medium grained, brown, with roots				
								SM	Silty Clayey SAND, fine grained, brown	M	MD		Alluvial
						1		CI	Silty Sandy CLAY, medium plasticity, red brown	M<PL	St-VSt		
						2							
						3							
						4							
						5							
						6		CI-CH	Silty CLAY, medium to high plasticity, grey	M<PL	VSt-H		
	▼					7							
						8							Groundwater at 8.0m
						9							
									SANDSTONE, fine to medium grained, brown,				Bedrock

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH211
Date : 06/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅8.8

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						10			extremely weathered, with clay bands				
									Started coring at 10.3m				
						11							
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH211
Date : 05/12/2017
Logged/Checked by : MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅8.8

core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	defect spacing (mm) 2000 1000 500 300 100 50	DEFECT DETAILS DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
		10		Started coring at 10.3m					
				SANDSTONE, fine to medium grained, grey, with iron staining	EW-DW	M-H			10.40m, Bp=0° planar 10.60m, Bp=0° planar 10.65m, Bp=0° planar
		11		SANDSTONE, fine to medium grained, grey, with some iron staining	SW	H			11.60m, Bp=0° planar 11.88m, Bp=0° planar 12.00m, Decomposed Seam 12.30m, Decomposed Seam 12.50m, Jo=45° Stepped 12.75m, Jo=45° Stepped 12.80m, Decomposed Seam
		12							
		13		Borehole No 211 terminated at 13.0m					
		14							
		15							
		16							
		17							
		18							
		19							

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Job No 13787/3 BH211 Started Coring at 10.3m

10.0m Coring at 10.3m

11.0m

12.0m

BH211 terminated at 13.0m

GEOTECHNIQUE
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engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH212
Date : 06/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅10.8

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			TOPSOIL/FILL: Silty Sand, fine to medium grained, brown, with roots and gravel				
								CI-CH	Silty Sandy CLAY, medium to high plasticity, orange brown	M<PL	St		Alluvial
						1		CI-CH	Silty CLAY, medium to high plasticity, red grey	M<PL	VSt-H		
						2							
						3							
						4							
						5							
						6							
	▼					7		CI-CH	Silty CLAY, medium to high plasticity, grey red	M<PL	VSt-H		
						8							
						9							

GEOTECHNIQUE
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engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH212
Date : 06/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅10.8

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						10			SANDSTONE, fine to medium grained, grey brown, extremely weathered, with ironstone				Bedrock
									Started coring at 10.6m				
						11							
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH212
Date : 05/12/2017
Logged/Checked by : MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅10.8
core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	defect spacing (mm) 2000 1000 500 300 100 50	DEFECT DETAILS DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Started coring at 10.6m					
		11		SANDSTONE, fine to medium grained, grey, with iron staining and clay bands	DW	M	×		10.75m, Bp=0° planar 10.90m, Bp=0° planar 11.15m, Bp=0° planar 11.40m, Crushed Seam 11.50m, Infilled Seam 11.70m, Bp=0° planar
		12					×		12.00m, Infilled Seam
				SANDSTONE, fine to medium grained, grey, with some iron staining	SW	M-H	×		12.15m, Infilled Seam
		13		SANDSTONE, medium grained, grey	F	H-VH			12.80m, Infilled Seam 13.10m, Infilled Seam
		14					×		13.80m, Infilled Seam
				Borehole No 212 terminated at 14.5m					
		15							
		16							
		17							
		18							
		19							

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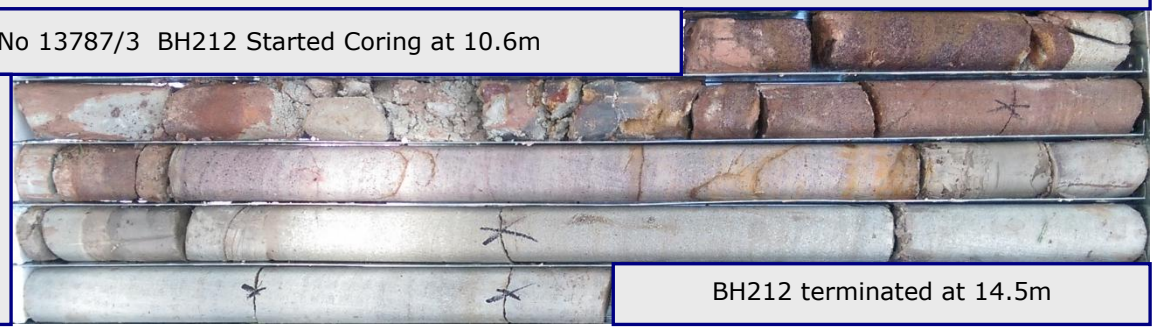
Job No 13787/3 BH212 Started Coring at 10.6m



BH212 terminated at 14.5m

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engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH218
Date : 08/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅6.4

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						0			TOPSOIL: Silty Sand, fine to medium grained, brown, with roots				
								SM	Silty SAND, fine to medium grained, grey	M	MD		Alluvial
						1		CI	Silty Sandy CLAY, medium plasticity, red brown	M<PL	St-VSt		
						2							
						3							
						4							
						5							
						6		CI-CH	Silty CLAY, medium to high plasticity, grey	M<PL	VSt-H		
						7							
	▼					8							Groundwater at 8.3m
						9							
									SANDSTONE, fine to medium grained, grey red, extremely weathered				Bedrock

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH218
Date : 08/12/2017
Logged/Checked by: MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅6.4

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
						10							
									Started coring at 10.3m				
						11							
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : Knowles Group
Project : Aged Care Facility
Location : 23-27 Warriewood Road Warriewood

Job No. : 13787/3
Borehole No. : BH218
Date : 12/12/2017
Logged/Checked by : MT

drill model and mounting : Edson Truck Mounted **slope :** **deg.** **R.L. surface :** ≅5.7
core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
		10		Started coring at 10.3m					
				SANDSTONE, fine to medium grained, grey, with ironstone	DW	M			10.50m, Infilled Seam 10.80m, Infilled Seam
		11		SANDSTONE, fine to medium grained, brown red	SW	M-H			11.10m, Bp=0° planar 11.48m, Bp=0° planar 11.60m, Bp=0° planar
		12							12.00m, Infilled Seam
				SANDSTONE, fine to medium grained, grey	SW-F	H-VH			12.68m, Bp=0° planar
		13		Borehole No 218 terminated at 13.1m					
		14							
		15							
		16							
		17							
		18							
		19							

GEOTECHNIQUE
PTY LTD

Job No 13787/3 BH218 Started Coring at 10.3m

10.0m Coring at 10.3m

11.0m

12.0m

13.0m

BH218 terminated at 13.1m

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Log Symbols & Abbreviations (Non-cored Borehole Log)

Log Column	Symbol/Value		Description
Drilling Method	V-bit TC-bit RR DB BB		Hardened steel 'V' shaped bit attached to auger Tungsten Carbide bit attached to auger Tricone (Rock Roller) bit Drag bit Blade bit
Groundwater	Dry 		Groundwater not encountered to the drilled or auger refusal depth Groundwater level at depths shown on log Groundwater seepage at depths shown on log
Environment Sample	GP G P		Glass bottle and plastic bag sample over depths shown on log Glass bottle sample over depths shown on log Plastic bag sample over depths shown on log
PID Reading	100		PID reading in ppm
Geotechnical Sample	DS DB U_{50}		Disturbed Small bag sample over depths shown on log Disturbed Bulk sample over depths shown on log Undisturbed 50mm tube sample over depths shown on log
Field Test	N=10 3,5,5 N=R 10,15/100		Standard Penetration Test (SPT) 'N' value. Individual numbers indicate blows per 150mm penetration. 'R' represents refusal to penetration in hard/very dense soils or in cobbles or boulders. The first number represents10 blows for 150mm penetration whereas the second number represents 15 blows for 100mm penetration where SPT met refusal
	DCP/PSP	5 6 R/10	Dynamic Cone Penetration (DCP) or Perth Sand Penetrometer (PSP). Each number represents blows per 100mm penetration. 'R/10' represents refusal after 10mm penetration in hard/very dense soils or in gravels or boulders.
Classification	GP GW GM GC SP SW SM SC ML MI MH CL CI CH		Poorly Graded GRAVEL Well graded GRAVEL Silty GRAVEL Clayey GRAVEL Poorly graded SAND Well graded SAND Silty SAND Clayey SAND SILT / Sandy SILT / clayey SILT, low plasticity SILT / Sandy SILT / clayey SILT, medium plasticity SILT / Sandy SILT / clayey SILT, high plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, low plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, medium plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, high plasticity
Moisture Condition Cohesive soils Cohesionless soils	 M<PL M=PL M>PL D M W		 Moisture content less than Plastic Limit Moisture content equal to Plastic Limit Moisture content to be greater than Plastic Limit Dry - Runs freely through hand Moist - Tends to cohere Wet - Tends to cohere

Consistency Cohesive soils	Term	Undrained shear strength, C_u (kPa)	Hand Penetrometer (Qu)
VS	Very Soft	≤12	<25
S	Soft	>12 ≤25	25 – 50
F	Firm	>25 ≤50	50 – 100
St	Stiff	>50 ≤100	100 – 200
VSt	Very Stiff	>100 ≤200	200 – 400
H	Hard	>200	>400

Density Index Cohesionless soils	Term	Density Index, I_D (%)	SPT 'N' (blows/300mm)
VL	Very Loose	≤15	≤5
L	Loose	>15 ≤35	>5 ≤10
M	Medium Dense	>35 ≤65	>10 ≤30
D	Dense	>65 ≤85	>30 ≤50
VD	Very Dense	>85	>50

Hand Penetrometer	100 200	Unconfined compressive strength (q_u) in kPa determined using pocket penetrometer, at depths shown on log
Remarks	 Residual Alluvium Colluvial Aeolian Marine	Geological origin of soils Residual soils above bedrock River deposited Alluvial soils Gravity deposited Colluvial soils Wind deposited Aeolian soils Marine Soils

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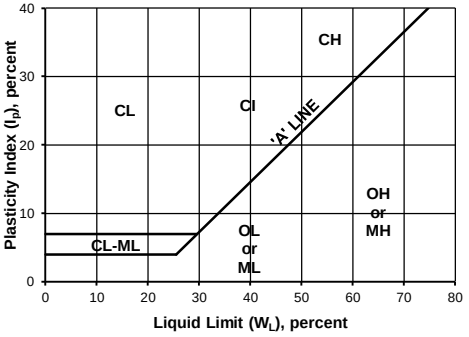
AS1726 – Unified Soil Classification System

Major Divisions		Particle size (mm)	Group Symbol	Typical Names	Field Identifications Sand and Gravels			Laboratory classification				
	BOULDERS	200						% (2) < 0.075mm	Plasticity of Fine Fraction	$C_u = D_{60}/D_{10}$	$C_c = (D_{30})^2/(D_{10}D_{60})$	Notes
	COBBLES	63										
COARSE GRAINED SOILS (more than half of material less 63mm is larger than 0.075mm)	GRAVELS (more than half of coarse fraction is larger than 2.36mm)	Coarse 20	GW	Well-graded gravels, 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			0-5	-	>4	between 1 and 3	1. Identify lines by the method given for fine grained soils 2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.075mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC
			GP	Poorly graded gravels, 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			0-5	-	Fails to comply with above		
		Medium 6	GM	Silty gravels, gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
		Fine 2.36	GC	Clayey gravels, gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line or I_p>7	-	-	
	SANDS (more than half of coarse fraction is smaller than 2.36mm)	Coarse 0.6	SW	Well-graded sands, gravelly sands, 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			0-5	-	>6	between 1 and 3	
		Medium 0.2	SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
		Fine 0.075	SM	Silty sands, sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
			SC	Clayey sand, sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line of I_p>7	-	-	
FINE GRAINED SOILS (more than half of material less than 63mm is smaller than 0.075mm)					**Dry Strength**	**Dilatancy**	**Toughness**					
	SILTS & CLAYS (liquid limit < 50%)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	None to low	Quick to slow	None	More than 50% passing 0.075mm	Below 'A' line			
			CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to very slow	Medium		Above 'A' line			
			OL	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low		Below 'A' line			
	SILTS & CLAYS (liquid limit > 50%)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Low to medium	Slow to none	Low to medium		Below 'A' line			
			CH	Inorganic clays of medium to high plasticity, fat clays	High to very high	None	High		Above 'A' line			
			OH	Organic clays of medium to high plasticity, organic silts	Medium to high	None to very slow	Low to medium		Below 'A' line			
	HIGHLY ORGANIC SOILS		Pt	Peat and highly organic soils	Identified by colour, odour, spongy feel and generally by fibrous texture			Effervesces with H_2O_2				

Use the gradation of material passing 63mm for classification of fractions according to the criteria given in 'Major Divisions'

Log Symbols & Abbreviations (Cored Borehole Log)

Log Column	Symbol	Description
Core Size		Nominal Core Size (mm)
	NQ	47
	NMLC	52
	HQ	63
Water Loss	◀	Complete water loss
	◁	Partial water loss
Weathering	FR	Fresh — Rock shows no sign of decomposition or staining
	SW	Slightly Weathered — Rock is slightly discoloured but shows little or no change of strength from fresh rock
	DW	Distinctly Weathered — Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased by deposition of weathering products in pores
	EW	Extremely Weathered — Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrate or can be remoulded, in water
	RS	Residual Soil — Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but soil has not been significantly transported
Strength		Term — Point Load Strength Index (I_{s50}, MPa)
	EL	Extremely Low — ≤0.03
	VL	Very Low — >0.03 ≤0.1
	L	Low — >0.1 ≤0.3
	M	Medium — >0.3 ≤1
	H	High — >1 ≤3
	VH	Very High — >3 ≤10
	EH	Extremely High — >10
Defect Spacing		Description — Spacing (mm)
		Extremely closely spaced — <20
		Very closely spaced — 20 to 60
		Closely spaced — 60 to 200
		Medium spaced — 200 to 600
		Widely spaced — 600 to 2000
		Very widely spaced — 2000 to 6000
		Extremely widely spaced — >6000
Defect Description		
Type	Bp	Bedding parting
	Fp	Foliation parting
	Jo	Joint
	Sh	Sheared zone
	Cs	Crushed seam
	Ds	Decomposed seam
	Is	Infilled seam
Macro-surface geometry	St	Stepped
	Cu	Curved
	Un	Undulating
	Ir	Irregular
	Pl	Planar
Micro-surface geometry	Ro	Rough
	Sm	Smooth
	Sl	Slickensided
Coating or infilling	cn	clean
	sn	stained
	vn	veneer
	cg	coating

AS1726 – Identification of Sedimentary Rocks for Engineering Purposes

Grain Size mm		Bedded rocks (mostly sedimentary)									
More than 20	20	Grain Size Description				At least 50% of grains are of carbonate				At least 50% of grains are of fine-grained volcanic rock	
	6	RUDACEOUS		CONGLOMERATE Rounded boulders, cobbles and gravel cemented in a finer matrix		LIMESTONE and DOLOMITE (undifferentiated)		Calcirudite		Fragments of volcanic ejecta in a finer matrix	SALINE ROCKS
	2			Breccia Irregular rock fragments in a finer matrix						Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	Halite Anhydrite
	0.6	ARENACEOUS	Coarse	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals				Calcarenite		Cemented volcanic ash	Gypsum
	0.2		Medium	Quartzite Quartz grains and siliceous cement						TUFF	
	0.06		Fine	Arkose Many feldspar grains Greywacke Many rock chips							
	0.002	ARGILLACEOUS		MUDSTONE	SILTSTONE Mostly silt	Calcareous Mudstone		Calcisiltite	CHALK	Fine-grained TUFF	
	Less than 0.002			SHALE Fissile	CLAYSTONE Mostly clay			Calcilutite		Very fine-grained TUFF	
Amorphous or crypto-crystalline				Flint: occurs as hands of nodules in the chalk Chert: occurs as nodules and beds in limestone and calcareous sandstone							COAL LIGNITE
				Granular cemented – except amorphous rocks							
				SILICEOUS		CALCAREOUS				SILICEOUS	CARBONACEOUS
				SEDIMENTARY ROCKS Granular cemented rocks vary greatly in strength, some sandstones are stronger than many Igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils Calcareous rocks contain calcite (calcium carbonate) which effervesces with dilute hydrochloric acid						

AS1726 – Identification of Metamorphic and Igneous Rocks for Engineering Purposes

Obviously foliated rocks (mostly metamorphic)		Rocks with massive structure and crystalline texture (mostly igneous)						Grain size (mm)
Grain size description			Grain size description	Pegmatite			Pyrosenite	More than 20
		MARBLE						20
COARSE	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands	QUARTZITE	COARSE	GRANITE	Diorite	GABBRO	Peridorite	6
	Migmatite Irregularly foliated: mixed schists and gneisses	Granulite HORNFELS		These rocks are sometimes phorphyritic and are then described, for example, as porphyritic granite				2
MEDIUM	SCHIST Well developed undulose foliation; generally much mica	Amphibolite	MEDIUM	Micorgranite	Microdiorite	Dolerite		0.6
		Serpentine		These rocks are sometimes phorphyritic and are then described as porphyries				0.2
								0.06
FINE	PHYLLITE Slightly undulose foliation; sometimes 'spotted'		FINE	RHYOLITE	ANDESITE	BASALT		0.002
	SLATE Well developed plane cleavage (foliation)			These rocks are sometimes phorphyritic and are then described as porphyries				Less than 0.002
	Mylonite Found in fault zones, mainly in igneous and metamorphic areas			Obsidian	Volcanic glass			Amorphous or cryptocrystalline
CRYSTALLINE				Pale<----------->Dark				
SILICEOUS		Mainly SILICEOUS		ACID Much quartz	INTERMEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC	
METAMORPHIC ROCKS Most metamorphic rocks are distinguished by foliation which may impart fissility. Foliation in gneisses is best observed in outcrop. Non-foliated metamorphics are difficult to recognize except by association. Any rock baked by contact metamorphism is described as 'hornfels' and is generally somewhat stronger than the parent rock Most fresh metamorphic rocks are strong although perhaps fissile			IGNEOUS ROCKS Composed of closely interlocking mineral grains. Strong when fresh; not porous Mode of occurrence : 1 Batholith; 2 Laccoliths; 3 Sills; 4 Dykes; 5 Lava Flows; 6 Veins					

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Indra Jworchan
Client	Geotechnique
Address	P.O. Box 880 NSW 2751
Telephone	02 4722 2700
Facsimile	02 4722 6161
Email	indra.jworchan@geotech.com.au
Project	**13787-1 23-27 Warriewood Road Warriewood**
Order Number	(Not specified)
Samples	19

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE155019 R0**
Date Received	20/7/2016
Date Reported	29/7/2016

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(4354).

SIGNATORIES

Dong Liang
Metals/Inorganics Team Leader

Ly Kim Ha
Organic Section Head

Conductivity and TDS by Calculation - Soil [AN106] Tested: 28/7/2016

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL - 18/7/2016 SE155019.001	BH1 2.0-2.45 SOIL - 18/7/2016 SE155019.002	BH1 3.5-3.95 SOIL - 18/7/2016 SE155019.003	BH1 5.0-5.45 SOIL - 18/7/2016 SE155019.004	BH1 6.5-6.95 SOIL - 18/7/2016 SE155019.005
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	37	61	49	85	170

PARAMETER	UOM	LOR	BH1 8.0-8.45 SOIL - 18/7/2016 SE155019.006	BH4 1.0-1.45 SOIL - 18/7/2016 SE155019.007	BH4 3.0-3.45 SOIL - 18/7/2016 SE155019.008	BH4 5.0-5.45 SOIL - 18/7/2016 SE155019.009	BH4 6.5-6.95 SOIL - 18/7/2016 SE155019.010
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	180	74	65	160	86

PARAMETER	UOM	LOR	BH6 0.5-0.95 SOIL - 18/7/2016 SE155019.011	BH6 1.5-1.95 SOIL - 18/7/2016 SE155019.012	BH6 3.0-3.45 SOIL - 18/7/2016 SE155019.013	BH6 4.5-4.95 SOIL - 18/7/2016 SE155019.014	BH6 6.0-6.45 SOIL - 18/7/2016 SE155019.015
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	220	140	76	94	120

PARAMETER	UOM	LOR	BH6 7.5-7.95 SOIL - 18/7/2016 SE155019.016	BH8 3.0-3.5 SOIL - 18/7/2016 SE155019.017	BH8 5.0-5.5 SOIL - 18/7/2016 SE155019.018	BH8 8.9-9.0 SOIL - 18/7/2016 SE155019.019
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	85	47	47	100

pH in soil (1:2) [AN101] Tested: 28/7/2016

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL - 18/7/2016 SE155019.001	BH1 2.0-2.45 SOIL - 18/7/2016 SE155019.002	BH1 3.5-3.95 SOIL - 18/7/2016 SE155019.003	BH1 5.0-5.45 SOIL - 18/7/2016 SE155019.004	BH1 6.5-6.95 SOIL - 18/7/2016 SE155019.005
pH (1:2)	pH Units	-	6.7	4.6	4.6	4.9	4.6

PARAMETER	UOM	LOR	BH1 8.0-8.45 SOIL - 18/7/2016 SE155019.006	BH6 1.5-1.95 SOIL - 18/7/2016 SE155019.012	BH6 3.0-3.45 SOIL - 18/7/2016 SE155019.013	BH6 4.5-4.95 SOIL - 18/7/2016 SE155019.014	BH6 6.0-6.45 SOIL - 18/7/2016 SE155019.015
pH (1:2)	pH Units	-	4.8	4.8	4.9	4.9	4.7

PARAMETER	UOM	LOR	BH6 7.5-7.95 SOIL - 18/7/2016 SE155019.016	BH8 3.0-3.5 SOIL - 18/7/2016 SE155019.017	BH8 5.0-5.5 SOIL - 18/7/2016 SE155019.018	BH8 8.9-9.0 SOIL - 18/7/2016 SE155019.019
pH (1:2)	pH Units	-	5.1	5.1	5.1	5.0

Conductivity (1:2) in soil [AN106] Tested: 28/7/2016

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL - 18/7/2016 SE155019.001	BH1 2.0-2.45 SOIL - 18/7/2016 SE155019.002	BH1 3.5-3.95 SOIL - 18/7/2016 SE155019.003	BH1 5.0-5.45 SOIL - 18/7/2016 SE155019.004	BH1 6.5-6.95 SOIL - 18/7/2016 SE155019.005
Conductivity (1:2) @25 C*	µS/cm	1	60	73	68	120	270
Resistivity (1:2)*	ohm cm	-	17000	14000	15000	8100	3700

PARAMETER	UOM	LOR	BH1 8.0-8.45 SOIL - 18/7/2016 SE155019.006	BH6 1.5-1.95 SOIL - 18/7/2016 SE155019.012	BH6 3.0-3.45 SOIL - 18/7/2016 SE155019.013	BH6 4.5-4.95 SOIL - 18/7/2016 SE155019.014	BH6 6.0-6.45 SOIL - 18/7/2016 SE155019.015
Conductivity (1:2) @25 C*	µS/cm	1	250	200	120	150	170
Resistivity (1:2)*	ohm cm	-	4000	5000	8200	6900	6000

PARAMETER	UOM	LOR	BH6 7.5-7.95 SOIL - 18/7/2016 SE155019.016	BH8 3.0-3.5 SOIL - 18/7/2016 SE155019.017	BH8 5.0-5.5 SOIL - 18/7/2016 SE155019.018	BH8 8.9-9.0 SOIL - 18/7/2016 SE155019.019
Conductivity (1:2) @25 C*	µS/cm	1	130	56	58	140
Resistivity (1:2)*	ohm cm	-	7800	18000	17000	6900

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography [AN245] Tested: 26/7/2016

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL - 18/7/2016 SE155019.001	BH1 2.0-2.45 SOIL - 18/7/2016 SE155019.002	BH1 3.5-3.95 SOIL - 18/7/2016 SE155019.003	BH1 5.0-5.45 SOIL - 18/7/2016 SE155019.004	BH1 6.5-6.95 SOIL - 18/7/2016 SE155019.005
Chloride	mg/kg	0.25	5.9	6.0	7.5	15	110
Sulphate	mg/kg	0.5	20	46	50	87	100

PARAMETER	UOM	LOR	BH1 8.0-8.45 SOIL - 18/7/2016 SE155019.006	BH6 1.5-1.95 SOIL - 18/7/2016 SE155019.012	BH6 3.0-3.45 SOIL - 18/7/2016 SE155019.013	BH6 4.5-4.95 SOIL - 18/7/2016 SE155019.014	BH6 6.0-6.45 SOIL - 18/7/2016 SE155019.015
Chloride	mg/kg	0.25	130	61	21	19	22
Sulphate	mg/kg	0.5	89	100	100	100	140

PARAMETER	UOM	LOR	BH6 7.5-7.95 SOIL - 18/7/2016 SE155019.016	BH8 3.0-3.5 SOIL - 18/7/2016 SE155019.017	BH8 5.0-5.5 SOIL - 18/7/2016 SE155019.018	BH8 8.9-9.0 SOIL - 18/7/2016 SE155019.019
Chloride	mg/kg	0.25	24	2.5	7.7	25
Sulphate	mg/kg	0.5	89	46	48	120

Moisture Content [AN002] Tested: 26/7/2016

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL - 18/7/2016 SE155019.001	BH1 2.0-2.45 SOIL - 18/7/2016 SE155019.002	BH1 3.5-3.95 SOIL - 18/7/2016 SE155019.003	BH1 5.0-5.45 SOIL - 18/7/2016 SE155019.004	BH1 6.5-6.95 SOIL - 18/7/2016 SE155019.005
% Moisture	%w/w	0.5	11.4	17.9	15.0	16.9	20.1

PARAMETER	UOM	LOR	BH1 8.0-8.45 SOIL - 18/7/2016 SE155019.006	BH4 1.0-1.45 SOIL - 18/7/2016 SE155019.007	BH4 3.0-3.45 SOIL - 18/7/2016 SE155019.008	BH4 5.0-5.45 SOIL - 18/7/2016 SE155019.009	BH4 6.5-6.95 SOIL - 18/7/2016 SE155019.010
% Moisture	%w/w	0.5	22.2	14.2	16.2	17.0	9.7

PARAMETER	UOM	LOR	BH6 0.5-0.95 SOIL - 18/7/2016 SE155019.011	BH6 1.5-1.95 SOIL - 18/7/2016 SE155019.012	BH6 3.0-3.45 SOIL - 18/7/2016 SE155019.013	BH6 4.5-4.95 SOIL - 18/7/2016 SE155019.014	BH6 6.0-6.45 SOIL - 18/7/2016 SE155019.015
% Moisture	%w/w	0.5	18.6	14.7	17.9	14.7	14.8

PARAMETER	UOM	LOR	BH6 7.5-7.95 SOIL - 18/7/2016 SE155019.016	BH8 3.0-3.5 SOIL - 18/7/2016 SE155019.017	BH8 5.0-5.5 SOIL - 18/7/2016 SE155019.018	BH8 8.9-9.0 SOIL - 18/7/2016 SE155019.019
% Moisture	%w/w	0.5	15.7	15.3	16.8	18.8

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:2 and the pH determined and reported on the extract after 1 hour extraction (pH 1:2) or after 1 hour extraction and overnight aging (pH (1:2) aged). Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos /cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2510 B.
AN106	Resistivity of the extract is reported on the extract basis and is the reciprocal of conductivity. Salinity and TDS can be calculated from the extract conductivity and is reported back to the soil basis.
AN245	Anions by Ion Chromatography: A water sample or extract is injected into an eluent stream that passes through the ion chromatographic system where the anions of interest ie Br, Cl, NO2, NO3 and SO4 are separated on their relative affinities for the active sites on the column packing material. Changes to the conductivity and the UV-visible absorbance of the eluent enable identification and quantitation of the anions based on their retention time and peak height or area. APHA 4110 B

FOOTNOTES

*	NATA accreditation does not cover the performance of this service.	-	Not analysed.	UOM	Unit of Measure.
		NVL	Not validated.	LOR	Limit of Reporting.
**	Indicative data, theoretical holding time exceeded.	IS	Insufficient sample for analysis.	↑↓	Raised/lowered Limit of Reporting.
		LNR	Sample listed, but not received.		

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical Documents/MP-AU-ENV-QU-022 QA QC Plan.pdf

STATEMENT OF QA/QC PERFORMANCE

SE155019 R0

CLIENT DETAILS

Contact	Indra Jworchan
Client	Geotechnique
Address	P.O. Box 880 NSW 2751
Telephone	02 4722 2700
Facsimile	02 4722 6161
Email	indra.jworchan@geotech.com.au
Project	**13787-1 23-27 Warriewood Road Warriewood**
Order Number	(Not specified)
Samples	19

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE155019 R0**
Date Received	20 Jul 2016
Date Reported	29 Jul 2016

COMMENTS

All the laboratory data for each environmental matrix was compared to SGS' stated Data Quality Objectives (DQO). Comments arising from the comparison were made and are reported below.

The data relating to sampling was taken from the Chain of Custody document and was supplied by the Client.
This QA/QC Statement must be read in conjunction with the referenced Analytical Report.
The Statement and the Analytical Report must not be reproduced except in full.

All Data Quality Objectives were met with the exception of the following:

Extraction Date	Conductivity (1:2) in soil	14 items
	Conductivity and TDS by Calculation - Soil	19 items
	pH in soil (1:2)	14 items
	Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography	14 items
Analysis Date	Conductivity (1:2) in soil	14 items
	Conductivity and TDS by Calculation - Soil	19 items

SAMPLE SUMMARY

Sample counts by matrix	19 Soils	Type of documentation received	COC
Date documentation received	22/7/16 @ 11.27am	Samples received in good order	Yes
Samples received without headspace	N/A	Sample temperature upon receipt	16.8°C
Sample container provider	SGS	Turnaround time requested	Standard
Samples received in correct containers	Yes	Sufficient sample for analysis	Yes
Sample cooling method	None	Samples clearly labelled	Yes
Complete documentation received	Yes		

HOLDING TIME SUMMARY

SE155019 R0

SGS holding time criteria are drawn from current regulations and are highly dependent on sample container preservation as specified in the SGS “Field Sampling Guide for Containers and Holding Time” (ref: GU-(AU)-ENV.001). Soil samples guidelines are derived from NEPM "Schedule B(3) Guideline on Laboratory Analysis of Potentially Contaminated Soils". Water sample guidelines are derived from "AS/NZS 5667.1 : 1998 Water Quality - sampling part 1" and APHA "Standard Methods for the Examination of Water and Wastewater" 21st edition 2005.

Extraction and analysis holding time due dates listed are calculated from the date sampled, although holding times may be extended after laboratory extraction for some analytes. The due dates are the suggested dates that samples may be held before extraction or analysis and still be considered valid.

Extraction and analysis dates are shown in **Green** when within suggested criteria or **Red** with an appended dagger symbol (†) when outside suggested criteria. If the sampled date is not supplied then compliance with criteria cannot be determined. If the received date is after one or both due dates then holding time will fail by default.

Conductivity (1:2) in soil

Method: ME-(AU)-[ENV]AN106

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH1 0.5-0.95	SE155019.001	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 2.0-2.45	SE155019.002	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 3.5-3.95	SE155019.003	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 5.0-5.45	SE155019.004	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 6.5-6.95	SE155019.005	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 8.0-8.45	SE155019.006	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 1.5-1.95	SE155019.012	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 3.0-3.45	SE155019.013	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 4.5-4.95	SE155019.014	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 6.0-6.45	SE155019.015	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 7.5-7.95	SE155019.016	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH8 3.0-3.5	SE155019.017	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH8 5.0-5.5	SE155019.018	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH8 8.9-9.0	SE155019.019	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†

Conductivity and TDS by Calculation - Soil

Method: ME-(AU)-[ENV]AN106

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH1 0.5-0.95	SE155019.001	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 2.0-2.45	SE155019.002	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 3.5-3.95	SE155019.003	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 5.0-5.45	SE155019.004	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 6.5-6.95	SE155019.005	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH1 8.0-8.45	SE155019.006	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH4 1.0-1.45	SE155019.007	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH4 3.0-3.45	SE155019.008	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH4 5.0-5.45	SE155019.009	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH4 6.5-6.95	SE155019.010	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 0.5-0.95	SE155019.011	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 1.5-1.95	SE155019.012	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 3.0-3.45	SE155019.013	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 4.5-4.95	SE155019.014	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 6.0-6.45	SE155019.015	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH6 7.5-7.95	SE155019.016	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH8 3.0-3.5	SE155019.017	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH8 5.0-5.5	SE155019.018	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†
BH8 8.9-9.0	SE155019.019	LB106404	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	25 Jul 2016	29 Jul 2016†

Moisture Content

Method: ME-(AU)-[ENV]AN002

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH1 0.5-0.95	SE155019.001	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH1 2.0-2.45	SE155019.002	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH1 3.5-3.95	SE155019.003	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH1 5.0-5.45	SE155019.004	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH1 6.5-6.95	SE155019.005	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH1 8.0-8.45	SE155019.006	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH4 1.0-1.45	SE155019.007	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH4 3.0-3.45	SE155019.008	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH4 5.0-5.45	SE155019.009	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH4 6.5-6.95	SE155019.010	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH6 0.5-0.95	SE155019.011	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH6 1.5-1.95	SE155019.012	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH6 3.0-3.45	SE155019.013	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH6 4.5-4.95	SE155019.014	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH6 6.0-6.45	SE155019.015	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH6 7.5-7.95	SE155019.016	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH8 3.0-3.5	SE155019.017	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH8 5.0-5.5	SE155019.018	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016
BH8 8.9-9.0	SE155019.019	LB106180	18 Jul 2016	20 Jul 2016	01 Aug 2016	26 Jul 2016	31 Jul 2016	29 Jul 2016

pH in soil (1:2)

Method: ME-(AU)-[ENV]AN101

Sample Name	Sample No.	QC Ref

HOLDING TIME SUMMARY

SE155019 R0

SGS holding time criteria are drawn from current regulations and are highly dependent on sample container preservation as specified in the SGS “Field Sampling Guide for Containers and Holding Time” (ref: GU-(AU)-ENV.001). Soil samples guidelines are derived from NEPM "Schedule B(3) Guideline on Laboratory Analysis of Potentially Contaminated Soils". Water sample guidelines are derived from "AS/NZS 5667.1 : 1998 Water Quality - sampling part 1" and APHA "Standard Methods for the Examination of Water and Wastewater" 21st edition 2005.

Extraction and analysis holding time due dates listed are calculated from the date sampled, although holding times may be extended after laboratory extraction for some analytes. The due dates are the suggested dates that samples may be held before extraction or analysis and still be considered valid.

Extraction and analysis dates are shown in **Green** when within suggested criteria or **Red** with an appended dagger symbol (†) when outside suggested criteria. If the sampled date is not supplied then compliance with criteria cannot be determined. If the received date is after one or both due dates then holding time will fail by default.

pH in soil (1:2) (continued)

Method: ME-(AU)-[ENV]AN101

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH1 0.5-0.95	SE155019.001	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH1 2.0-2.45	SE155019.002	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH1 3.5-3.95	SE155019.003	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH1 5.0-5.45	SE155019.004	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH1 6.5-6.95	SE155019.005	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH1 8.0-8.45	SE155019.006	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH6 1.5-1.95	SE155019.012	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH6 3.0-3.45	SE155019.013	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH6 4.5-4.95	SE155019.014	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH6 6.0-6.45	SE155019.015	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH6 7.5-7.95	SE155019.016	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH8 3.0-3.5	SE155019.017	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH8 5.0-5.5	SE155019.018	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016
BH8 8.9-9.0	SE155019.019	LB106415	18 Jul 2016	20 Jul 2016	25 Jul 2016	28 Jul 2016†	29 Jul 2016	29 Jul 2016

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography

Method: ME-(AU)-[ENV]AN245

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH1 0.5-0.95	SE155019.001	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH1 2.0-2.45	SE155019.002	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH1 3.5-3.95	SE155019.003	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH1 5.0-5.45	SE155019.004	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH1 6.5-6.95	SE155019.005	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH1 8.0-8.45	SE155019.006	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH6 1.5-1.95	SE155019.012	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH6 3.0-3.45	SE155019.013	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH6 4.5-4.95	SE155019.014	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH6 6.0-6.45	SE155019.015	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH6 7.5-7.95	SE155019.016	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH8 3.0-3.5	SE155019.017	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH8 5.0-5.5	SE155019.018	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016
BH8 8.9-9.0	SE155019.019	LB106253	18 Jul 2016	20 Jul 2016	25 Jul 2016	26 Jul 2016†	23 Aug 2016	29 Jul 2016

Surrogate results are evaluated against upper and lower limit criteria established in the SGS QA /QC plan (Ref: MP-(AU)-[ENV]QU-022). At least two of three routine level soil sample surrogate spike recoveries for BTEX/VOC are to be within 70-130% where control charts have not been developed and within the established control limits for charted surrogates. Matrix effects may void this as an acceptance criterion. Water sample surrogate spike recoveries are to be within 40-130%. The presence of emulsions, surfactants and particulates may void this as an acceptance criterion.

Result is shown in **Green** when within suggested criteria or **Red** with an appended reason identifer when outside suggested criteria. Refer to the footnotes section at the end of this report for failure reasons.

No surrogates were required for this job.

Blank results are evaluated against the limit of reporting (LOR), for the chosen method and its associated instrumentation, typically 2.5 times the statistically determined method detection limit (MDL).

Result is shown in **Green** when within suggested criteria or **Red** with an appended dagger symbol (†) when outside suggested criteria.

Conductivity (1:2) in soil

Method: ME-(AU)-[ENV]AN106

Sample Number	Parameter	Units	LOR	Result
LB106415.001	Conductivity (1:2) @25 C*	µS/cm	1	<1

Conductivity and TDS by Calculation - Soil

Method: ME-(AU)-[ENV]AN106

Sample Number	Parameter	Units	LOR

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography

Method: ME-(AU)-[ENV]AN245

Sample Number	Parameter	Units	LOR

Duplicates are calculated as Relative Percentage Difference (RPD) using the formula: RPD = | OriginalResult - ReplicateResult | x 100 / Mean

The RPD is evaluated against the Maximum Allowable Difference (MAD) criteria and can be graphically represented by a curve calculated from the Statistical Detection Limit (SDL) and Limiting Repeatability (LR) using the formula: MAD = 100 x SDL / Mean + LR

Where the Maximum Allowable Difference evaluates to a number larger than 200 it is displayed as 200.

RPD is shown in **Green** when within suggested criteria or **Red** with an appended reason identifer when outside suggested criteria. Refer to the footnotes section at the end of this report for failure reasons.

Conductivity (1:2) in soil

Method: ME-(AU)-[ENV]AN106

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
SE155019.006	LB106415.010	Conductivity (1:2) @25 C*	µS/cm	1	250	249	31	1
		Resistivity (1:2)*	ohm cm	-	4000	)16.06425702E	15	1
SE155019.019	LB106415.020	Conductivity (1:2) @25 C*	µS/cm	1	140	150	31	3
		Resistivity (1:2)*	ohm cm	-	6900	6700	15	3

Conductivity and TDS by Calculation - Soil

Method: ME-(AU)-[ENV]AN106

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
SE155019.009	LB106404.014	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	160	53.285256222	31	5
SE155019.019	LB106404.025	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	100	03.590276243	32	2

Moisture Content

Method: ME-(AU)-[ENV]AN002

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
SE155019.009	LB106180.011	% Moisture	%w/w	0.5	17.0	17.8	36	5
SE155019.019	LB106180.022	% Moisture	%w/w	0.5	18.8	18.7	35	1
SE155053.010	LB106180.033	% Moisture	%w/w	0.5	9.79443772679	.5872170439	40	2
SE155053.025	LB106180.044	% Moisture	%w/w	0.5	10.2230483271	9.4311377245	40	8
SE155053.027	LB106180.046	% Moisture	%w/w	0.5	0	0	200	0

pH in soil (1:2)

Method: ME-(AU)-[ENV]AN101

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
SE155019.006	LB106415.010	pH (1:2)	pH Units	-	4.8	4.78	32	0
SE155019.019	LB106415.020	pH (1:2)	pH Units	-	5.0	5.0	32	1

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography

Method: ME-(AU)-[ENV]AN245

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
SE155019.006	LB106253.009	Chloride	mg/kg	0.25	130	35.8623968561	30	4
		Sulphate	mg/kg	0.5	89	96.1598428290	32	8
SE155019.019	LB106253.018	Chloride	mg/kg	0.25	25	24.6655248618	31	2
		Sulphate	mg/kg	0.5	120	19.5822099447	32	2

Laboratory Control Standard (LCS) results are evaluated against an expected result, typically the concentration of analyte spiked into the control during the sample preparation stage, producing a percentage recovery. The criteria applied to the percentage recovery is established in the SGS QA /QC plan (Ref: MP-(AU)-[ENV]QU-022). For more information refer to the footnotes in the concluding page of this report.

Recovery is shown in **Green** when within suggested criteria or **Red** with an appended dagger symbol (†) when outside suggested criteria.

Conductivity (1:2) in soil

Method: ME-(AU)-[ENV]AN106

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB106415.002	Conductivity (1:2) @25 C*	µS/cm	1	300	303	85 - 115	100

Conductivity and TDS by Calculation - Soil

Method: ME-(AU)-[ENV]AN106

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB106404.002	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	NA	303	85 - 115	100

pH in soil (1:2)

Method: ME-(AU)-[ENV]AN101

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB106415.003	pH (1:2)	pH Units	-	7.4	7.415	98 - 102	99

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography

Method: ME-(AU)-[ENV]AN245

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB106253.002	Chloride	mg/kg	0.25	NA	40	70 - 130	92
	Sulphate	mg/kg	0.5	NA	40	70 - 130	96

Matrix Spike (MS) results are evaluated as the percentage recovery of an expected result, typically the concentration of analyte spiked into a field sub -sample during the sample preparation stage. The original sample's result is subtracted from the sub-sample result before determining the percentage recovery. The criteria applied to the percentage recovery is established in the SGS QA/QC plan (ref: MP-(AU)-[ENV]QU-022). For more information refer to the footnotes in the concluding page of this report.

Recovery is shown in **Green** when within suggested criteria or **Red** with an appended reason identifer when outside suggested criteria. Refer to the footnotes section at the end of this report for failure reasons.

No matrix spikes were required for this job.

MATRIX SPIKE DUPLICATES

SE155019 R0

Matrix spike duplicates are calculated as Relative Percent Difference (RPD) using the formula: RPD = | OriginalResult - ReplicateResult | x 100 / Mean

The original result is the analyte concentration of the matrix spike. The Duplicate result is the analyte concentration of the matrix spike duplicate.

The RPD is evaluated against the Maximum Allowable Difference (MAD) criteria and can be graphically represented by a curve calculated from the Statistical Detection Limit (SDL) and Limiting Repeatability (LR) using the formula: MAD = 100 x SDL / Mean + LR

Where the Maximum Allowable Difference evaluates to a number larger than 200 it is displayed as 200.

RPD is shown in **Green** when within suggested criteria or **Red** with an appended reason identifer when outside suggested criteria. Refer to the footnotes section at the end of this report for failure reasons.

No matrix spike duplicates were required for this job.

Samples analysed as received.

Solid samples expressed on a dry weight basis.

QC criteria are subject to internal review according to the SGS QA/QC plan and may be provided on request or alternatively can be found here: http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical Documents/MP-AU-ENV-QU-022 QA QC Plan.pdf

*	NATA accreditation does not cover tthe performance of this service.
-	Sample not analysed for this analyte.

IS	Insufficient sample for analysis.
LNR	Sample listed, but not received.
LOR	Limit of reporting.
QFH	QC result is above the upper tolerance.
QFL	QC result is below the lower tolerance.

①	At least 2 of 3 surrogates are within acceptance criteria.
②	RPD failed acceptance criteria due to sample heterogeneity.
③	Results less than 5 times LOR preclude acceptance criteria for RPD.
④	Recovery failed acceptance criteria due to matrix interference.
⑤	Recovery failed acceptance criteria due to the presence of significant concentration of analyte (i.e. the concentration of analyte exceeds the spike level).
⑥	LOR was raised due to sample matrix interference.
⑦	LOR was raised due to dilution of significantly high concentration of analyte in sample.
⑧	Reanalysis of sample in duplicate confirmed sample heterogeneity and inconsistency of results.
⑨	Recovery failed acceptance criteria due to sample heterogeneity.
⑩	LOR was raised due to high conductivity of the sample (required dilution).
†	Refer to Analytical Report comments for further information.

22/7/16 @ 11.27 a

GEOTECHNIQUE PTY LTD

Laboratory Test Request / Chain of Custody Record

Lemko Place
PENRITH NSW 2750

P O Box 880
PENRITH NSW 2751

Tel: (02) 4722 2700
Fax: (02) 4722 6161
email: info@geotech.com.au

Page 1

TO:	SGS ENVIRONMENTAL SERVICES UNIT 16 33 MADDOX STREET ALEXANDRIA NSW 2015	Sampling By: AP	Job No: 13787/1 Project: Proposed Residential Aged Care Facility
PH:	02 8594 0400 FAX: 02 8594 0499	Project Manager: IJ	Location: 23-27 Warriewood Road, Warriewood
ATTN:	Ms Emily Yin		

Sampling details / **Results required by:**

	Location	Depth (m)	Soil	Water	EC(1:5)	Aggressivity							Notes	Keep Sample
1	BH1	0.5-0.95	DSP		✓	✓							Aggressivity test includes pH	
2		2.0-2.45	DSP		✓	✓							chloride, sulphate and resistivity	
3		3.5-3.95	DSP		✓	✓								
4		5.0-5.45	DSP		✓	✓								
5		6.5-6.95	DSP		✓	✓								
6		8.0-8.45	DSP		✓	✓								
	BH2	0.5-0.95	DSP											
		2.0-2.45	DSP											
		5.0-5.45	DSP											
	BH3	0.5-0.95	DSP											
		2.5-2.95	DSP											
		5.5-5.95	DSP											
		8.0-8.5	DSP											
7	BH4	1.0-1.45	DSP		✓									
8		3.0-3.45	DSP		✓									
9		5.0-5.45	DSP		✓									
10		6.5-6.95	DSP		✓									

SGS Alexandria Environmental
SE155019 COC
Received: 20-Jul-2016

Relinquished by Name	Signature	Date	Received by Name	Signature	Date
Indra Jworchan		18-Jul-16	Hamish	HG	20/7 2pm

Legend:

WG	USG	Undisturbed soil sample (glass	DSP	Disturbed soil sample (small plastic bag)	* Purge & Trap
WP	DSG	Disturbed soil sample (glass ja	✓	Test required	# Geotechnique Screen

Form No 4.7F2-5 SGS

GEOTECHNIQUE PTY LTD

Laboratory Test Request / Chain of Custody Record

Lemko Place
PENRITH NSW 2750

P O Box 880
PENRITH NSW 2751

Tel: (02) 4722 2700
Fax: (02) 4722 6161
email: info@geotech.com.au

TO:	SGS ENVIRONMENTAL SERVICES UNIT 16 33 MADDOX STREET ALEXANDRIA NSW 2015	Sampling By:	AP
		Job No:	13787/1
		Project:	Proposed Residential Aged Care Facility
PH:	02 8594 0400	FAX:	02 8594 0499
ATTN:	Ms Emily Yin	Project Manager:	IJ
		Location:	23-27 Warriewood Road, Warriewood

Sampling details				Results required by:									
Location	Depth (m)	Soil	Water	EC(1:5)	Aggressivity							Notes	Keep Sample
BH5	1.0-1.45	DSP										Aggressivity test includes pH	
	2.5-2.95	DSP										chloride, sulphate and resistivity	
	3.5-4.0	DSP											
	5.0-5.45	DSP											
	7.0-7.5	DSP											
11 BH6	0.5-0.95	DSP		✓									
12	1.5-1.95	DSP		✓	✓								
13	3.0-3.45	DSP		✓	✓								
14	4.5-4.95	DSP		✓	✓								
15	6.0-6.45	DSP		✓	✓								
16	7.5-7.95	DSP		✓	✓								
BH7	0.5-1.0	DSP											
	1.5-1.95	DSP											
	3.0-3.45	DSP											
	4.5-4.95	DSP											
	6.0-6.45	DSP											
	7.5-7.95	DSP											

Relinquished by			Received by		
Name	Signature	Date	Name	Signature	
Indra Jworchan		18-Jul-16	Hamish	HS	20/7 8pm

Legend:

WG	USG	Undisturbed soil sample (glass	DSP	Disturbed soil sample (small plastic bag)	* Purge & Trap
WP	DSG	Disturbed soil sample (glass ja	✓	Test required	# Geotechnique Screen

GEOTECHNIQUE PTY LTD

Laboratory Test Request / Chain of Custody Record

Lemko Place
PENRITH NSW 2750

P O Box 880
PENRITH NSW 2751

Tel: (02) 4722 2700
Fax: (02) 4722 6161
email: info@geotech.com.au

TO:	**SGS ENVIRONMENTAL SERVICES** **UNIT 16** **33 MADDOX STREET** **ALEXANDRIA NSW 2015**	**Sampling By:** AP	**Job No:** 13787/1
			Project: Proposed Residential Aged Care Facility
PH:	**02 8594 0400** **FAX:** **02 8594 0499**	**Project Manager:** IJ	**Location:** 23-27 Warriewood Road, Warriewood
ATTN:	**Ms Emily Yin**		

	Sampling details				Results required by:								
	Location	**Depth (m)**	**Soil**	**Water**	**EC(1:5)**	**Aggresivity**						**Notes**	**Keep Sample**
17	BH8	3.0-3.5	DSP		✓	✓						Aggressivity test includes pH	
18		5.0-5.5	DSP		✓	✓						chloride, sulphate and resistivity	
19		8.9-9.0	DSP		✓	✓							

Relinquished by			Received by		
Name	Signature	Date	Name	Signature	
Indra Jworchan		18-Jul-16	Hamish	HS	20/7 2pm

Legend:

WG	USG	Undisturbed soil sample (glass	DSP	Disturbed soil sample (small plastic bag)	* Purge & Trap
WP	DSG	Disturbed soil sample (glass ja	✓	Test required	# Geotechnique Screen

SAMPLE RECEIPT ADVICE

SE155019

CLIENT DETAILS

Contact	Indra Jworchan
Client	Geotechnique
Address	P.O. Box 880 NSW 2751
Telephone	02 4722 2700
Facsimile	02 4722 6161
Email	indra.jworchan@geotech.com.au
Project	**13787-1 23-27 Warriewood Road Warriewood**
Order Number	(Not specified)
Samples	19

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
Samples Received	Wed 20/7/2016
Report Due	Fri 29/7/2016
SGS Reference	**SE155019**

SUBMISSION DETAILS

This is to confirm that 19 samples were received on Wednesday 20/7/2016. Results are expected to be ready by Friday 29/7/2016. Please quote SGS reference SE155019 when making enquiries. Refer below for details relating to sample integrity upon receipt.

Sample counts by matrix	19 Soils	Type of documentation received	COC
Date documentation received	22/7/16 @ 11.27am	Samples received in good order	Yes
Samples received without headspace	N/A	Sample temperature upon receipt	16.8°C
Sample container provider	SGS	Turnaround time requested	Standard
Samples received in correct containers	Yes	Sufficient sample for analysis	Yes
Sample cooling method	None	Samples clearly labelled	Yes
Complete documentation received	Yes		

Unless otherwise instructed, water and bulk samples will be held for one month from date of report, and soil samples will be held for two months.

COMMENTS

18 soil samples, which were not marked for analyses on the COC, have been placed on hold.

SAMPLE RECEIPT ADVICE

SE155019

CLIENT DETAILS

Client Geotechnique

Project 13787-1 23-27 Warriewood Road Warriewood

SUMMARY OF ANALYSIS

No.	Sample ID	Conductivity (1:2) in soil	Conductivity and TDS by Calculation - Soil	Moisture Content	pH in soil (1:2)	Soluble Anions in Soil from 1:2 DI Extract by Ion
001	BH1 0.5-0.95	2	1	1	1	2
002	BH1 2.0-2.45	2	1	1	1	2
003	BH1 3.5-3.95	2	1	1	1	2
004	BH1 5.0-5.45	2	1	1	1	2
005	BH1 6.5-6.95	2	1	1	1	2
006	BH1 8.0-8.45	2	1	1	1	2
007	BH4 1.0-1.45	-	1	1	-	-
008	BH4 3.0-3.45	-	1	1	-	-
009	BH4 5.0-5.45	-	1	1	-	-
010	BH4 6.5-6.95	-	1	1	-	-
011	BH6 0.5-0.95	-	1	1	-	-
012	BH6 1.5-1.95	2	1	1	1	2
013	BH6 3.0-3.45	2	1	1	1	2
014	BH6 4.5-4.95	2	1	1	1	2
015	BH6 6.0-6.45	2	1	1	1	2
016	BH6 7.5-7.95	2	1	1	1	2
017	BH8 3.0-3.5	2	1	1	1	2
018	BH8 5.0-5.5	2	1	1	1	2
019	BH8 8.9-9.0	2	1	1	1	2

The above table represents SGS' interpretation of the client-supplied Chain Of Custody document.
The numbers shown in the table indicate the number of results requested in each package.
Please indicate as soon as possible should your request differ from these details .
Testing as per this table shall commence immediately unless the client intervenes with a correction .

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Indra Jworchan
Client	Geotechnique
Address	P.O. Box 880 NSW 2751
Telephone	02 8594 0400
Facsimile	02 8594 0499
Email	au.environmental.sydney@sgs.com
Project	**13787-1 23-27 Warriewood rd Warriewood**
Order Number	**SE154900**
Samples	6

LABORATORY DETAILS

Manager	Jon Dicker
Laboratory	SGS Cairns Environmental
Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	+61 07 4035 5111
Facsimile	+61 07 4035 5122
Email	AU.Environmental.Cairns@sgs.com
SGS Reference	**CE122159 R0**
Date Received	21 Jul 2016
Date Reported	27 Jul 2016

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(3146)

SIGNATORIES

Anthony Nilsson
Operations Manager

Jon Dicker
Manager Northern QLD

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE122159.001 Soil 18 Jul 2016 BH2 2.0-2.45	CE122159.002 Soil 18 Jul 2016 BH3 0.5-0.95	CE122159.003 Soil 18 Jul 2016 BH3 2.5-2.95	CE122159.004 Soil 18 Jul 2016 BH3 5.5-5.95
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 26/7/2016							
Chromium Reducible Sulphur (Scr)	%	0.005		<0.005	<0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5		<5	<5	<5	<5
Moisture Content Method: AN002 Tested: 21/7/2016							
% Moisture	%w/w	0.5		**14**	**16**	**14**	**14**
TAA (Titratable Actual Acidity) Method: AN219 Tested: 26/7/2016							
pH KCl	pH Units	-		**4.0**	**5.9**	**4.0**	**3.8**
Titratable Actual Acidity	kg H2SO4/T	0.25		**3.2**	**0.31**	**2.8**	**4.0**
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5		**65**	**6**	**57**	**82**
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01		**0.10**	**0.01**	**0.09**	**0.13**
Sulphur (SKCl)	%w/w	0.005		**0.027**	<0.005	**0.013**	**0.020**
Calcium (CaKCl)	%w/w	0.005		**0.020**	**0.13**	**0.007**	<0.005
Magnesium (MgKCl)	%w/w	0.005		**0.023**	**0.024**	**0.024**	**0.021**
TPA (Titratable Peroxide Acidity) Method: AN218 Tested: 26/7/2016							
Peroxide pH (pH Ox)	pH Units	-		**4.5**	**6.0**	**5.1**	**4.9**
TPA as kg H_2SO_4/tonne	kg H2SO4/T	0.25		**3.2**	<0.25	**2.8**	**4.3**
TPA as moles H+/tonne	moles H+/T	5		**65**	<5	**57**	**87**
TPA as S % W/W	%w/w S	0.01		**0.10**	<0.01	**0.09**	**0.14**
Titratable Sulfidic Acidity as moles H+/tonne	moles H+/T	5		<5	<5	<5	<5
Titratable Sulfidic Acidity as kg H_2SO_4/tonne	kg H2SO4/T	0.25		<0.25	<0.25	<0.25	<0.25
Titratable Sulfidic Acidity as S % W/W	%w/w S	0.01		<0.01	<0.01	<0.01	<0.01
ANCE as % $CaCO_3$	% CaCO3	0.01		<0.01	<0.01	<0.01	<0.01
ANCE as moles H+/tonne	moles H+/T	5		<5	<5	<5	<5
ANCE as S % W/W	%w/w S	0.01		<0.01	<0.01	<0.01	<0.01
Peroxide Oxidisable Sulphur (Spos)	%w/w	0.005		<0.005	<0.005	<0.005	<0.005
Peroxide Oxidisable Sulphur as moles H+/tonne	moles H+/T	5		<5	<5	<5	<5
Sulphur (Sp)	%w/w	0.005		**0.028**	<0.005	**0.014**	**0.023**
Calcium (Cap)	%w/w	0.005		**0.018**	**0.12**	**0.008**	<0.005
Reacted Calcium (CaA)	%w/w	0.005		<0.005	<0.005	<0.005	<0.005
Reacted Calcium (CaA)	moles H+/T	5		<5	<5	<5	<5
Magnesium (Mgp)	%w/w	0.005		**0.023**	**0.023**	**0.022**	**0.022**
Reacted Magnesium (MgA)	%w/w	0.005		<0.005	<0.005	<0.005	<0.005
Reacted Magnesium (MgA)	moles H+/T	5		<5	<5	<5	<5
Net Acid Soluble Sulphur as % w/w	%w/w	0.005		**0.072**	-	**0.020**	**0.008**
Net Acid Soluble Sulphur as moles H+/tonne	moles H+/T	5		**45**	-	**13**	**5**

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE122159.001 Soil 18 Jul 2016 BH2 2.0-2.45	CE122159.002 Soil 18 Jul 2016 BH3 0.5-0.95	CE122159.003 Soil 18 Jul 2016 BH3 2.5-2.95	CE122159.004 Soil 18 Jul 2016 BH3 5.5-5.95
HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 27/7/2016							
Acid Soluble Sulphur (SHCl)	%w/w	0.005		**0.099**	-	**0.033**	**0.029**
SPOCAS Net Acidity Calculations Method: AN220 Tested: 27/7/2016							
s-Net Acidity	%w/w S	0.01		**0.16**	**0.01**	**0.11**	**0.14**
a-Net Acidity	moles H+/T	5		**99**	**7**	**68**	**88**
Liming Rate	kg CaCO3/T	0.1		**7.4**	NA	**5.1**	**6.6**
Verification s-Net Acidity	%w/w S	-20		**0.00**	**0.00**	**0.00**	**0.00**
a-Net Acidity without ANCE	moles H+/T	5		**99**	**7**	**68**	**88**
Liming Rate without ANCE	kg CaCO3/T	0.1		**7.4**	NA	**5.1**	**6.6**

Parameter	Units	LOR	Sample Number: CE122159.005 Sample Matrix: Soil Sample Date: 18 Jul 2016 Sample Name: BH3 8.0-8.45	Sample Number: CE122159.006 Sample Matrix: Soil Sample Date: 18 Jul 2016 Sample Name: BH5 7.0-7.5
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 26/7/2016				
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5
Moisture Content Method: AN002 Tested: 21/7/2016				
% Moisture	%w/w	0.5	**15**	**14**
TAA (Titratable Actual Acidity) Method: AN219 Tested: 26/7/2016				
pH KCl	pH Units	-	**3.8**	**3.8**
Titratable Actual Acidity	kg H2SO4/T	0.25	**4.3**	**5.0**
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	**87**	**102**
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	**0.14**	**0.16**
Sulphur (SKCl)	%w/w	0.005	**0.013**	**0.016**
Calcium (CaKCl)	%w/w	0.005	<0.005	<0.005
Magnesium (MgKCl)	%w/w	0.005	**0.021**	**0.020**
TPA (Titratable Peroxide Acidity) Method: AN218 Tested: 26/7/2016				
Peroxide pH (pH Ox)	pH Units	-	**5.1**	**5.0**
TPA as kg H_2SO_4/tonne	kg H2SO4/T	0.25	**4.4**	**5.5**
TPA as moles H+/tonne	moles H+/T	5	**90**	**112**
TPA as S % W/W	%w/w S	0.01	**0.14**	**0.18**
Titratable Sulfidic Acidity as moles H+/tonne	moles H+/T	5	<5	**10**
Titratable Sulfidic Acidity as kg H_2SO_4/tonne	kg H2SO4/T	0.25	<0.25	**0.49**
Titratable Sulfidic Acidity as S % W/W	%w/w S	0.01	<0.01	**0.02**
ANCE as % $CaCO_3$	% CaCO3	0.01	<0.01	<0.01
ANCE as moles H+/tonne	moles H+/T	5	<5	<5
ANCE as S % W/W	%w/w S	0.01	<0.01	<0.01
Peroxide Oxidisable Sulphur (Spos)	%w/w	0.005	<0.005	<0.005
Peroxide Oxidisable Sulphur as moles H+/tonne	moles H+/T	5	<5	<5
Sulphur (Sp)	%w/w	0.005	**0.013**	**0.020**
Calcium (Cap)	%w/w	0.005	<0.005	<0.005
Reacted Calcium (CaA)	%w/w	0.005	<0.005	<0.005
Reacted Calcium (CaA)	moles H+/T	5	<5	<5
Magnesium (Mgp)	%w/w	0.005	**0.020**	**0.019**
Reacted Magnesium (MgA)	%w/w	0.005	<0.005	<0.005
Reacted Magnesium (MgA)	moles H+/T	5	<5	<5
Net Acid Soluble Sulphur as % w/w	%w/w	0.005	<0.005	**0.007**
Net Acid Soluble Sulphur as moles H+/tonne	moles H+/T	5	<5	<5

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE122159.005 Soil 18 Jul 2016 BH3 8.0-8.45	CE122159.006 Soil 18 Jul 2016 BH5 7.0-7.5
HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014 Tested: 27/7/2016					
Acid Soluble Sulphur (SHCl)	%w/w	0.005		**0.016**	**0.023**
SPOCAS Net Acidity Calculations Method: AN220 Tested: 27/7/2016					
s-Net Acidity	%w/w S	0.01		**0.14**	**0.17**
a-Net Acidity	moles H+/T	5		**89**	**110**
Liming Rate	kg CaCO3/T	0.1		**6.7**	**8.1**
Verification s-Net Acidity	%w/w S	-20		**0.00**	**0.00**
a-Net Acidity without ANCE	moles H+/T	5		**89**	**110**
Liming Rate without ANCE	kg CaCO3/T	0.1		**6.7**	**8.1**

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Chromium Reducible Sulphur (CRS) **Method: ME-(AU)-[ENV]AN217**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB038118	%	0.005	<0.005	0%	89%
Chromium Reducible Sulphur (Scr)	LB038118	moles H+/T	5	<5		

TAA (Titratable Actual Acidity) **Method: ME-(AU)-[ENV]AN219**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH KCl	LB038117	pH Units	-	5.9	0 - 2%	101%
Titratable Actual Acidity	LB038117	kg H2SO4/T	0.25	<0.25	0 - 4%	NA
Titratable Actual Acidity (TAA) moles H+/tonne	LB038117	moles H+/T	5	<5	0 - 4%	92%
Titratable Actual Acidity (TAA) S%w/w	LB038117	%w/w S	0.01	<0.01	0 - 4%	92%
Sulphur (SKCl)	LB038117	%w/w	0.005	<0.005	5 - 12%	87%
Calcium (CaKCl)	LB038117	%w/w	0.005	<0.005	1 - 6%	99%
Magnesium (MgKCl)	LB038117	%w/w	0.005	<0.005	0 - 3%	92%

TPA (Titratable Peroxide Acidity) **Method: ME-(AU)-[ENV]AN218**

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Peroxide pH (pH Ox)	LB038116	pH Units	-	6.3	0 - 2%	100%
TPA as kg H_2SO_4/tonne	LB038116	kg H2SO4/T	0.25	<0.25	0 - 4%	99%
TPA as moles H+/tonne	LB038116	moles H+/T	5	<5	0 - 4%	99%
TPA as S % W/W	LB038116	%w/w S	0.01	<0.01	0 - 4%	99%
ANCE as % $CaCO_3$	LB038116	% CaCO3	0.01	<0.01	0%	
ANCE as moles H+/tonne	LB038116	moles H+/T	5	<5	0%	
ANCE as S % W/W	LB038116	%w/w S	0.01	<0.01	0%	
Sulphur (Sp)	LB038116	%w/w	0.005	<0.005	4 - 6%	102%
Calcium (Cap)	LB038116	%w/w	0.005	<0.005	0 - 3%	115%
Magnesium (Mgp)	LB038116	%w/w	0.005	<0.005	0 - 5%	107%

METHOD SUMMARY

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN014	This method is for the determination of soluble sulfate (SO4-S) by extraction with hydrochloric acid. Sulphides should not react and would normally be expelled. Sulfur is determined by ICP.
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H2S) which is collected and titrated with iodine (I2(aq)) to measure SCR.
AN218	Soil samples are subjected to extreme oxidising conditions using hydrogen peroxide. Continuous application of heat and peroxide ensure all sulfide is converted to sulfuric acid. Excess peroxide is broken down by a copper catalyst prior to titration for acidity. Calcium, magnesium, and sulfur are determined by ICP-OES. Also included is a carbonate modification step which, depending on pH after the initial oxidation, gives a measure of ANC.
AN219	Dried pulped sample is extracted for 4 hours in a 1 M KCl solution. The ratio of sample to solution is 1:40. The extract is titrated for acidity. Calcium, magnesium, and sulfur are determined by ICP-AES.
AN220	SPOCAS Suite: Scheme for the calculation of net acidities and liming rates using a Fineness Factor of 1.5.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
		NVL	Not Validated

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical Documents/MP-AU-ENV-QU-022 QA QC Plan.pdf

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1 – To be submitted with Development Application

Development Application for Knowles Group
Address of site *25-27 Warriewood Road, Warriewood*

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, Indra Jworchan, on behalf of Geotechnique Pty Ltd

on this the *28 May 2019* certify that I am a geotechnical engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $2million.

I have:

Please mark appropriate box

√ Prepared the Geotechnical Investigation Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

√ I am willing to technically verify that the Geotechnical Investigation Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

√ Have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.

□ Have examined the site and the proposed development/alteration in detail and am of the opinion that the Development Application only involves Minor Development/Alterations that do not require a Detailed Geotechnical Risk Assessment and hence my report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements for Minor Development/Alterations.

□ Provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: Geotechnical Investigation Report – Report No 13787/1-3AH

Report Date: 28 May 2020

Author: Indra Jworchan

Author's Company/Organisation: Geotechnique Pty Ltd

Documentation which relate to or are relied upon in report preparation:

Australian Geomechanics Society (AGS), Landslide Zoning Working Group. "Guideline for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning", Journal and News of Australian Geomechanics Society, Volume 42, No 1, March, 2007.

Pittwater Council, Geotechnical Risk Management Policy for Pittwater- 2009

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the Geotechnical Risk Management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature .
Name - Indra Jworchan
Chartered Professional Status - CPEng
Membership No.- 806995
Company - Geotechnique Pty Ltd

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for Knowles Group
Address of site *25-27 Warriewood Road, Warriewood*

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

Geotechnical Report Details:

Report Title: Geotechnical Investigation Report
Report Date: 28 May 2020
Author: Indra Jworchan
Author's Company/Organisation: Geotechnique Pty Ltd

Please mark appropriate box

√ Comprehensive site mapping conducted 4 December 2017 and 28 February 2019
√ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
√ Subsurface investigation required

- ☐ No Justification …Difficult site access but excavation faces observed
- √ Yes Date conducted 4 December 2017

√ Geotechnical model developed and reported as an inferred subsurface type-section
√ Geotechnical hazards identified

- √ Above the site
- √ On the site
- √ Below the site
- ☐ Beside the site

√ Geotechnical hazards described and reported
√ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009

- √ Consequence analysis
- √ Frequency analysis

√ Risk calculation
√ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
√ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
√ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
√ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
√ Design Life Adopted:

- √ 100 years
- ☐ Other ……
  specify

√ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
√ Additional action to remove risk where reasonable and practical have been identified and included in the report.
☐ Risk assessment within Bushfire Asset Protection Zone.

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated, and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature .
Name - Indra Jworchan
Chartered Professional Status - CPEng
Membership No.- 806995
Company - Geotechnique Pty Ltd