GEOTECHNIQUE® PTY LTD
ABN 64 002 841 063

Job No: 14396/1
Our Ref: 14396/1-AA
12 March 2019

ZYGT Pty Ltd
c/-Craig & Rhodes Pty Ltd
P O Box 3220
RHODES NSW 2138
Email: JBlaine@crhodes.com.au

Attention: Mr J Blaine

Dear Sir

re: **Proposed Residential Subdivision**
53B Warriewood Road, Warriewood
Geotechnical Investigation

This report provides a geotechnical investigation report for the proposed development at 53B Warriewood Road, Warriewood, hereafter referred to as the site.

We understand that the site is proposed to be subdivided into 17 lots (including 1 residue lot), and the proposed subdivision development includes demolition of existing structures, drainage works, earthworks, and the extension of existing Lorikeet Grove and widening of existing Pheasant Place. The attached subdivision plan showing the proposed lot layout was provided for preparation of this report.

A geotechnical investigation report is required to assess subsurface conditions across the site in order to ascertain that the site is suitable for the proposed development from geotechnical engineering considerations, and provide geotechnical recommendations on earthworks and design of floor slabs, footings and pavement.

Geotechnique Pty Ltd completed a geotechnical investigation for the proposed residential development at 53, 53B and 53C Warriewood Road in 2014 and submitted Report No 13234/1-AA dated 15 August 2014. This report is prepared for the proposed development in 53B Warriewood Road, and is based on information presented in Report No 13234/1-AA. We understand that the site conditions have not changed since preparation of Report No 13234/1-AA. However, this report can be read independently as all information relevant to 53B Warriewood Road is reproduced in this report.

Background Information

Based on the Geological Map of Sydney (scale 1:100,000), the subsurface materials across the site are anticipated to be stream alluvium and/or estuarine sand, comprising silty to peaty quartz sand, silt and clay, ferruginous and humic at places, with shell layers.

Reference to the Soil Landscape Map of Sydney (scale 1:100,000) indicates that the landscape at the site belongs to Warriewood Group, which is characterised by level to gently undulating swales, depressions and infilled lagoons on Quaternary sand, with local relief of less than 10m, ground slopes of less than 3%, and depth to water table of less than 2.0m. Soils in this group comprise sandy humus, sand and peaty, with thickness exceeding 1.5m. This landscape has high water table and is subjected to flooding.

The Acid Sulphate Soil Risk Map (Edition 2, scale 1:25,000) of Hornsby/Mona Vale, prepared by Department of Land and Water Conservation, indicates that there is a high probability of occurrence of acid sulphate soil materials within the soil profile across the site. Therefore, there is a severe environmental risk if the proposed development results in disturbance of acid sulphate soils.

Field Work

Field work for the geotechnical investigation was carried out from 25 to 29 July 2014, and consisted of the following:

- A walkover survey to assess general site conditions.
- Review 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 eight boreholes (BH1 to BH8) using a truck mounted drilling rig fully equipped for geotechnical investigation. Boreholes were drilled using V-bit and terminated in alluvial soils or bedrock at depths of about 6.5m to 19.2m from existing ground surface. Approximate borehole locations are indicated on the attached Drawing No 13234/1-AA1. Borehole logs and explanatory notes are also attached. It should be noted that boreholes BH1 to BH4 were uniformly distributed in the southern half of the site, and BH5-8 were located within the adjoining lot, and used to infer subsurface conditions in the northern portion of the site.
- Carry out Standard Penetration Tests (SPT) in the boreholes at regular depth intervals to assess the strength characteristics of the sub-surface soils.
- 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 Field Engineer from this company, responsible for nominating the borehole locations, sampling, and preparation of field logs.

Site Conditions

The site is of trapezoidal shape and measures about 34.6m along the street frontage and about 215m to 250m in depth. The following observations were made during field work:

- The site is bound by Warriewood Road, Warriewood to the north-east, Narrabeen Creek to the south-west, residential lots to the south-east, and vacant land to the north-west.
- There is a single storey house, a swimming pool, and sheds in the north-eastern half of the site, and the remaining portions of the site are vacant and grass covered.
- The natural ground surface across the site dips from north-east to south-west. The ground surface slope in the northern half of the site is about 4 to 5 degrees, while the southern half of the site is almost flat.

Sub-surface profiles encountered in the boreholes 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)
BH1	3.6	18.50	0.0-0.3	0.3->18.50	Not Encountered	1.2
BH2	3.2	15.45	0.0-0.2	0.2->15.45	Not Encountered	0.9
BH3	4.0	15.45	0.0-0.5	0.5->15.45	Not Encountered	1.4
BH4	4.4	15.45	0.0-0.2	0.2-15.45	Not Encountered	0.8
BH5	10.0	6.50	0.0-0.5	0.5-6.40	6.40	Not Encountered
BH6	5.8	14.80	0.0-0.2	0.2-14.50	14.50	3.5
BH7	7.0	10.70	0.0-0.3	0.3-10.50	10.50	1.5
BH8	3.2	19.50	0.0-1.0	1.0-19.20	19.20	1.0

RL 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 depth to alluvial soils and bedrock across the site is anticipated to vary from 0.2m to 1.0m and 5.0m to 20.0m, respectively.

Topsoil was predominantly fine to medium grained silty clayey sand, and silty sand with some roots and gravel. Fill included silty sandy clay of medium plasticity with some gravel and crushed concrete. Alluvial soils included fine to coarse grained silty sand, and silty clayey sand with layers of medium plasticity silty clay and silty sandy clay. Bedrock to borehole termination depths was fine to medium grained sandstone.

Groundwater level was encountered in all boreholes, at depths ranging from 0.9m to 3.5m from existing ground surface, except borehole BH5. Borehole BH5 is located in the adjoining lot at a higher elevation (RL 10.0 AHD), where bedrock was encountered at a depth of 6.4m. In the remaining portions of the site, the elevation of groundwater surface is assessed to vary from about RL2.0m to 5.5m AHD. It should be noted that the depth to groundwater level could be affected by rainfall and other factors not evident during investigation.

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 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)	Assessed Salinity	Borehole No	Depth (m)	EC (µS/cm)	Assessed Salinity
BH1	0.5-0.95	86.0	Non-Saline	BH3	15.0-15.45	110.0	Non-Saline
BH1	1.5-1.95	75.0	Non-Saline	BH4	1.0-1.45	45.0	Non-Saline
BH1	3.0-3.45	56.0	Non-Saline	BH4	3.0-3.45	50.0	Non-Saline
BH1	4.5-4.95	33.0	Non-Saline	BH4	6.0-6.45	110.0	Non-Saline
BH1	7.5-7.95	130.0	Non-Saline	BH5	1.0-1.45	57.0	Non-Saline
BH1	6.0-6.45	780.0	Very Saline	BH5	3.0-3.45	54.0	Non-Saline
BH1	9.0-9.45	95.0	Non-Saline	BH5	6.0-6.45	80.0	Non-Saline
BH1	10.5-10.95	41.0	Non-Saline	BH6	1.0-1.45	140.0	Non-Saline
BH1	15.0-15.45	40.0	Non-Saline	BH6	3.0-3.45	82.0	Non-Saline
BH2	1.0-1.45	30.0	Non-Saline	BH6	6.0-6.45	70.0	Non-Saline
BH2	3.0-3.45	100.0	Non-Saline	BH7	1.0-1.45	75.0	Non-Saline
BH2	6.0-6.45	220.0	Slightly Saline	BH7	3.0-3.45	72.0	Non-Saline
BH2	9.0-9.45	130.0	Non-Saline	BH7	6.0-6.45	110.0	Non-Saline
BH2	12.0-12.45	63.0	Non-Saline	BH7	9.0-9.45	73.0	Non-Saline
BH2	15.0-15.45	59.0	Non-Saline	BH8	0.5-1.0	80.0	Non-Saline
BH3	1.0-1.45	69.0	Non-Saline	BH6	120-12.45	120.0	Non-Saline
BH3	3.0-3.45	76.0	Non-Saline	BH8	3.0-3.45	60.0	Non-Saline
BH3	6.0-6.45	120.0	Non-Saline	BH8	6.0-6.45	62.0	Non-Saline
BH3	9.0-9.45	71.0	Non-Saline	BH8	9.0-9.45	30.0	Non-Saline
BH3	12.0-12.45	53.0	Non-Saline	BH8	12.0-12.45	33.0	Non-Saline

Table 3 – Results of Soil Aggressivity Tests

Borehole No	Depth (m)	pH	Chloride (mg/kg)	Sulphate (mg/kg)	Resistivity (ohm-cm)
BH1	0.5-0.95	7.2	4.3	8.7	5500
BH1	1.5-1.95	5.3	21.0	56.0	5800
BH1	3.0-3.45	5.5	26.0	4.0	13000
BH1	4.5-4.95	5.4	21.0	6.3	15000
BH1	7.5-7.95	6.4	16.0	110.0	4100
BH1	6.0-6.45	6.9	35.0	630.0	1200
BH1	9.0-9.45	6.6	22.0	25.0	4700
BH1	10.5-10.95	6.6	16.0	16.0	11000
BH1	15.0-15.45	5.6	7.4	23.0	18000
BH5	1.0-1.45	4.2	5.9	46.0	18000
BH5	3.0-3.45	3.7	4.5	57.0	16000
BH5	6.0-6.45	3.9	20.0	70.0	9900
BH6	120-12.45	4.4	140.0	41.0	7200

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)
BH1	0.5-1.0	6.2	4.6	<5	<5	<5	0.022	<0.005
BH1	1.5-2.0	6.2	5.3	<5	<5	<5	0.009	<0.005
BH5	0.5-1.0	6.0	5.0	<5	<5	<5	0.009	<0.005
BH8	1.5-2.0	4.4	4.5	60	61	<5	0.028	0.022

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.

DISCUSSION AND RECOMMENDATIONS

Soil Salinity

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 1). 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 classifications are shown in the following Table 5 (Reference 1).

Table 5 –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 forty representative soil samples are summarised in Table 2. For sandy soils encountered across the site, a multiplying factor of 12 to 14 is considered appropriate. The ECe values for a multiplying factor of 14 vary from about 0.42dS/m to 10.92dS/m. However, only one sample has an ECe value of more than 4.0dS/m.

Therefore, it is our assessment that the soils likely to be disturbed or excavated during proposed development works are non-saline.

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 2), are given below in Table 6.

Table 6 – Soil Aggressivity Classification for Steel/Iron

Chloride		pH	Resistivity (ohm cm)	Soil Condition A*	Soil Condition B#
In Soil (%)	In Water (ppm)				
<0.5	<1000	>5.0	>5000	Non-aggressive	Non-aggressive
0.5-2.0	1000-10000	4.0-5.0	2000-5000	Mild	Non-aggressive
2.0-5.0	10000-20000	3.0-4.0	1000-2000	Moderate	Mild
>5.0	>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 3 are given below in Table 7.

Table 7 – Soil Aggressivity Classification for Concrete

Sulphate expressed as SO_3		pH	Chloride in Water (ppm)	Soil Condition A	Soil Condition B
In Soil (%)	In Groundwater (ppm)				
<0.2	<300	>6.5	<2000	Non-aggressive	Non-aggressive
0.2-0.5	300-1000	5.0-6.0	2000-6000	Mild	Non-aggressive
0.5-1.0	1000-2500	4.5-5.0	6000-12000	Moderate	Mild
1.0-2.0	2500-500	4.0-4.5	12000-30000	Severe	Moderate
>2.0	>5000	<4.0	>30000	Very Severe	Severe

Approximately 100ppm of SO_4 = 80ppm of SO_3

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

- The pH value of soils varies from 3.7 to 7.2, indicating that the site is non-aggressive to moderately aggressive to steel/iron, but mildly to severely aggressive to concrete. Severely aggressive site condition is anticipated to be localised at depths exceeding 4.0m.
- Chloride contents in soils vary from 4.0ppm to 140.0ppm, indicating the site is non-aggressive to both steel and concrete.
- Sulphate contents in soils vary from 4.0ppm to 630.0 ppm, indicating the site is non-aggressive to concrete.
- Resistivity of soil varies from 1200 ohm-cm to 18000 ohm-cm, indicating the site is non-aggressive to steel.

Based on the laboratory test results and the assumption that soils are predominantly sandy, the site is assessed to be mildly aggressive towards steel, and moderately aggressive towards concrete. Therefore, we recommend use of construction materials, such as concrete and steel, that are appropriate to the 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 that there is a high probability of occurrence of acid sulphate soil materials within the soil profile across at the site.
- The southern portion of the site is almost flat, with an elevation of RL 3.0m to 3.5m AHD and is located adjacent to Narrabeen Creek. The elevation and geomorphology of the site indicate that acid sulphate or potentially acid sulphate soils are likely 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 are acid sulphate or potentially acid sulphate soils.
- Groundwater level is likely to be shallower then 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 likely that the proposed development works will lower the groundwater level, which might adversely impact acid sulphate or potentially acid sulphate soils, if encountered during construction.

The above assessments are based on the review of available information, and indicate that acid sulphate or potentially acid sulphate soils might be encountered at the proposed development site. Therefore, representative soil samples from various depths were tested for acid sulphate or potentially acid sulphate soils. The laboratory test results summarised in Table 5 indicate the following:

- The pH_{kcl} (field pH) values range from 4.4 to 6.2, 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 4.5 to 5.3, lower than the pH_{kcl} values, indicating that oxidation of soils is likely to produce some acid. However, the reduction in pH values for three samples out of four samples is less than 1 unit. Furthermore, pH_{ox} values are higher than 4.5, indicating soils across the site are unlikely to be actual or potential acid sulphate soils.
- 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 3) recommends “Action Criteria” (Table 8) 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 8 – 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 that soils likely to be disturbed or excavated during proposed development are silty sand (medium to coarse texture). Therefore, even if the volume of soils to be disturbed or excavated during proposed development works is more than 1000 tonnes, the laboratory test results presented in Table 4 are below the Action Criteria for both Sulphur Trail and Acid Trail presented in Table 8.

Therefore, even if the information review indicates the possibility of acid sulphate soils across the site, it is our assessment that the soils likely to be excavated or disturbed during the proposed development are unlikely to be acid sulphate or potentially acid sulphate soils. Therefore, excavations and disturbance of soils during the proposed development works may be carried out without an approved “Acid Sulphate Soils Management Plan”.

Foundation Conditions

As indicated in Table 1, the sub-surface profile across the site comprises a sequence of topsoil/fill and alluvial soils, underlain by bedrock. The table also indicates the following:

- The depth to alluvial soils across the site is anticipated to vary from about 0.2m to 1.0m from existing ground surface. In most portions of the site, the alluvial soils are very weak (very soft or very loose) to depths of about 1.0m to 3.0m from existing ground surface. In the southern portion of the site, adjacent to the creek, the alluvial soils are very weak to depths of 10.0m to 15.0m. The approximate extent of thick (more than 10m) and very weak alluvial soils is indicated on the attached Drawing No 13234/1-AA1. This drawing indicates very week alluvial soils extend to a distance of about 50m to 75m from Narrabeen Creek.
- The depth to bedrock across the site is anticipated to vary from about 5.0m to 20.0m from the existing ground surface. The depth to bedrock increases from about 5.0m along the northern boundary to about 20.0m along the southern boundary. The depth to bedrock is anticipated to be more than 15.0m in southern half of the site. Contours showing approximate depths to bedrock, based on information from limited number of boreholes, are indicated on the attached Drawing No 13234/1-AA1.

Based on the above observations, we provide the following assessments:

- The thick very weak alluvial soils are not suitable as foundation materials unless significant ground improvement works are carried out, and/or deep footings are used, founded in bedrock at depths of 15.0mm to 20.0m. Appropriate ground improvement methods include preloading and/or chemical/cement stabilisation. If ground improvement methods are to be implemented, a detailed investigation, testing and analysis should be completed to provide design recommendations.
- The thin very weak alluvial soils are assessed to be suitable as foundation materials if some ground improvement works are carried out and/or shallow or deep footings are used, founded in medium dense or better alluvial soils or bedrock at depths of 3.0m to 15.0m from existing ground surface.

The assessments and recommendations presented below in this report are applicable for the portion of the site with thin weak alluvial soils. However, some discussion is presented about footings in the area with thick weak alluvial soils. It is reiterated that a detailed investigation, testing and analysis should be completed to provide design recommendations to improve ground conditions in the portion of the site with thick very weak alluvial soils.

Excavation Condition

It is anticipated that the proposed development across the site will involve excavation up to about 3.0m deep. Therefore, 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.

Observation during borehole drilling indicated that the depth to groundwater level is likely to be in range of 0.9m to 3.5m from the existing ground surface. The depth to groundwater level in the portion of the site with deep weak soils is anticipated to be about 1.0m from existing ground surface, and the depth to ground water level in remaining portions of the site is anticipated to be 1.5m or more. 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. Therefore, 3.0m deep excavation is likely to encounter groundwater inflow. Minor groundwater inflow could be managed by a conventional sump and pump method. If significant groundwater inflow is encountered, we suggest that a specialist contractor is engaged to design an appropriate dewatering system.

Fill Placement

We anticipate site preparation for the proposed development works and 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 disposal off the site. Topsoils may be used in landscaping, and fill materials and may be selectively used as controlled fill.

- Strip weak alluvial soils, anticipated to be 1.0m to 3.0m thick and stockpile separately for possible future uses as controlled fill. Observations in boreholes indicated that the depth to groundwater level varies from about 0.9m to 3.5m. Therefore, groundwater inflow might occur during removal of weak alluvial soils and there may be a need for dewatering to ensure groundwater level is at least 300mm lower than the base of weak alluvial soils.
- Undertake proof rolling of the exposed alluvial soil (anticipated to be medium dense sandy soil) using an 8 to 10 tonne roller, to detect potentially weak spots (ground heave). Excavate areas of localised heaving to depth 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 dewatering, 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 sandy 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 4). 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 excavation up to about 3.0m deep. Since 1.0m to 3.0m thick weak alluvial soils will be removed or replaced with controlled fill, most of the excavation is anticipated to occur within medium dense sandy 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.

- Batter slope for short term stability = 1 vertical to 2 horizontal
- Batter slope 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 any site boundaries or existing structures.

As the materials in the excavation faces are anticipated to comprise sandy soils, it is unlikely that steep slopes could be maintained. Furthermore, groundwater level is likely to be encountered during excavation. Therefore, it is preferable that excavation faces be retained by engineered retaining structures. Appropriate retaining structures for the proposed excavation would comprise contiguous bored pier walls or secant pier walls installed before excavation is commenced, or cantilever walls or gravity walls installed after excavation is completed. Secant pile walls will 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:

$$p_h = 0.65 \gamma k H$$

Where,

p_h = Horizontal active pressure (kN/m^2)
γ = Total density of materials to be retained (say $17.0kN/m^3$)
k = Coefficient of earth pressure (k_a or k_o)
H = Retained height (m)

If retaining walls are embedded below the base of excavation, distribution of passive pressure may 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= 2.7. 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.

We anticipate that the base of excavations will be lower than the groundwater level. Therefore, retaining structures are likely to be subjected to groundwater pressure unless a pumping system is installed to maintain the groundwater level below the base of excavation permanently. The groundwater pressure on retaining structures is anticipated to increase linearly from zero at the surface of groundwater level to ten times the depth of water at the base of excavation. Actual groundwater pressure can be estimated once the depth of the excavation and groundwater level at that location are confirmed.

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

Floor Slabs

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 recommendation presented in this report. For design of floor slabs bearing on controlled fill, we recommend a Modulus of Subgrade Reaction Value of 15kPa/mm.

Footings in Area with Thin Very Weak Alluvial Soils

Exact loadings from the proposed structures are not known at this stage. However, we anticipate that appropriate footings would comprise shallow footings (pad or strip footings) founded on controlled fill or alluvial soils at depths of less than 2.0m from the base of the basement excavation, and/or deep footings (screw piles, driven piles, bored piers, grout injected piles) founded in alluvial soils at depths exceeding 3.0m from base of the basement excavation and bedrock. Deep footings may be preferable if footings are required to withstand lateral and uplift loads. Due to very loose or very soft nature of alluvial soils, we do not recommend that footings are founded at depths less than 3.0m from existing ground surface.

Screw piles, driven piles or grout injected piles would be preferable due to the presence of groundwater at shallow depths, but the acceptability of ground vibration during pile driving may determine whether driven piles can be used. The recommended allowable bearing pressures for design of shallow and deep footings are presented in Table 9.

Table 9 – Recommended Allowable Bearing Pressures

Founding Materials	Founding Depth from Ground Surface* (m)	Depth from Base of 3.0m deep Excavation* (m)	Allowable End Bearing Pressure (kPa)	Allowable Shaft Adhesion (kPa)
Controlled Fill	0.5-1.0	0.0-0.5	100.0	Ignore
Alluvial Soils	3.0-5.0	0.0-2.0	125.0	Ignore
Alluvium Soils	5.0-9.0	2.0-6.0	250.0	5.0
Sandstone – Class V	5.0-20.0	2.0-17.0	900.0	50.0

*Approximate only.

Allowable end bearing pressures presented in Table 10 are for driven piles and screw piles. For bored piers and grout injected piers, appropriate values would be halves of those presented in Table 9. Likewise, allowable shaft adhesion values presented in Table 10 are for compressive loads. For uplift loads, allowable shaft adhesion values may be assumed to be halves of those presented in Table 9.

As shown in Table 9, the depths to alluvial soils of similar strength and bedrock across the site vary significantly. Therefore, the appropriate founding level at a specific location will have to be confirmed by an experienced Geotechnical Engineer, on the basis of assessment made during footing excavation or pier hole drilling. The engineer should ensure that the design strength of soil and rock is achieved.

Design of footings (both shallow and deep) should be based on allowable bearing pressures for the foundation materials and acceptable total and differential footing settlements. For shallow footings founded in controlled fill and alluvial soils, total settlement is anticipated to be about 25mm. However, for deep footings (screw piles, driven piles, bored piers and grout injected piles piers) of 0.5m to 1.0m diameter, total settlement is estimated to be 10mm to 15mm. The differential settlements for both shallow and deep footings are estimated to be about halves of the estimated total settlements.

Footings in Area with Thick Very Weak Alluvial Soils

As indicated earlier in this report, the deep and very weak alluvial soils are not suitable as foundation materials unless significant ground improvement works are carried out. If ground improvement methods are to be implemented, a detailed investigation, testing and analysis should be completed to provide design recommendations.

Alternatively, the entire structure may be designed and constructed as a suspended structure supported by deep footings founded in sandstone bedrock at depths of 15.0m to 20.0m from the existing ground surface. We recommend an allowable bearing pressure of 1000kPa for deep footings founded in bedrock. For footings founded in bedrock, total settlements under the recommended allowable bearing pressure are estimated to be about 1% of pier diameter or minimum footing dimension. Differential settlement is estimated to be about half the estimated total settlements.

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 6), 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 in its current state 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 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 are essential to reduce the 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 are required to reduce the 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 the proposed development.

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 the 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 6) 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, the assessed risk to Loss of Life for the person most at risk due to probable landslides/slope failures at its existing conditions, are presented in Table 10.

Table 10 – 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	1.0×10^{-5}	1.0	0.05	0.10	3.5×10^{-8}
Sum of the risk for the person most at risk from landslide hazards					**3.5×10^{-8}**

The sum of risk to Loss of Life, from likely landslides/slope failures across the site in its existing condition, for an individual most at risk is $3.5x10^{-8}$ per annum. Australian Geomechanics Society (Reference 6) 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 conditions, 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 conditions is assessed to be suitable for the proposed subdivision development.

However, proposed development works will involve alteration of site conditions, including 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.

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), 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 appropriate and adequate drainage should form part of site preparation and retaining wall construction. However, the consequence of landslide or slope failure, if any, after proposed development works may be severe due to the presence of proposed 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 proposed development works are as following:

- 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 the 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 11.

Table 11 – 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 proposed development works, it is our assessment that the risk of slope instability is tolerable even after construction of proposed buildings.

Therefore, from risk of slope instability consideration, the site is assessed to be suitable for the proposed subdivision, provided site preparation, design and construction of retaining structures, floor slabs and footings are carried out in general accordance with geotechnical recommendations provided in this report. Form 1 and 1A are attached.

General

Assessments and recommendations presented in this report are based on site observation and information from boreholes drilled within and in the vicinity of 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 could differ from those encountered in boreholes. Likewise, comments on depth 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.

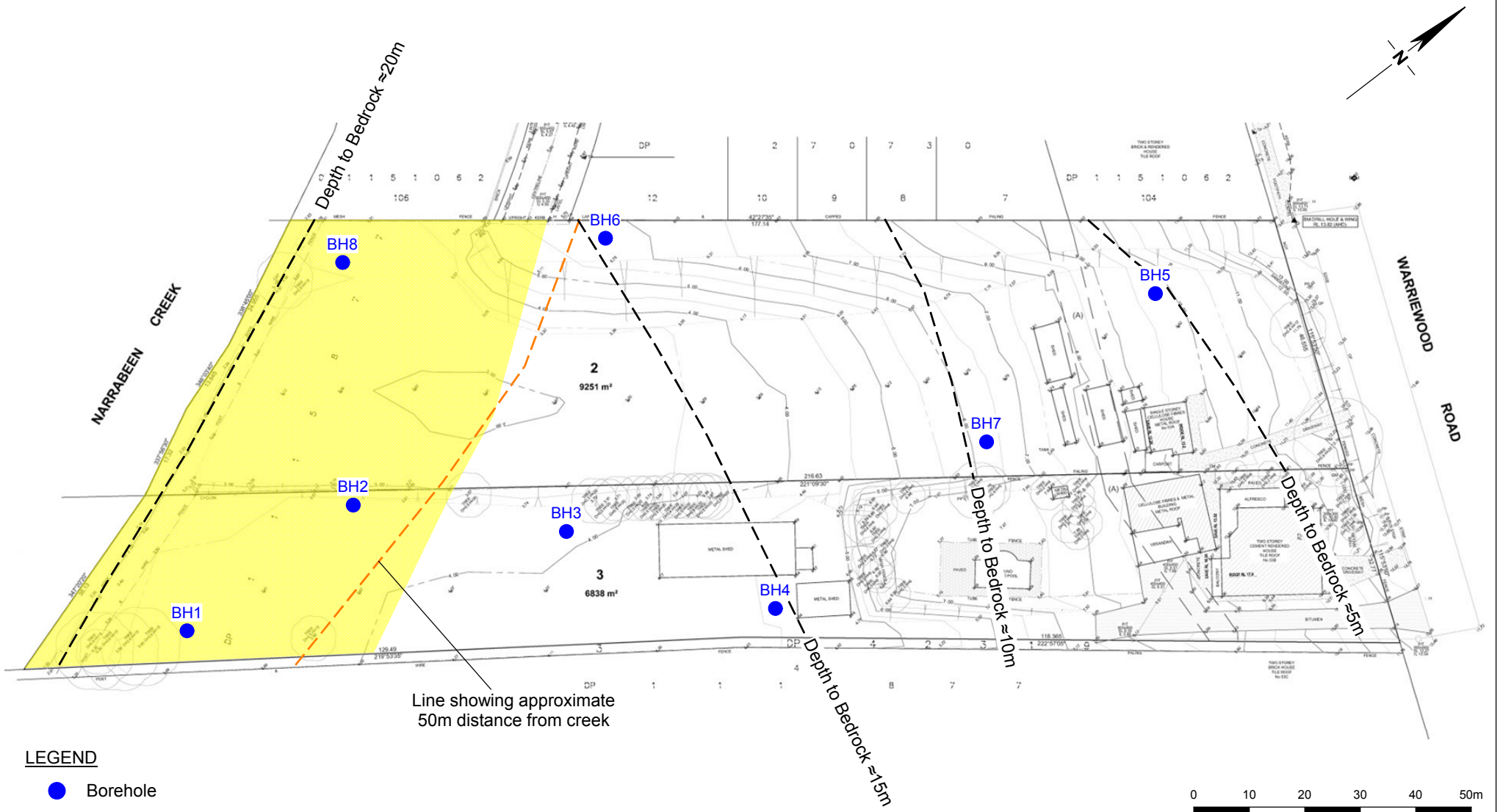
Yours faithfully
GEOTECHNIQUE PTY LTD

INDRA JWORCHAN
Principal Geotechnical Engineer

Attached
Drawing No 13234/1-AA1 – Borehole Location Plan
Borehole Logs, Core Photos & Explanatory Notes
Laboratory Test Results
Forms 1 and 1A

References

1. Lillicrap, A and McGhie, S., Site Investigation for Urban Salinity, Department of Land and Water Conservation, 2002.
2. Standard Australia- AS2159-1995, Piling – Design and Installation, 1995.
3. New South Wales, Acid sulphate Soil Management Advisory Committee, 1988 – Acid sulphate Soil Manual.
4. Australian Standard AS3798-2007, Guidelines on Earthworks for Commercial and Residential Developments, 2007.
5. Australian Geomechanics Society Landslide Taskforce, Landslide Practice Note Working Group - "Practice Note Guidelines for Landslide Risk Management", March 2007.



LEGEND

- Borehole
- Area with very loose or very soft soil to 10-15m deep

0 10 20 30 40 50m

Scale 1:1000

GEOTECHNIQUE® PTY LTD

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NOTES

1. Site features are indicative and are not to scale.
2. This drawing has been produced using a base plan provided by others to which additional information e.g test pits, borehole locations or notes have been added. Some or all of the plan may not be relevant at the time of producing this drawing

Intercapital Consultants
Proposed Residential Development
Lots 2,3, & 4 in DP111587 and Lot 3 in DP942319
53R Warriewood Road, Warriewood

Borehole Locations

Drawing No: 13234/1-AA1
Job No: 13234/1
Drawn By: MH
Date: 18 August 2014
Checked By: IJ

File No: 13234-1
Layers: 0, AA1

GEOTECHNIQUE
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engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 1
Date : 25/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅3.01

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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			FILL; Silty Clayey Sand, fine grained, brown				
								SM	Silty SAND, fine to medium grained, brown yellow	M	L		Alluvial
		ES			N=5 3,3,2	1							
	▼							SM	Silty SAND, fine to coarse grained, dark brown	M	VL		Groundwater at 1.2m
		ES			N=1 0,1,0			SM	Silty Clayey SAND, fine to medium grained, dark brown	W	VL		
						2							
					N=0 0,0,0	3		SM	Silty SAND, fine to medium grained, dark brown	W	VL		
						4							
					N=3 0,2,1			SM	Silty SAND, fine to coarse grained, dark brown	W	VL		
						5							
					N=0 0,0,0	6		CI	Silty Sandy CLAY, medium plasticity, dark brown	M>PL	VS		
						7							
					N=7 0,3,4								
						8							
					N=0 0,0,0	9		CI	Silty CLAY, medium plasticity, brown	M>PL	VS		

GEOTECHNIQUE PTY LTD

engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 1
Date : 25/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅3.01

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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							
					N=5 3,2,3			SM	Silty Clayey SAND, fine to medium grained	W	L		
						11							
					N=11 3,6,5	12		SM	Silty SAND, fine to medium grained, grey	W	MD		
						13							
						14							
					N=38 10,17,21	15		SM	Silty SAND, fine to medium grained, grey, with some fine grained gravel	W	VD		
						16							
						17		SM	Silty SAND, fine to coarse grained, grey, with some fine grained gravel	W	VD		Getting harder to drill
						18							
						19			Borehole No 1 terminated at 18.5m				

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engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 2
Date : 25/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅3.97

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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
	▼				N=2 1,1,1	0		SM	FILL; Silty Clayey Sand, fine to medium grained, brown, with some gravel and sandstone	M	VL		Alluvial
						1			Silty SAND, fine to medium grained, brown to dark brown				Groundwater at 0.9m
						2		SM	Silty Clayey SAND, fine to medium grained	W	VL		
					N=0 0,0,0	3		CI	Silty Sandy CLAY, medium plasticity, grey	M>PL	VS		
					N=0 0,0,0	6		SM	Silty SAND, fine to medium grained, brown	W	VL		
					N=14 1,6,8	9		SM	Silty SAND, fine to medium grained, dark brown	W	MD		

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engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 2
Date : 25/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅3.97

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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							
						12							
					N=23 5,10,13			SM	Silty SAND, fine to medium grained, dark brown	W	MD		
						13							
						14							
						15		SM	Silty SAND, fine to medium grained, dark brown to grey	W	MD		
					N=16 12,10,6								
									Borehole No 2 terminated at 15.45m				
						16							
						17							
						18							
						19							

GEOTECHNIQUE
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engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 3
Date : 28/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅4.0

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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			FILL; Silty Clayey Sand, fine to medium grained, brown, red, with some concrete cobbles and gravel				
								SM	Silty Clayey SAND, fine to medium grained, dark brown	M	L		Alluvial
	▼				N=6 3,2,4	1							Groundwater at 1.4m
						2		SM	Silty SAND, fine to medium grained, grey to light grey	W	MD		
					N=15 4,7,8	3							
						4							
						5							
					N=29 2,7,22	6		SM	Silty Clayey SAND, fine to medium grained, grey, with some medium plasticity fines	W	MD		Slight resistance at 7.2m (200mm)
						7							
						8		Cl	Silty Sandy CLAY, medium plasticity, grey	M>PL	VSt		
					N=11 6,6,5	9							

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engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 3
Date : 28/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅4.0

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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		SM	Silty Clayey SAND, fine to medium grained, grey	W	MD		
					N=9 2,4,5	11							
						12							
						13							
						14							
					N=10 4,4,6	15		SM	Silty SAND, fine to medium grained, dark brown	W	MD		
									Borehole No 3 terminated at 15.45m				
						16							
						17							
						18							
						19							

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engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 4
Date : 28/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅4.04

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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			FILL; Silty Sand, fine to medium grained, brown, with gravel				
								SM	Silty SAND, fine grained, dark brown	M	VL		Groundwater at 0.8m
					N=0 0,0,0	1							
						2		SM	Silty SAND, fine to medium grained, grey	W	L		Alluvial
					N=21 7,10,11	3		SM	Silty SAND, fine to medium grained, grey	W	MD		Getting hard at 3.7m
						4							
						5							
					N=12 3,5,7	6		SM	Silty Clayey SAND, fine to medium grained, grey	W	MD		
						7							
						8							
					N=9 2,4,5	9		SM	Silty Clayey SAND, fine to medium grained, light grey	W	MD		

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engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 4
Date : 28/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅4.04

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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							Getting harder at 11.7m
					N=6 2,3,3	12		SM	Silty Clayey SAND, fine to medium grained, grey to red	W	L		
						13		SM	Silty Clayey SAND, fine to medium grained, reddish grey, with some ironstone	W	VD		
					N=34 4,12,22	14							
						15							
									Borehole No 4 terminated at 15.45m				
						16							
						17							
						18							
						19							

GEOTECHNIQUE
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engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 5
Date : 28/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅9.5

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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, dark brown, with roots				
		ES						SM	Silty Clayey SAND, fine to medium grained, orange to yellow	M	MD		Residual
					N=15 5,7,8	1							
						2		SM	Silty Clayey SAND, fine to medium grained, red orange, with some medium plasticity clay	M	MD		
					N=20 7,9,11	3		SM	Silty Clayey SAND, fine to medium grained, red grey to pink, with some ironstone	M	MD		
						4							
						5							
					N=R 5,10,20/ 50	6		SM	Silty Clayey SAND, fine to medium grained, grey, with red ironstone and extremely weathered sandstone	M	VD		
	Dry												Bedrock
									SANDSTONE, extremely to distinctly weathered, fine to medium grained, red grey, with ironstone				
						7			Borehole No 5 terminated at 6.5m				
						8							
						9							

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 6
Date : 29/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅6.75

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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			FILL; Silty Sandy Clay, medium plasticity, grey brown, with some sandstone and gravel				
					N=16 5,9,7	1							
						2		SM	Silty Clayey SAND, fine to medium grained, grey	M	MD		Residual
	▼				N=9 2,3,6	3		Cl	Silty Sandy CLAY, medium plasticity, grey brown	M<PL	St		Groundwater at 3.5m
						4		SM	Silty SAND, fine to medium grained, grey	W	MD		
						5							
					N=15 6,7,8	6		SM	Silty SAND, fine to medium grained, grey	W	MD		
						7							
						8							
					N=9 2,3,6	9		SM	Silty Clayey SAND, fine to medium grained, grey	W	L		

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 6
Date : 29/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅6.75

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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		SM	Silty Clayey SAND, fine to medium grained, reddish brown to pink	W	MD		
					N=23 5,10,13	12		SM	Silty Clayey SAND, fine to medium grained, red grey, with some ironstone	W	MD		
						14		SM	Silty Clayey SAND, fine to medium grained, reddish pink, with some ironstone	W	MD		
									SANDSTONE, extremely weathered, grey to reddish grey to pink, with some ironstone				Bedrock
						15			Borehole No 6 terminated at 14.8m				
						16							
						17							
						18							
						19							

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 7
Date : 29/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅6.5

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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; Clayey Silt, low plasticity, dark brown, with grass roots				
								SM	Silty SAND, fine to medium grained, grey brown to red	M	MD		Residual (Distinct smell) from septic tank
		ES											
	▼				N=10 3,5,5	1							Groundwater at 1.5m
						2		SM	Silty Clayey SAND, fine to medium grained, grey brown	W	MD		
						3		SM	Silty SAND, fine to medium grained, grey	W	MD		
					N=18 5,8,10								
						4		SM	Silty Clayey SAND, fine to medium grained, reddish grey to pink	W	MD		
						5							
						6		SM	Silty Clayey Sand, fine to medium grained, pink grey, with some ironstone	W	MD		
					N=26 6,10,16								
						7							
						8							
						9		CI	Silty Sandy CLAY, medium plasticity, grey to pink, with ironstone	M>PL	H		
					N=43 8,18,25								

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 7
Date : 29/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅6.5

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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, extremely weathered, grey pink, with some ironstone				Bedrock
						11			Borehole No 7 terminated at 10.7m				
						12							
						13							
						14							
						15							
						16							
						17							
						18							
						19							

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 8
Date : 29/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅3.05

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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, dark brown				
	▼	ES											
						1		CI	Silty Sandy CLAY, medium plasticity, grey brown	M>PL	F		Alluvial Groundwater at 1.0m
		ES				2							
								SM	Silty SAND, fine to medium grained, grey	W	MD		
					N=13 3,7,6	3							
						4							
						5							
						6		SM	Silty SAND, fine to medium grained, dark brown	W	VL		
					N=1 0,1,0								
						7							
						8							Getting harder
						9		SM	Silty SAND, fine to medium grained, grey	W	MD		
					N=10 2,4,6								

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 8
Date : 29/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅3.05

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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							
								SM	Silty SAND, fine to coarse grained, grey, with some fine grained gravel	W	VD		
					N=63 34,24,39	12							
						13							
						14		SM	Silty SAND, fine to coarse grained, grey, with some fine grained gravel	W	VD		
						15							
						16							
						17		SM	Silty SAND, fine to coarse grained, grey, with fine grained gravel	W	VD		
						18							
						19							
									SANDSTONE, extremely to slightly weathered, grey				Bedrock

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : Intercapital Consultants
Project : Proposed Residential Developments
Location : 53 & 53C Warriewood Road, Warriewood

Job No. : 13234/1
Borehole No. : 8
Date : 29/07/2014
Logged/Checked by: MT/IJ

drill model and mounting : Kommachio Track Mounted **slope :** **deg.** **R.L. surface :** ≅3.05

hole diameter : 100 **mm** **bearing :** **deg.** **datum :**

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
						20			Borehole No 8 terminated at 19.5m				
						21							
						22							
						23							
						24							
						25							
						26							
						27							
						28							
						29							

EXPLANATORY NOTES

Introduction
These notes have been provided to simplify the geotechnical report with regard to investigation procedures, classification methods and certain matters relating to the Discussion and Comments section. Not all notes are necessarily relevant to all reports.

Geotechnical reports are based on information gained from finite sub-surface probing, excavation, boring, sampling or other means of investigation, supplemented by experience and knowledge of local geology. For this reason they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods
The methods of description and classification of soils and rocks used in this report are based on AS1726 - 1993 "Geotechnical Site Investigations". In general, descriptions cover the following properties; strength or density, colour, structure, soil or rock type, and inclusions. Identification and classification of soil and rock involves, to a large extent, judgement within the acceptable level commonly adopted by current geotechnical practices.

Soil types are described according to the predominating particle size, qualified by the grading or other particles present (e.g. sandy clay) on the following basis:

Soil Classification	Particle Size
Clay	Less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2.00mm
Gravel	2.00mm to 60.00mm

Cohesive soils are classified on the basis of strength, either by laboratory testing or engineering examination. The strength terms are defined as follows:

Classification	Undrained Shear Strength kPa
Very Soft	Less than 12
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT), as below:

Relative Density	SPT 'N' Value (blows/300mm)	CPT Cone Value (q_c-MPQ)
Very Loose	Less than 5	Less than 2
Loose	5 – 10	2 – 5
Medium Dense	10 – 30	5 – 15
Dense	30 – 50	15 – 25
Very Dense	>50	>25

Rock types are classified by their geological names, together with descriptive terms on degrees of weathering, strength, defects and other minor components. Where relevant, further information regarding rock classification is given on the following sheet.

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

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

Undisturbed samples are taken by pushing a thin walled sample tube (normally known as U_{50}) into the soil and withdrawing a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Details of the type and method of sampling are given in the report.

Field Investigation Methods
The following is a brief summary of investigation methods currently carried out by this Company and comments on their use and application.

Hand Auger Drilling
The borehole is advanced by manually operated equipment. The diameter of the borehole ranges from 50mm to 100mm. Penetration depth of hand augered boreholes may be limited by premature refusal on a variety of materials, such as hard clay, gravels or ironstone.

Test Pits
These are excavated with a tractor-mounted backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3.0m for a backhoe and up to 6.0m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Care must be taken if construction is to be carried out near, or within the test pit locations, to either adequately recompact the backfill during construction, or to design the structure to accommodate the poorly compacted backfill.

Large Diameter Auger (e.g. Pengo)
The hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed, but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers and is usually supplemented by occasional undisturbed tube sampling.

Continuous Spiral Flight Augers
The hole is advanced by using 90mm-115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be highly mixed with soil of other stratum.

Information from the drilling (as distinct from specific sampling by SPT or undisturbed samples) is of relatively lower reliability due to remoulding, mixing or softening of samples by groundwater, resulting in uncertainties of the original sample depth.

The spiral augers are usually advanced by using a V-bit through the soil profile to refusal, followed by Tungsten Carbide (TC) bit, to penetrate into bedrock. The quality and continuity of the bedrock may be assessed by examination of recovered rock fragments and through observation of the drilling penetration resistance.

Non-core Rotary Drilling (Wash Boring)
The hole is advanced by a rotary bit, with water being pumped down the drill rod and returned up the annulus carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the feel and rate of penetration.

Rotary Mud Stabilised Drilling
This is similar to rotary drilling, but uses drilling mud as a circulating fluid, which may consist of a range of products from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (e.g. SPT and U_{50}) samples).

Continuous Core Drilling
A continuous core sample is obtained using a diamond tipped core barrel. Providing full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush.

Portable Proline Drilling
This is manually operated equipment and is only used in sites which require bedrock core sampling and there is restricted site access to truck mounted drill rigs. The boreholes are usually advanced initially using a tricone roller bit and water circulation to penetrate the upper soil profile. In some instances, a hand auger may be used to penetrate the soil profile. Subsequent drilling into bedrock involves the use of NMLC triple tube equipment, using water as a lubricant.

Standard Penetration Tests
Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils, as a means of determining density or strength and of obtaining a relatively undisturbed sample. The test procedure is described in AS1289 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 769mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

  N = 13
  4,6,7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm as;

  15, 30/40mm

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally the test method is used to obtain samples in 50mm diameter thin walled sample tubes in clays. In these circumstances, the test results are shown on the bore logs in brackets.

Cone Penetrometer Testing and Interpretation
Cone penetrometer testing (sometimes referred to as Dutch Cone-CPT) described in this report, has been carried out using an electrical friction cone penetrometer and the test is described in AS1289 6.5.1.

In the test, a 35mm diameter rod with cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig, which is fitted with a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

- Cone resistance - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa *
- Sleeve friction - the frictional force on the sleeve divided by the surface area, expressed in kPa

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and very soft clays, rising to 4% to 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6)\ N \text{ (blows per 300mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:

$$q_c=(12 \text{ to } 18)C_u$$

Interpretation of CPT values can also be made to allow estimate of modulus or compressibility values, to allow calculation of foundation settlements. Inferred stratification, as shown on the attached report, is assessed from the cone and friction traces, from experience and information from nearby boreholes etc.

This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties and where precise information or soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometer (DCP)
Portable Dynamic Cone Penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows per successive 100mm increment of penetration.

There are two similar tests, Cone Penetrometer (commonly known as Scala Penetrometer) AS1289 6.3.2 and the Perth Sand Penetrometer AS1289 6.3.3. Scala Penetrometer is commonly adopted by this company and consists of a 16mm rod with a 20mm diameter cone end, driven with a 9kg hammer, dropping 510mm (AS1289 Test P3.2).

Laboratory Testing
Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedures are given on the individual report forms.

Engineering Logs
The engineering logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, however, this is not always practicable or possible to justify economically. As it is, the boreholes represent only a small sample of the total sub-surface profile. Interpretation of the information and its application to design and construction should take into account the spacing of boreholes, frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

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

- in low permeability soils groundwater, although present, may enter the hole slowly or perhaps not at all during the investigation period
- a localised perched water table may lead to an erroneous indication of the true water table
- water table levels will vary from time to time due to the seasons or recent weather changes. They may not be the same at the time of construction as indicated in the report
- the use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole if water observations are to be made

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

Engineering Reports
Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, perhaps a three-storey building, the information and interpretation may not be relevant if the design proposal is changed, say to a twenty-storey building. If this occurs, the Company will be pleased to review the report and sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of sub-surface conditions, discussions of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

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

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

Site Anomalies
In the event that conditions encountered on-site during construction appear to vary from those that were expected from the information contained in the report, the Company requests immediate notification. Most problems are much more easily resolved when conditions are exposed rather than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes
Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institute of Engineers Australia. Where information obtained from this Investigation is provided for tendering purposes; it is recommended that all information, including the written report and discussion, be made available.

In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or make additional copies of the report available for contract purposes, at a nominal charge.

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

Review of Design
Where major civil or structural developments are proposed, or where only a limited investigation has been completed, or where the geotechnical conditions are complex, it is prudent to have the design reviewed by a Senior Geotechnical Engineer.

ANALYTICAL REPORT

WORLD RECOGNISED ACCREDITATION

CLIENT DETAILS

Contact	Indra Jworchan
Client	Geotechnique
Address	P.O. Box 880 PENRITH NSW 2751
Telephone	02 4722 2700
Facsimile	02 4722 6161
Email	indra.jworchan@geotech.com.au
Project	**13234-1- 53C Warriewood Rd, Warriewood**
Order Number	(Not specified)
Samples	45
Date Received	30/7/2014

LABORATORY DETAILS

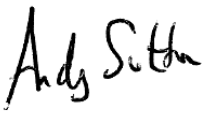
Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE130132 R0**
Report Number	0000088691
Date Reported	7/8/2014
Date Started	1/8/2014

COMMENTS

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

SPOCAS and Cr reducible suite subcontracted to SGS Cairns, 2/58 Comport St, Portsmith QLD 4870, NATA Accreditation Number: 2562, Site Number: 3146.

SIGNATORIES



Andy Sutton
Senior Organic Chemist

Dong Liang
Metals/Inorganics Team Leader

Sheila Lepasana
Senior Technician

pH in soil (1:2) [AN101]

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL 30/7/2014 SE130132.001	BH1 1.5-1.95 SOIL 30/7/2014 SE130132.004	BH1 3.0-3.45 SOIL 30/7/2014 SE130132.005	BH1 4.5-4.95 SOIL 30/7/2014 SE130132.006	BH1 7.5-7.95 SOIL 30/7/2014 SE130132.007	BH1 6.0-6.45 SOIL 30/7/2014 SE130132.008
pH (1:2)	pH Units	-	7.2	5.3	5.5	5.4	6.4	6.9

PARAMETER	UOM	LOR	BH1 9.0-9.45 SOIL 30/7/2014 SE130132.009	BH1 10.5-10.95 SOIL 30/7/2014 SE130132.010	BH1 15.0-15.45 SOIL 30/7/2014 SE130132.011	BH5 1.0-1.45 SOIL 30/7/2014 SE130132.028	BH5 3.0-3.45 SOIL 30/7/2014 SE130132.029	BH5 6.0-6.45 SOIL 30/7/2014 SE130132.030
pH (1:2)	pH Units	-	6.6	6.6	5.6	4.2	3.7	3.9

PARAMETER	UOM	LOR	BH6_12.0-12.45 SOIL 30/7/2014 SE130132.041
pH (1:2)	pH Units	-	4.4

Conductivity (1:2) in soil [AN106]

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL 30/7/2014 SE130132.001	BH1 1.5-1.95 SOIL 30/7/2014 SE130132.004	BH1 3.0-3.45 SOIL 30/7/2014 SE130132.005	BH1 4.5-4.95 SOIL 30/7/2014 SE130132.006	BH1 7.5-7.95 SOIL 30/7/2014 SE130132.007	BH1 6.0-6.45 SOIL 30/7/2014 SE130132.008
Conductivity (1:2) @25 C*	µS/cm	1.0	180	170	78	66	240	840
Resistivity (1:2)*	ohm cm	-	5500	5800	13000	15000	4100	1200

PARAMETER	UOM	LOR	BH1 9.0-9.45 SOIL 30/7/2014 SE130132.009	BH1 10.5-10.95 SOIL 30/7/2014 SE130132.010	BH1 15.0-15.45 SOIL 30/7/2014 SE130132.011	BH5 1.0-1.45 SOIL 30/7/2014 SE130132.028	BH5 3.0-3.45 SOIL 30/7/2014 SE130132.029	BH5 6.0-6.45 SOIL 30/7/2014 SE130132.030
Conductivity (1:2) @25 C*	µS/cm	1.0	220	93	56	57	62	100
Resistivity (1:2)*	ohm cm	-	4700	11000	18000	18000	16000	9900

PARAMETER	UOM	LOR	BH6_12.0-12.45 SOIL 30/7/2014 SE130132.041
Conductivity (1:2) @25 C*	µS/cm	1.0	140
Resistivity (1:2)*	ohm cm	-	7200

Conductivity and TDS by Calculation - Soil [AN106]

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL 30/7/2014 SE130132.001	BH1 1.5-1.95 SOIL 30/7/2014 SE130132.004	BH1 3.0-3.45 SOIL 30/7/2014 SE130132.005	BH1 4.5-4.95 SOIL 30/7/2014 SE130132.006	BH1 7.5-7.95 SOIL 30/7/2014 SE130132.007	BH1 6.0-6.45 SOIL 30/7/2014 SE130132.008
Conductivity of Extract (1:5 dry	µS/cm	1.0	86	75	56	33	130	780

PARAMETER	UOM	LOR	BH1 9.0-9.45 SOIL 30/7/2014 SE130132.009	BH1 10.5-10.95 SOIL 30/7/2014 SE130132.010	BH1 15.0-15.45 SOIL 30/7/2014 SE130132.011	BH2 1.0-1.45 SOIL 30/7/2014 SE130132.012	BH2 3.0-3.45 SOIL 30/7/2014 SE130132.013	BH2 6.0-6.45 SOIL 30/7/2014 SE130132.014
Conductivity of Extract (1:5 dry	µS/cm	1.0	95	41	40	30	100	220

PARAMETER	UOM	LOR	BH2 9.0-9.45 SOIL 30/7/2014 SE130132.015	BH2 12.0-12.45 SOIL 30/7/2014 SE130132.016	BH2 15.0-15.45 SOIL 30/7/2014 SE130132.017	BH3 1.0-1.45 SOIL 30/7/2014 SE130132.018	BH3 3.0-3.45 SOIL 30/7/2014 SE130132.019	BH3 6.0-6.45 SOIL 30/7/2014 SE130132.020
Conductivity of Extract (1:5 dry	µS/cm	1.0	130	63	59	69	76	120

PARAMETER	UOM	LOR	BH3 9.0-9.45 SOIL 30/7/2014 SE130132.021	BH3 12.0-12.45 SOIL 30/7/2014 SE130132.022	BH3 15.0-15.45 SOIL 30/7/2014 SE130132.023	BH4 1.0-1.45 SOIL 30/7/2014 SE130132.024	BH4 3.0-3.45 SOIL 30/7/2014 SE130132.025	BH4 6.0-6.45 SOIL 30/7/2014 SE130132.026
Conductivity of Extract (1:5 dry	µS/cm	1.0	71	53	110	45	50	110

PARAMETER	UOM	LOR	BH5 1.0-1.45 SOIL 30/7/2014 SE130132.028	BH5 3.0-3.45 SOIL 30/7/2014 SE130132.029	BH5 6.0-6.45 SOIL 30/7/2014 SE130132.030	BH6 1.0-1.45 SOIL 30/7/2014 SE130132.031	BH6 3.0-3.45 SOIL 30/7/2014 SE130132.032	BH6 6.0-6.45 SOIL 30/7/2014 SE130132.033
Conductivity of Extract (1:5 dry	µS/cm	1.0	57	54	80	140	82	70

PARAMETER	UOM	LOR	BH7 1.0-1.45 SOIL 30/7/2014 SE130132.035	BH7 3.0-3.45 SOIL 30/7/2014 SE130132.036	BH7 6.0-6.45 SOIL 30/7/2014 SE130132.037	BH7 9.0-9.45 SOIL 30/7/2014 SE130132.038	BH8 0.5-1.0 SOIL 30/7/2014 SE130132.039	BH6_12.0-12.45 SOIL 30/7/2014 SE130132.041
Conductivity of Extract (1:5 dry	µS/cm	1.0	75	72	110	73	80	120

PARAMETER	UOM	LOR	BH8 3.0-3.45 SOIL 30/7/2014 SE130132.042	BH8 6.0-6.45 SOIL 30/7/2014 SE130132.043	BH8 9.0-9.45 SOIL 30/7/2014 SE130132.044	BH8 12.0-12.45 SOIL 30/7/2014 SE130132.045
Conductivity of Extract (1:5 dry	µS/cm	1.0	60	62	30	33

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography [AN245]

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL 30/7/2014 SE130132.001	BH1 1.5-1.95 SOIL 30/7/2014 SE130132.004	BH1 3.0-3.45 SOIL 30/7/2014 SE130132.005	BH1 4.5-4.95 SOIL 30/7/2014 SE130132.006	BH1 7.5-7.95 SOIL 30/7/2014 SE130132.007	BH1 6.0-6.45 SOIL 30/7/2014 SE130132.008
Chloride	mg/kg	0.250	4.3	21	26	21	16	35
Sulphate	mg/kg	0.50	8.7	56	4.0	6.3	110	630

PARAMETER	UOM	LOR	BH1 9.0-9.45 SOIL 30/7/2014 SE130132.009	BH1 10.5-10.95 SOIL 30/7/2014 SE130132.010	BH1 15.0-15.45 SOIL 30/7/2014 SE130132.011	BH5 1.0-1.45 SOIL 30/7/2014 SE130132.028	BH5 3.0-3.45 SOIL 30/7/2014 SE130132.029	BH5 6.0-6.45 SOIL 30/7/2014 SE130132.030
Chloride	mg/kg	0.250	22	16	7.4	5.9	4.5	20
Sulphate	mg/kg	0.50	25	16	23	46	57	70

PARAMETER	UOM	LOR	BH6_12.0-12.45 SOIL 30/7/2014 SE130132.041
Chloride	mg/kg	0.250	140
Sulphate	mg/kg	0.50	41

Moisture Content [AN002]

PARAMETER	UOM	LOR	BH1 0.5-0.95 SOIL 30/7/2014 SE130132.001	BH1 1.5-1.95 SOIL 30/7/2014 SE130132.004	BH1 3.0-3.45 SOIL 30/7/2014 SE130132.005	BH1 4.5-4.95 SOIL 30/7/2014 SE130132.006	BH1 7.5-7.95 SOIL 30/7/2014 SE130132.007	BH1 6.0-6.45 SOIL 30/7/2014 SE130132.008
% Moisture	%	0.50	16	31	27	17	17	36

PARAMETER	UOM	LOR	BH1 9.0-9.45 SOIL 30/7/2014 SE130132.009	BH1 10.5-10.95 SOIL 30/7/2014 SE130132.010	BH1 15.0-15.45 SOIL 30/7/2014 SE130132.011	BH2 1.0-1.45 SOIL 30/7/2014 SE130132.012	BH2 3.0-3.45 SOIL 30/7/2014 SE130132.013	BH2 6.0-6.45 SOIL 30/7/2014 SE130132.014
% Moisture	%	0.50	27	19	17	17	31	21

PARAMETER	UOM	LOR	BH2 9.0-9.45 SOIL 30/7/2014 SE130132.015	BH2 12.0-12.45 SOIL 30/7/2014 SE130132.016	BH2 15.0-15.45 SOIL 30/7/2014 SE130132.017	BH3 1.0-1.45 SOIL 30/7/2014 SE130132.018	BH3 3.0-3.45 SOIL 30/7/2014 SE130132.019	BH3 6.0-6.45 SOIL 30/7/2014 SE130132.020
% Moisture	%	0.50	23	13	17	17	20	28

PARAMETER	UOM	LOR	BH3 9.0-9.45 SOIL 30/7/2014 SE130132.021	BH3 12.0-12.45 SOIL 30/7/2014 SE130132.022	BH3 15.0-15.45 SOIL 30/7/2014 SE130132.023	BH4 1.0-1.45 SOIL 30/7/2014 SE130132.024	BH4 3.0-3.45 SOIL 30/7/2014 SE130132.025	BH4 6.0-6.45 SOIL 30/7/2014 SE130132.026
% Moisture	%	0.50	18	16	28	18	17	16

PARAMETER	UOM	LOR	BH5 1.0-1.45 SOIL 30/7/2014 SE130132.028	BH5 3.0-3.45 SOIL 30/7/2014 SE130132.029	BH5 6.0-6.45 SOIL 30/7/2014 SE130132.030	BH6 1.0-1.45 SOIL 30/7/2014 SE130132.031	BH6 3.0-3.45 SOIL 30/7/2014 SE130132.032	BH6 6.0-6.45 SOIL 30/7/2014 SE130132.033
% Moisture	%	0.50	18	16	15	12	13	15

PARAMETER	UOM	LOR	BH7 1.0-1.45 SOIL 30/7/2014 SE130132.035	BH7 3.0-3.45 SOIL 30/7/2014 SE130132.036	BH7 6.0-6.45 SOIL 30/7/2014 SE130132.037	BH7 9.0-9.45 SOIL 30/7/2014 SE130132.038	BH8 0.5-1.0 SOIL 30/7/2014 SE130132.039	BH6_12.0-12.45 SOIL 30/7/2014 SE130132.041
% Moisture	%	0.50	17	15	18	17	21	15

PARAMETER	UOM	LOR	BH8 3.0-3.45 SOIL 30/7/2014 SE130132.042	BH8 6.0-6.45 SOIL 30/7/2014 SE130132.043	BH8 9.0-9.45 SOIL 30/7/2014 SE130132.044	BH8 12.0-12.45 SOIL 30/7/2014 SE130132.045
% Moisture	%	0.50	17	20	13	17

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 (glass plus reference 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 2520 B.
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

*	Analysis not covered by the scope of accreditation.	-	Not analysed.	UOM	Unit of Measure.
**	Indicative data, theoretical holding time exceeded.	NVL	Not validated.	LOR	Limit of Reporting.
^	Performed by outside laboratory.	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.

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

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.pv.sgsv3/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

STATEMENT OF QA/QC PERFORMANCE

SE130132 R0

CLIENT DETAILS

Contact	Indra Jworchan
Client	Geotechnique
Address	P.O. Box 880 PENRITH NSW 2751
Telephone	02 4722 2700
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Email	indra.jworchan@geotech.com.au
Project	**13234-1- 53C Warriewood Rd, Warriewood**
Order Number	(Not specified)
Samples	45

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
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Telephone	+61 2 8594 0400
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Email	au.environmental.sydney@sgs.com
SGS Reference	SE130132 R0
Report Number	0000088692
Date Reported	07 Aug 2014

COMMENTS

All the laboratory data for each environmental matrix was compared to SGS Environmental Services' 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:

Analysis Date	Conductivity and TDS by Calculation - Soil	35 items

SAMPLE SUMMARY

Sample counts by matrix	45 Soils	Type of documentation received	COC
Date documentation received	30/07/2014@11:53a	Samples received in good order	Yes
Samples received without headspace	Yes	Sample temperature upon receipt	4.0°C
Sample container provider	SGS	Turnaround time requested	Standard
Samples received in correct containers	Yes	Sufficient sample for analysis	Yes
Sample cooling method	Ice Bricks	Samples clearly labelled	Yes
Complete documentation received	Yes		

HOLDING TIME SUMMARY

SE130132 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	SE130132.001	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH1 1.5-1.95	SE130132.004	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH1 3.0-3.45	SE130132.005	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH1 4.5-4.95	SE130132.006	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH1 7.5-7.95	SE130132.007	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH1 6.0-6.45	SE130132.008	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH1 9.0-9.45	SE130132.009	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH1 10.5-10.95	SE130132.010	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH1 15.0-15.45	SE130132.011	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH5 1.0-1.45	SE130132.028	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH5 3.0-3.45	SE130132.029	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH5 6.0-6.45	SE130132.030	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH6_12.0-12.45	SE130132.041	LB061948	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014

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	SE130132.001	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH1 1.5-1.95	SE130132.004	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH1 3.0-3.45	SE130132.005	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH1 4.5-4.95	SE130132.006	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH1 7.5-7.95	SE130132.007	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH1 6.0-6.45	SE130132.008	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH1 9.0-9.45	SE130132.009	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH1 10.5-10.95	SE130132.010	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH1 15.0-15.45	SE130132.011	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH2 1.0-1.45	SE130132.012	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH2 3.0-3.45	SE130132.013	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH2 6.0-6.45	SE130132.014	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH2 9.0-9.45	SE130132.015	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH2 12.0-12.45	SE130132.016	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH2 15.0-15.45	SE130132.017	LB061944	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	06 Aug 2014	07 Aug 2014†
BH3 1.0-1.45	SE130132.018	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH3 3.0-3.45	SE130132.019	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH3 6.0-6.45	SE130132.020	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH3 9.0-9.45	SE130132.021	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH3 12.0-12.45	SE130132.022	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH3 15.0-15.45	SE130132.023	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH4 1.0-1.45	SE130132.024	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH4 3.0-3.45	SE130132.025	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH4 6.0-6.45	SE130132.026	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH5 1.0-1.45	SE130132.028	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH5 3.0-3.45	SE130132.029	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH5 6.0-6.45	SE130132.030	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH6 1.0-1.45	SE130132.031	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH6 3.0-3.45	SE130132.032	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH6 6.0-6.45	SE130132.033	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH7 1.0-1.45	SE130132.035	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH7 3.0-3.45	SE130132.036	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH7 6.0-6.45	SE130132.037	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH7 9.0-9.45	SE130132.038	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH8 0.5-1.0	SE130132.039	LB061945	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014†
BH6_12.0-12.45	SE130132.041	LB061946	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH8 3.0-3.45	SE130132.042	LB061946	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH8 6.0-6.45	SE130132.043	LB061946	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH8 9.0-9.45	SE130132.044	LB061946	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014
BH8 12.0-12.45	SE130132.045	LB061946	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014	06 Aug 2014

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	SE130132.001	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH1 1.5-1.95	SE130132.004	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014

HOLDING TIME SUMMARY

SE130132 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.

Moisture Content (continued)

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

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH1 3.0-3.45	SE130132.005	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH1 4.5-4.95	SE130132.006	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH1 7.5-7.95	SE130132.007	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH1 6.0-6.45	SE130132.008	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH1 9.0-9.45	SE130132.009	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH1 10.5-10.95	SE130132.010	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH1 15.0-15.45	SE130132.011	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH2 1.0-1.45	SE130132.012	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH2 3.0-3.45	SE130132.013	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH2 6.0-6.45	SE130132.014	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH2 9.0-9.45	SE130132.015	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH2 12.0-12.45	SE130132.016	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH2 15.0-15.45	SE130132.017	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH3 1.0-1.45	SE130132.018	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH3 3.0-3.45	SE130132.019	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH3 6.0-6.45	SE130132.020	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH3 9.0-9.45	SE130132.021	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH3 12.0-12.45	SE130132.022	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH3 15.0-15.45	SE130132.023	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH4 1.0-1.45	SE130132.024	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH4 3.0-3.45	SE130132.025	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH4 6.0-6.45	SE130132.026	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH5 1.0-1.45	SE130132.028	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH5 3.0-3.45	SE130132.029	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH5 6.0-6.45	SE130132.030	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH6 1.0-1.45	SE130132.031	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH6 3.0-3.45	SE130132.032	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH6 6.0-6.45	SE130132.033	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH7 1.0-1.45	SE130132.035	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH7 3.0-3.45	SE130132.036	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH7 6.0-6.45	SE130132.037	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH7 9.0-9.45	SE130132.038	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH8 0.5-1.0	SE130132.039	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH6_12.0-12.45	SE130132.041	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH8 3.0-3.45	SE130132.042	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH8 6.0-6.45	SE130132.043	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH8 9.0-9.45	SE130132.044	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014
BH8 12.0-12.45	SE130132.045	LB061715	30 Jul 2014	30 Jul 2014	13 Aug 2014	01 Aug 2014	06 Aug 2014	04 Aug 2014

pH in soil (1:2)

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

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH1 0.5-0.95	SE130132.001	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH1 1.5-1.95	SE130132.004	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH1 3.0-3.45	SE130132.005	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH1 4.5-4.95	SE130132.006	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH1 7.5-7.95	SE130132.007	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH1 6.0-6.45	SE130132.008	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH1 9.0-9.45	SE130132.009	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH1 10.5-10.95	SE130132.010	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH1 15.0-15.45	SE130132.011	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH5 1.0-1.45	SE130132.028	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH5 3.0-3.45	SE130132.029	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH5 6.0-6.45	SE130132.030	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014
BH6_12.0-12.45	SE130132.041	LB061947	30 Jul 2014	30 Jul 2014	06 Aug 2014	06 Aug 2014	07 Aug 2014	06 Aug 2014

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	SE130132.001	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH1 1.5-1.95	SE130132.004	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH1 3.0-3.45	SE130132.005	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH1 4.5-4.95	SE130132.006	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014

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.

Soluble Anions in Soil from 1:2 DI Extract by Ion Chromatography (continued) **Method: ME-(AU)-[ENV]AN245**

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH1 7.5-7.95	SE130132.007	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH1 6.0-6.45	SE130132.008	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH1 9.0-9.45	SE130132.009	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH1 10.5-10.95	SE130132.010	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH1 15.0-15.45	SE130132.011	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH5 1.0-1.45	SE130132.028	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH5 3.0-3.45	SE130132.029	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH5 6.0-6.45	SE130132.030	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014
BH6_12.0-12.45	SE130132.041	LB061747	30 Jul 2014	30 Jul 2014	06 Aug 2014	01 Aug 2014	29 Aug 2014	06 Aug 2014

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 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 and TDS by Calculation - Soil

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

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
SE130132.007	LB061944.013	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	130	43.680686767	31	9
SE130132.017	LB061944.024	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	59	61.4190393013	33	4
SE130132.028	LB061945.013	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	57	54.1311465892	34	5
SE130132.039	LB061945.024	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	80	84.2092653061	32	6
SE130206.002	LB061946.013	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	2200	2356.8408	30	6
SE130261.003	LB061946.019	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	330	305.246065808	31	8

Moisture Content

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

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
SE130132.012	LB061715.011	% Moisture	%w/w	0.5	17	20	35	14
SE130132.022	LB061715.022	% Moisture	%	0.5	16	15	36	3
SE130132.033	LB061715.033	% Moisture	%	0.5	15	14	37	4
SE130132.045	LB061715.044	% Moisture	%	0.5	17	16	36	5
SE130139.001	LB061715.046	% Moisture	%	0.5	17	17	36	1

pH in soil (1:2)

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

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
SE130132.028	LB061947.012	pH (1:2)	pH Units	-	4.2	4.2	32	0

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 and TDS by Calculation - Soil — Method: ME-(AU)-[ENV]AN106

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB061944.002	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	NA	303	85 - 115	100
LB061945.002	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	NA	303	85 - 115	104
LB061946.002	Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	NA	303	85 - 115	103

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 %
LB061747.002	Chloride	mg/kg	0.25	NA	40	70 - 130	93
	Sulphate	mg/kg	0.5	NA	40	70 - 130	95

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

SE130132 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%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

*	Non-accredited analysis.
-	Sample not analysed for this analyte.
^	Analysis performed by external laboratory.

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.

ANALYTICAL REPORT

WORLD RECOGNISED ACCREDITATION

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Indra Jworchan	Manager	Jon Dicker
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Project	**SE130132 13234-1-Proposed Residential**	SGS Reference	**CE111063 R0**
Order Number	(Not specified)	Report Number	0000019196
Samples	4	Date Reported	05 Aug 2014
Date Started	04 Aug 2014	Date Received	01 Aug 2014

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	CE111063.001 Soil 30 Jul 2014 BH1 0.5-1.0	CE111063.002 Soil 30 Jul 2014 BH1 1.5-2.0	CE111063.003 Soil 30 Jul 2014 BH5 0.5-1.0	CE111063.004 Soil 30 Jul 2014 BH8 1.5-2.0
Moisture Content Method: AN002							
% Moisture	%	0.5		**8.8**	**13**	**15**	**27**
TAA (Titratable Actual Acidity) Method: AN219							
pH KCl	pH Units	-		**6.2**	**6.2**	**6.0**	**4.4**
Titratable Actual Acidity	kg H2SO4/T	0.25		<0.25	<0.25	<0.25	**3.0**
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5		<5	<5	<5	**61**
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01		<0.01	<0.01	<0.01	**0.10**
Sulphur (SKCl)	%w/w	0.005		<0.005	<0.005	<0.005	**0.008**
Calcium (CaKCl)	%w/w	0.005		**0.15**	**0.048**	**0.12**	**0.016**
Magnesium (MgKCl)	%w/w	0.005		**0.033**	<0.005	<0.005	**0.056**
TPA (Titratable Peroxide Acidity) Method: AN218							
Peroxide pH (pH Ox)	pH Units	-		**4.6**	**5.3**	**5.0**	**4.5**
TPA as kg H_2SO_4/tonne	kg H2SO4/T	0.25		<0.25	<0.25	<0.25	**2.9**
TPA as moles H+/tonne	moles H+/T	5		<5	<5	<5	**60**
TPA as S % W/W	%w/w S	0.01		<0.01	<0.01	<0.01	**0.10**
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		**0.022**	**0.009**	**0.009**	**0.028**
Peroxide Oxidisable Sulphur as moles H+/tonne	moles H+/T	5		**14**	**5**	**6**	**18**
Sulphur (Sp)	%w/w	0.005		**0.023**	**0.009**	**0.009**	**0.036**
Calcium (Cap)	%w/w	0.005		**0.17**	**0.053**	**0.13**	**0.017**
Reacted Calcium (CaA)	%w/w	0.005		**0.021**	<0.005	**0.006**	<0.005
Reacted Calcium (CaA)	moles H+/T	5		**10**	<5	<5	<5
Magnesium (Mgp)	%w/w	0.005		**0.040**	<0.005	<0.005	**0.060**
Reacted Magnesium (MgA)	%w/w	0.005		**0.006**	<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		-	-	-	**0.005**
Net Acid Soluble Sulphur as moles H+/tonne	moles H+/T	5		-	-	-	<5

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE111063.001 Soil 30 Jul 2014 BH1 0.5-1.0	CE111063.002 Soil 30 Jul 2014 BH1 1.5-2.0	CE111063.003 Soil 30 Jul 2014 BH5 0.5-1.0	CE111063.004 Soil 30 Jul 2014 BH8 1.5-2.0
SPOCAS Net Acidity Calculations Method: AN220							
s-Net Acidity	%w/w S	0.01		<0.01	<0.01	<0.01	**0.11**
a-Net Acidity	moles H+/T	5		**6**	<5	<5	**70**
Liming Rate	kg CaCO3/T	0.1		NA	<0.1	<0.1	**5.2**
Verification s-Net Acidity	%w/w S	-20		NA	NA	NA	NA
a-Net Acidity without ANCE	moles H+/T	5		**15**	**7**	**8**	**81**
Liming Rate without ANCE	kg CaCO3/T	0.1		NA	NA	NA	**6.1**
Chromium Reducible Sulphur (CRS) Method: AN217							
Chromium Reducible Sulphur (Scr)	%	0.005		<0.005	<0.005	<0.005	**0.022**
Chromium Reducible Sulphur (Scr)	moles H+/T	5		<5	<5	<5	**14**
HCl Extractable S, Ca and Mg in Soil ICP OES Method: AN014							
Acid Soluble Sulphur (SHCl)	%w/w	0.005		-	-	-	**0.013**

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)	LB019097	%	0.005	<0.005	0%	101%
Chromium Reducible Sulphur (Scr)	LB019097	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	LB019094	pH Units	-	6.6	0%	101%
Titratable Actual Acidity	LB019094	kg H2SO4/T	0.25	<0.25	0%	NA
Titratable Actual Acidity (TAA) moles H+/tonne	LB019094	moles H+/T	5	<5	0%	87%
Titratable Actual Acidity (TAA) S%w/w	LB019094	%w/w S	0.01	<0.01	0%	87%
Sulphur (SKCl)	LB019094	%w/w	0.005	<0.005	0 - 2%	
Calcium (CaKCl)	LB019094	%w/w	0.005	<0.005	0%	109%
Magnesium (MgKCl)	LB019094	%w/w	0.005	<0.005	1 - 2%	94%

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

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Peroxide pH (pH Ox)	LB019095	pH Units	-	6.4	0 - 4%	100%
TPA as kg H_2SO_4/tonne	LB019095	kg H2SO4/T	0.25	<0.25	0 - 1%	93%
TPA as moles H+/tonne	LB019095	moles H+/T	5	<5	0 - 1%	93%
TPA as S % W/W	LB019095	%w/w S	0.01	<0.01	0 - 1%	93%
ANCE as % $CaCO_3$	LB019095	% CaCO3	0.01	<0.01	0%	
ANCE as moles H+/tonne	LB019095	moles H+/T	5	<5	0%	
ANCE as S % W/W	LB019095	%w/w S	0.01	<0.01	0%	
Sulphur (Sp)	LB019095	%w/w	0.005	<0.005	1 - 4%	100%
Calcium (Cap)	LB019095	%w/w	0.005	<0.005	0 - 1%	116%
Magnesium (Mgp)	LB019095	%w/w	0.005	<0.005	1 - 2%	99%

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.
AN004	Soils, sediments and sludges are pulverised using an LM2 ringmill. The dry sample is pulverised to a particle size of >90% passing through a -75µm sieve.
AN014	This method is for the determination of soluble sulphate (SO4-S) by extraction with hydrochloric acid. Sulphides should not react and would normally be expelled. Sulphur is determined by ICP.
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulphide (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 sulphide is converted to sulphuric acid. Excess peroxide is broken down by a copper catalyst prior to titration for acidity. Calcium, magnesium, and sulphur 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 sulphur 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
*	This analysis is not covered by the scope of accreditation.	QFH	QC result is above the upper tolerance
**	Indicative data, theoretical holding time exceeded.	QFL	QC result is below the lower tolerance
^	Performed by outside laboratory.	-	The sample was not analysed for this analyte
		NVL	Not Validated

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

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

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.pv.sgsv3/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

COC received 30/7/14 @ 1.45pm

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

PH: 8594 0400 **FAX:** 8594 0499

ATTN: Ms Angela Mamalicos

Sampling Date: 30/07/2014
Sampled By: MT
Project Manager: IJ

Job No: 13234/1
Project: Proposed Residential Subdivision
Location: 53C Warriewood Rd, Warriewood

Results required by:

	Sampling details: Location	Depth (m)	Sample type: Soil	Water	EC	Aggressivity	SPOCAS	Cr Reducible Sulphate		Notes	KEEP SAMPLE
1	BH1	0.5-0.95	DSP		✓	✓					YES
2		0.5-1.0	DSG				✓	✓		sPOCAS test includes pH(kcl), pH(ox), TPA,TAA,TSA	
3		1.5-2.0	DSG				✓	✓			
4		1.5-1.95	DSP		✓	✓					YES
5		3.0-3.45	DSP		✓	✓				CRS=Chromium Reducible Sulphur	YES
6		4.5-4.95	DSP		✓	✓					YES
7		7.5-7.95	DSP		✓	✓				Aggressivity testv includes pH, Chloride, Sulphate and Resistivity	YES
8		6.0-6.45	DSP		✓	✓					YES
9		9.0-9.45	DSP		✓	✓					YES
10		10.5-10.95	DSP		✓	✓					YES
11		15.0-15.45	DSP		✓	✓					YES
12	BH2	1.0-1.45	DSP		✓						YES
13		3.0-3.45	DSP		✓						YES
14		6.0-6.45	DSP		✓						YES
15		9.0-9.45	DSP		✓						YES
16		12.0-12.45	DSP		✓						YES
17		15.0-15.45	DSP		✓						YES

RECEIVED
30 JUL 2014
SE130132

Relinquished by: Name	Signature	Date	Received by: Name	Signature	Date
IJ	IJ	30/07/2014	Erin Adams		30/7/14 1.45pm

Legend:
WG Water sample, glass bottle
WP Water sample, plastic bottle
USG Undisturbed soil san
DSG Disturbed soil sample
DSP Disturbed soil sample (small plastic bag)
✓ Test required
* Purge & Trap
@ mole H^+/tonne
# 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**	**Sampling Date:**	30/07/2014
		Sampled By:	MT
		Project Manager:	IJ
PH:	**8594 0400** **FAX:** **8594 0499**		
ATTN:	Ms Angela Mamalicos		

Sampling details			**Sample type**		**Results required by:**									
Location		**Depth (m)**	**Soil**	**Water**	**EC**	**Aggressivity**	**SPOCAS**	**Cr Reducible Sulphate**						**KEEP SAMPLE**
18	BH3	1.0-1.45	DSP		✓									YES
19		3.0-3.45	DSP		✓									YES
20		6.0-6.45	DSP		✓									YES
21		9.0-9.45	DSP		✓									YES
22		12.0-12.45	DSP		✓									YES
23		15.0-15.45	DSP		✓									YES
24	BH4	1.0-1.45	DSP		✓									YES
25		3.0-3.45	DSP		✓									YES
26		6.0-6.45	DSP		✓									YES
27	BH5	0.5-1.0	DSG				✓	✓						
28		1.0-1.45	DSP		✓	✓								YES
29		3.0-3.45	DSP		✓	✓								YES
30		6.0-6.45	DSP		✓	✓								YES
31	BH6	1.0-1.45	DSP		✓									YES
32		3.0-3.45	DSP		✓									YES
33		6.0-6.45	DSP		✓									YES

Relinquished by			Received by		
Name	Signature	Date	Name	Signature	Date
IJ	IJ	30/07/2014	Erin Adams		30/7/14 4:45pm

Legend:

WG	Water sample, glass bottle	USG	Undisturbed soil sample (	DSP	Disturbed soil sample (small plastic bag)	* Purge & Trap	@ mole H^+/tonne
WP	Water sample, plastic bottle	DSG	Disturbed soil sample (gla	✓	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**	**Sampling Date:**	30/07/2014	**Job No:**	13234/1
		Sampled By:	MT	**Project:**	Proposed Residential Subdivision
PH:	**8594 0400** **FAX:** **8594 0499**	**Project Manager:**	IJ	**Location:**	53C Warriewood Rd, Warriewood
ATTN:	Ms Angela Mamalicos				

Sampling details		Sample type		Results required by:									
Location	Depth (m)	Soil	Water	EC	Aggressivity	SPOCAS	Cr Reducible Sulphate						KEEP SAMPLE
34 BH7	0.5-1.0	DSG											
35	1.0-1.45	DSP		✓									YES
36	3.0-3.45	DSP		✓									YES
37	6.0-6.45	DSP		✓									YES
38	9.0-9.45	DSP		✓									YES
39 BH8	0.5-1.0	DSG		✓									YES
40	1.5-2.0	DSG				✓	✓						YES
●	1.0-1.45	DSP				✓	✓						YES
42	3.0-3.45	DSP		✓									YES
43	6.0-6.45	DSP		✓									YES
44	9.0-9.45	DSP		✓									YES
45	12.0-12.45	DSP		✓									YES
41 B+G	12.0-12.45												

Relinquished by			Received by		
Name	Signature	Date	Name	Signature	Date
IJ	IJ	30/07/2014	Erin Ades		30/7/14

Legend:

WG	Water sample, glass bottle	USG	Undisturbed soil sample	DSP	Disturbed soil sample (small plastic bag)	* Purge & Trap	@ mole H^+/tonne
WP	Water sample, plastic bottle	DSG	Disturbed soil sample (g	✓	Test required	# Geotechnique Screen	

SAMPLE RECEIPT ADVICE

SE130132

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	**13234-1- 53C Warriewood Rd, Warriewood**
Order Number	(Not specified)
Samples	45

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 30/7/2014
Report Due	Wed 6/8/2014
SGS Reference	**SE130132**

SUBMISSION DETAILS

This is to confirm that 45 samples were received on Wednesday 30/7/2014. Results are expected to be ready by Wednesday 6/8/2014. Please quote SGS reference SE130132 when making enquiries. Refer below for details relating to sample integrity upon receipt.

Sample counts by matrix	45 Soils	Type of documentation received	COC
Date documentation received	30/07/2014@11:53am	Samples received in good order	Yes
Samples received without headspace	Yes	Sample temperature upon receipt	4.0°C
Sample container provider	SGS	Turnaround time requested	Standard
Samples received in correct containers	Yes	Sufficient sample for analysis	Yes
Sample cooling method	Ice Bricks	Samples clearly labelled	Yes
Complete documentation received	Yes		

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

COMMENTS

Sample "BH8_1.0-1.45" was not received at SGS.
Sample "BH7 0.5-1.0" has not been marked for analysis on COC. Sample has been placed on hold and will not be analysed, unless otherwise instructed by client.
Samples "BH8_3.0-3.45", "BH8_6.0-6.45", "BH8_9.0-9.45" and "BH8_12.0-12.45" were received on 31/07/2014.
Extra sample received, labelled as "BH6_12-12.45" has been placed for EC and aggressivity analyses, as per client's email request received on 30/07/2014@03:59pm.

CRS / SPOCAS - Subcontracted to SGS Cairns, 2/58 Comport St, Portsmith QLD 4870, NATA Accreditation Number: 2562, Site Number: 3146.

SAMPLE RECEIPT ADVICE

SE130132

CLIENT DETAILS

Client Geotechnique

Project 13234-1- 53C Warriewood Rd, Warriewood

SUMMARY OF ANALYSIS

No.	Sample ID	Chromium Reducible Sulphur (CRS)	Conductivity (1:2) in soil	Conductivity and TDS by Calculation - Soil	HCl Extractable S, Ca and Mg in Soil ICP OES	pH in soil (1:2)	Soluble Anions in Soil from 1:2 DI Extract by Ion	SPOCAS Net Acidity Calculations	TAA (Titratable Actual Acidity)	TPA (Titratable Peroxide Acidity)
001	BH1 0.5-0.95	-	2	1	-	1	2	-	-	-
002	BH1 0.5-1.0	3	-	-	3	-	-	6	7	21
003	BH1 1.5-2.0	3	-	-	3	-	-	6	7	21
004	BH1 1.5-1.95	-	2	1	-	1	2	-	-	-
005	BH1 3.0-3.45	-	2	1	-	1	2	-	-	-
006	BH1 4.5-4.95	-	2	1	-	1	2	-	-	-
007	BH1 7.5-7.95	-	2	1	-	1	2	-	-	-
008	BH1 6.0-6.45	-	2	1	-	1	2	-	-	-
009	BH1 9.0-9.45	-	2	1	-	1	2	-	-	-
010	BH1 10.5-10.95	-	2	1	-	1	2	-	-	-
011	BH1 15.0-15.45	-	2	1	-	1	2	-	-	-
012	BH2 1.0-1.45	-	-	1	-	-	-	-	-	-
013	BH2 3.0-3.45	-	-	1	-	-	-	-	-	-
014	BH2 6.0-6.45	-	-	1	-	-	-	-	-	-
015	BH2 9.0-9.45	-	-	1	-	-	-	-	-	-
016	BH2 12.0-12.45	-	-	1	-	-	-	-	-	-
017	BH2 15.0-15.45	-	-	1	-	-	-	-	-	-
018	BH3 1.0-1.45	-	-	1	-	-	-	-	-	-
019	BH3 3.0-3.45	-	-	1	-	-	-	-	-	-
020	BH3 6.0-6.45	-	-	1	-	-	-	-	-	-
021	BH3 9.0-9.45	-	-	1	-	-	-	-	-	-
022	BH3 12.0-12.45	-	-	1	-	-	-	-	-	-
023	BH3 15.0-15.45	-	-	1	-	-	-	-	-	-
024	BH4 1.0-1.45	-	-	1	-	-	-	-	-	-

CONTINUED OVERLEAF

The above table represents SGS Environmental Services' interpretation of the client-supplied Chain Of Custody document.
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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.

SAMPLE RECEIPT ADVICE

SE130132

CLIENT DETAILS

Client Geotechnique

Project 13234-1- 53C Warriewood Rd, Warriewood

SUMMARY OF ANALYSIS

No.	Sample ID	Chromium Reducible Sulphur (CRS)	Conductivity (1:2) in soil	Conductivity and TDS by Calculation - Soil	HCl Extractable S, Ca and Mg in Soil ICP OES	pH in soil (1:2)	Soluble Anions in Soil from 1:2 DI Extract by Ion	SPOCAS Net Acidity Calculations	TAA (Titratable Actual Acidity)	TPA (Titratable Peroxide Acidity)
025	BH4 3.0-3.45	-	-	1	-	-	-	-	-	-
026	BH4 6.0-6.45	-	-	1	-	-	-	-	-	-
027	BH5 0.5-1.0	3	-	-	3	-	-	6	7	21
028	BH5 1.0-1.45	-	2	1	-	1	2	-	-	-
029	BH5 3.0-3.45	-	2	1	-	1	2	-	-	-
030	BH5 6.0-6.45	-	2	1	-	1	2	-	-	-
031	BH6 1.0-1.45	-	-	1	-	-	-	-	-	-
032	BH6 3.0-3.45	-	-	1	-	-	-	-	-	-
033	BH6 6.0-6.45	-	-	1	-	-	-	-	-	-
035	BH7 1.0-1.45	-	-	1	-	-	-	-	-	-
036	BH7 3.0-3.45	-	-	1	-	-	-	-	-	-
037	BH7 6.0-6.45	-	-	1	-	-	-	-	-	-
038	BH7 9.0-9.45	-	-	1	-	-	-	-	-	-
039	BH8 0.5-1.0	-	-	1	-	-	-	-	-	-
040	BH8 1.5-2.0	3	-	-	3	-	-	6	7	21
041	BH6_12.0-12.45	-	2	1	-	1	2	-	-	-
042	BH8 3.0-3.45	-	-	1	-	-	-	-	-	-
043	BH8 6.0-6.45	-	-	1	-	-	-	-	-	-
044	BH8 9.0-9.45	-	-	1	-	-	-	-	-	-
045	BH8 12.0-12.45	-	-	1	-	-	-	-	-	-

CONTINUED OVERLEAF

The above table represents SGS Environmental Services' interpretation of the client-supplied Chain Of Custody document.
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SAMPLE RECEIPT ADVICE

SE130132

CLIENT DETAILS

Client Geotechnique

Project 13234-1- 53C Warriewood Rd, Warriewood

SUMMARY OF ANALYSIS

No.	Sample ID	Acid Neutralising Capacity (ANC)	Chromium Suite Net Acidity Calculations	Moisture Content
001	BH1 0.5-0.95	-	-	1
002	BH1 0.5-1.0	6	6	-
003	BH1 1.5-2.0	6	6	-
004	BH1 1.5-1.95	-	-	1
005	BH1 3.0-3.45	-	-	1
006	BH1 4.5-4.95	-	-	1
007	BH1 7.5-7.95	-	-	1
008	BH1 6.0-6.45	-	-	1
009	BH1 9.0-9.45	-	-	1
010	BH1 10.5-10.95	-	-	1
011	BH1 15.0-15.45	-	-	1
012	BH2 1.0-1.45	-	-	1
013	BH2 3.0-3.45	-	-	1
014	BH2 6.0-6.45	-	-	1
015	BH2 9.0-9.45	-	-	1
016	BH2 12.0-12.45	-	-	1
017	BH2 15.0-15.45	-	-	1
018	BH3 1.0-1.45	-	-	1
019	BH3 3.0-3.45	-	-	1
020	BH3 6.0-6.45	-	-	1
021	BH3 9.0-9.45	-	-	1
022	BH3 12.0-12.45	-	-	1
023	BH3 15.0-15.45	-	-	1
024	BH4 1.0-1.45	-	-	1

CONTINUED OVERLEAF

The above table represents SGS Environmental Services' interpretation of the client-supplied Chain Of Custody document.
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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.

SAMPLE RECEIPT ADVICE

SE130132

CLIENT DETAILS

Client Geotechnique

Project 13234-1- 53C Warriewood Rd, Warriewood

SUMMARY OF ANALYSIS

No.	Sample ID	Acid Neutralising Capacity (ANC)	Chromium Suite Net Acidity Calculations	Moisture Content
025	BH4 3.0-3.45	-	-	1
026	BH4 6.0-6.45	-	-	1
027	BH5 0.5-1.0	6	6	-
028	BH5 1.0-1.45	-	-	1
029	BH5 3.0-3.45	-	-	1
030	BH5 6.0-6.45	-	-	1
031	BH6 1.0-1.45	-	-	1
032	BH6 3.0-3.45	-	-	1
033	BH6 6.0-6.45	-	-	1
035	BH7 1.0-1.45	-	-	1
036	BH7 3.0-3.45	-	-	1
037	BH7 6.0-6.45	-	-	1
038	BH7 9.0-9.45	-	-	1
039	BH8 0.5-1.0	-	-	1
040	BH8 1.5-2.0	6	6	-
041	BH6_12.0-12.45	-	-	1
042	BH8 3.0-3.45	-	-	1
043	BH8 6.0-6.45	-	-	1
044	BH8 9.0-9.45	-	-	1
045	BH8 12.0-12.45	-	-	1

The above table represents SGS Environmental Services' 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.

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

Development Application for ZYGT Pty Ltd c/- Crain & Rhodes Pty Ltd
Address of site *53B 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 6 *March 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 14396/1-AA

Report Date: 6 March 2019

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 ZYGT Pty Ltd c/- Crain & Rhodes Pty Ltd
Address of site *53B 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 No 14396/1-AA
Report Date: 6 March 2019
Author: Indra Jworchan
Author's Company/Organisation: Geotechnique Pty Ltd

Please mark appropriate box

√ Comprehensive site mapping conducted 25-29 July 2014
√ 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