REPORT

TO
MIDSON GROUP PTY LTD

ON
GEOTECHNICAL INVESTIGATION

FOR
PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)

AT
238 MONA VALE ROAD, ST IVES, NSW

26 March 2013
Ref: 26305Zrpt2

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

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Date: 26 March 2013
Report No: 26305Zrpt2
Revision No: 0

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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed residential aged care facility (RACF) at 238 Mona Vale Road, St Ives, NSW. The investigation was commissioned by Mr Emmanuel Ghali of Midson Group Pty Ltd, by email dated 21 February 2013. We note that we previously completed a geotechnical assessment report for the proposed development at the subject site based on a desktop study, and the results were presented in our report (Ref 26305Zrpt) dated 6 February 2013. The current report supersedes our previous geotechnical assessment report.

We understand from the provided architectural drawings (Drawing Nos SK01.1c, 02h, 03h, 03.1d, 04h, 05h and 05.1d) prepared by Suters Architects, that the proposed development will comprise a three storey building, having a 'V' plan shape, with a central one storey entry wing. A basement level is proposed beneath the western wing of the building only. Maximum excavation depths of approximately 3.5m will be required to achieve the finished basement floor reduced level (RL) at 148.6m. The proposed basement will be set back approximately 5m from the south-western (Link Road) site boundary. We have assumed that typical structural loads for this type of development apply.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for comments and recommendations on excavation conditions, shoring, retaining walls, footings and on-grade floor slabs.

We note that our environmental division, Environmental Investigation Services (EIS), carried out a contamination investigation of the site in conjunction with the geotechnical investigation. The geotechnical report must be read in conjunction with the contamination report. We further note that Jeffery and Katauskas (now trading as JK Geotechnics) previously carried out an investigation of the northern portion of the site for a different development proposal. The borehole logs from the previous investigation have been included in Appendix A to this report, and the borehole locations have been marked up on attached Figure 1.

2 INVESTIGATION PROCEDURE

The fieldwork for the investigation was carried out on 28 February 2013 and included the auger drilling of six boreholes (BH101 to BH106) to depths of about 6m and 12m. The borehole locations, as indicated on attached Figure 1, were set out using taped measurements from existing surface features and were electromagnetically scanned for buried services prior to drilling commencing. The surface RLs at the borehole locations were estimated by interpolation between spot heights shown on the provided survey plan (Ref 4596-DET, Sheets 1/8 to 8/8) prepared by Usher & Company, and are therefore approximate. The survey datum is the Australian Height Datum (AHD).

The nature and composition of the subsurface soils and rocks were assessed by logging the materials recovered during drilling. The strength of the soil profile was assessed from the Standard Penetration Test (SPT) 'N' numbers, augmented by hand penetrometer readings on clay samples recovered in the SPT split tube sampler. The strength of the underlying bedrock was assessed by observation of drilling resistance when using a tungsten carbide (TC) bit, examination of the recovered rock chip samples, and subsequent correlation with laboratory moisture content testing. Groundwater observations were made during and on completion of drilling individual boreholes. Standpipes were installed in BH101 and BH102 and the groundwater levels were measured at the end of the day's fieldwork. Longer term groundwater monitoring was not carried out. For further details on the investigation procedure adopted, reference should be made to the attached Report Explanation Notes.

Our geotechnical engineer (David Schwarzer) was present full time on site during the fieldwork and set out the borehole locations, directed electromagnetic scanning, nominated sampling and testing, and logged the subsurface profile. The borehole logs are presented with this report together with a glossary of logging terms and symbols used.

Selected soil and rock chip samples were submitted to Soil Test Services Pty Ltd NATA registered laboratory for moisture content, Atterberg Limits, linear shrinkage, Standard compaction, and CBR testing. The test results are summarised in attached Tables A and B. Representative soil samples were also submitted to the Envirolab NATA registered laboratory for soil pH and chloride and sulphate content determinations. The test results are summarised in Section 3.3 below, and the Envirolab 'Certificate of Analysis' is presented in Appendix B.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is triangular in plan shape and is bounded by Mona Vale Road along the south-east, Link Road along the south-west, and Killeaton Street along the north. A localised shallow gully feature extends northwards through the centre of the site.

At the time of our investigation, the site comprised a disused nursery and the remains of several sheds, gardens, and asphaltic concrete (AC) surface areas were evident. There was a low height concrete retaining wall with some minor cracking along the boundary with Mona Vale Road.

One and two storey residential buildings were located across Killeaton Street to the north, low rise unit buildings were located across Link Road to the south-west and west, and the Corpus Christi Catholic Church with associated buildings were located across Mona Vale Road to the south-east.

3.2 Subsurface Conditions

The 1:100,000 geological map of Sydney indicates that the site is underlain by Ashfield Shales in close proximity to the contact with the underlying Hawkesbury Sandstone, which is indicated over the lower lying areas to the north, east and south. The contact between the Ashfield Shales and the underlying Hawkesbury Sandstone is demarcated by the relatively thin Mittagong Formation which comprises interbedded sandstones and shales.

The current and previous investigations revealed a generalised subsurface profile comprising surficial fill over residual silty clay with sandstone bedrock at variable depth, generally increasing towards the west. A variable groundwater level was also encountered. Reference should be made to the attached borehole logs for detailed subsurface conditions at specific locations. A summary of subsurface conditions as encountered is presented below:

- Fill was encountered in all boreholes and extended to depths between 0.2m (BH101) to 0.65m (BH2). The fill was variable in composition and included silty sandy gravel, silty sandy clay, silty sand, silty clay and gravel.
- Residual silty clay was encountered below the fill and extended to depths between 2m (BH106) and 9.4m (BH1). We note that BH101, BH102, BH103 and BH105 were terminated within the residual silty clay profile at depths of approximately 6m. The residual silty clay

was of high plasticity and generally very stiff to hard strength, although zones of stiff silty clay were encountered in BH103, BH104 and BH1.

- Weathered sandstone bedrock was encountered below the residual silty clay in BH104, BH105, BH1, BH2 and BH3. The sandstone was encountered between depths of 2m (BH106) over the east and 9.4m (BH1) over the west. The sandstone was often extremely weathered and of extremely low strength on first contact and improved to low and medium strength with depth. Medium and higher strength sandstone were encountered in BH1, BH2 and BH3.
- Groundwater seepage was encountered at a depth of 4.4m, 4.4m and 1.6m whilst drilling BH103, BH104 and BH2, respectively. The remaining boreholes were 'dry' on completion of auger drilling. Subsequent groundwater levels were measured as follows:

Borehole	Depth to Groundwater	Hours Following Completion of Drilling
BH101	4.5m	5
BH102	2.3m	4
BH103	3.4m	3.25
BH104	3.4m	2
BH105	5.5m	1
BH106	–	–
BH1	6.9m	4
BH2	1.6m	2
BH3	–	–

3.3 Laboratory Test Results

The Atterberg Limit test results confirmed our field assessed soil classifications and indicated that the residual silty clays were generally of moderate shrink-swell reactivity. The moisture content carried out on recovered rock chip samples correlated reasonably well with our field assessed rock strengths. A four-day soaked CBR value of 2% was indicated for the residual silty clay sampled from BH101 which was compacted to a density ratio of 93% at its insitu moisture content. The insitu moisture content was approximately 7% wetter than its Standard Optimum Moisture Content (SOMC).

The following chemical test results were indicated by the Envirolab testing:

Borehole	Depth	pH	Chloride (mg/kg)	Sulphate (mg/kg)
BH103	4.5m – 4.95m	4.8	18	22
BH105	4.5m – 4.95m	4.5	24	17
BH101	6.0m – 6.18m	4.8	33	11

4 COMMENTS AND RECOMMENDATIONS

4.1 Geotechnical Issues

The principal geotechnical issues associated with the proposed development at the subject site are as follows:

- The bedrock level below the site appears to slope steeply down towards the west.
- Groundwater was measured at depths above the proposed basement excavation level.

4.2 Excavation Conditions

Following demolition and site clearing, the excavation for the proposed basement over the south-western portion of the site to a maximum depth of about 3.5m will encounter the silty clay profile. The proposed excavation can therefore be completed using conventional earthworks equipment (eg. hydraulic excavators, small dozers, etc).

Reference should be made to the EIS report for guidelines on the offsite disposal of soils.

Some groundwater seepage into the bulk excavation may occur, particularly following periods of heavy or prolonged rainfall. We anticipate, however, that the groundwater inflows may be controlled using conventional sump pumping. We recommend that groundwater seepage into the bulk excavation be monitored by site personnel and the results (volume, source, location, etc) reported to the hydraulic and structural engineers, so that any unexpected conditions can be timeously addressed.

4.3 Excavation Support

Based on the investigation results, the proposed bulk excavation through the silty clay profile may be temporarily battered at 1 Vertical (V) in 1 Horizontal (H). Based on the architectural drawings and survey plans, it would appear that the above batters can be accommodated within the site geometry, although the crest of the batter will extend very close to the south-western site boundary. Possible groundwater seepage within the soil profile may cause localised instability of the batters and provision should be made for sand bagging or similar. Conventional retaining walls may then be constructed at the toe of the batter and subsequently backfilled.

Where batters cannot be accommodated within the site geometry, or where they are not preferred, a retention system will be required and should be installed prior to excavation commencing. Given the subsurface profile, suitable retention systems include a soldier pile wall using conventional bored piles with shotcrete infill panels. Lateral restraint in the form of anchors may be required in order to reduce deflections. Anchoring and shotcreting should be carried out progressively as the excavation proceeds.

4.4 Retaining Walls

Temporary and permanent retaining walls may be designed using the following parameters:

- Conventional free-standing cantilever walls which support areas where movement is not of concern (ie. where only garden or open areas are being retained), may be designed using a triangular lateral earth pressure distribution with an 'active' earth pressure coefficient, K_a, of 0.3, for the soil profile, assuming a horizontal retained surface.
- Cantilever walls, the tops of which are restrained by the proposed ground floor slabs prior to backfilling, should be designed using a triangular lateral earth pressure distribution and an 'at rest' earth pressure coefficient, K_o, of 0.55, for the soil profile, assuming a horizontal retained surface.
- A bulk unit weight of $20kN/m^3$ should be adopted for the soil profile.

- For anchored or internally propped walls which support areas where some minor movements are acceptable (ie. along all of the excavation faces, unless there are movement sensitive buried services in close proximity), may be designed using a trapezoidal lateral earth pressure distribution of 6H kPa for the soil profile, where 'H' is the retained height in metres. These pressures should be assumed to be uniform over the central 50% of the support system.
- For anchored or internally propped walls which are supporting areas highly sensitive to lateral movement (such as along the south-western site boundary, should there be movement sensitive buried services in close proximity), a trapezoidal lateral earth pressure distribution of 8H kPa should be adopted for the soil profile, where 'H' is the retained height in metres. These pressures should be assumed to be uniform over the central 50% of the support system.
- Any surcharge affecting the walls (eg. traffic loading, adjacent high level footings, construction loads, etc) should be allowed in the design using the appropriate earth pressure coefficient from above.
- The retaining walls should be designed as drained and measures taken to provide complete and permanent drainage of the ground behind the walls. Subsoil drains should incorporate a non-woven geotextile fabric (such as Bidim A34) to act as a filter against subsoil erosion.
- Lateral toe restraint can be achieved by adequate embedment of the footing into the soil in front of the wall. For embedment depth design, adopt a triangular lateral earth pressure distribution and a 'passive' earth pressure coefficient, K_p, of 3, for the clays of at least stiff strength. The upper 0.3m depth of soil profile below bulk excavation level should be ignored in the analysis to take excavation tolerances into account. Any localised excavations in front of the wall (eg. for drainage, footings, lift overrun pits, etc) should be taken into account in the wall design.
- If anchors are to be used, they will extend beyond the south-western site boundary, and therefore permission from the Authorities (ie. probably Council) would be required prior to installation. The anchors should be bonded into silty clay beyond an imaginary line which extends up at 45° from the toe of the excavation, using an allowable bond stress of 60kPa. Longer anchors which extend to the underlying bedrock can be designed based on an allowable bond stress of 150kPa. The anchors should be proof-tested to 1.3 times the working load under the direction of an experienced engineer independent of the anchor contractor. We recommend that only experienced contractors be considered for anchor installation. We assume that permanent lateral support for retaining walls will be provided

by the new structure. If not, permanent anchors will be required which should be designed for corrosion resistance and for long term durability.

4.5 Footings

Based on the investigation results, the site classifies as 'Class H1', in accordance with AS2798. We note, however, that the standard designs presented in AS2870 are not applicable to the proposed building at the subject site.

Given that the residual clays have strengths no higher than stiff at many locations, high level footings would need to be designed using an allowable bearing pressure of 150kPa. This is unlikely to provide a cost effective footing solution for the proposed three storey building. The alternative is to found the proposed building on piles which are founded in the underlying sandstone bedrock, where an allowable end bearing pressure of 1,000kPa is applicable. In addition, an allowable side adhesion of 100kPa may be adopted for rock sockets in compression. The use of piles founded in better quality clay is not recommended as often the very stiff and hard clay is underlain by stiff clay (eg. BH103 and BH104).

We note that the depth to bedrock slopes steeply from about 2m over the east (BH106) to 9.4m over the west (BH1).

We recommend that footings be excavated, cleaned, inspected and poured with minimal delay to avoid deterioration. If delays in pouring concrete are anticipated, we recommend that the base of the footings be protected with a blinding layer of concrete. Water should be prevented from ponding in the base of footings as this will tend to soften the foundation material, resulting in further excavation and cleaning being required. Groundwater inflow would be expected into bored pile excavations and we expect that this inflow would be controllable by conventional pumping methods. The bored piles should be drilled, cleaned, inspected and poured with minimal delay (ie. all on the same day). Care should be taken to avoid unnecessary drilling depths into the interbedded sandstone. All footings or pile holes should be inspected by a geotechnical engineer to confirm that adequate founding material has been exposed.

4.6 Durability

Based on the Envirolab test results, concrete piles at the site should be designed based on a 'mild' exposure classification, in accordance with AS2159-2009. Steel piles would probably require a 'non-aggressive' exposure classification.

4.7 On-Grade Floor Slabs

The proposed basement on-grade floor slab should be proof-rolled and provided with underfloor drainage. The proof-rolling should include at least five passes using a 3 tonne minimum, smooth drum, vibratory roller. The underfloor drainage should include a strong, durable, single sized, washed aggregate (such as 'blue metal' gravel). The underfloor drainage should connect with the wall drains and direct groundwater seepage to a sump for pumped discharge to the stormwater system.

Over the remainder of the building, the ground floor on-grade floor slab will be subject to shrink-swell movements as a result of the underlying reactive natural silty clay. Surface movements up to approximately 40mm are anticipated. Where the ground floor slab can accommodate such movements, slab-on-grade construction is feasible, provided the exposed subgrade is proof-rolled as detailed above. Where the ground floor slab cannot accommodate differential movements, it should be designed as suspended and poured over a void former at least 50mm thick.

The concrete on-grade floor slabs should be separated from all walls, footings, columns, etc to permit relative movement. Joints in concrete on-grade floor slabs should incorporate keys or dowels.

4.8 Pavements

The design of driveway and carpark pavements will depend on subgrade preparation, subgrade drainage, the nature and composition of new fill imported to the site, as well as vehicle loadings and use.

Based on the soaked CBR test results and provided subgrade preparation is carried out as described in Section 4.7 above, we recommend that the design of flexible or rigid pavements for the carpark and driveway areas be based on a CBR of 2%, a short term Young's Modulus of 15MPa, or an equivalent modulus of subgrade reaction of 10kPa/mm (750mm plate).

Concrete pavements should be supported on a subbase layer of RTA 3051 Specification unbound or equivalent good quality crushed rock, compacted to a density of at least 100% Standard Maximum Dry Density (SMDD. The subbase material would provide more uniform slab support and would reduce ‘pumping’ of subgrade ‘fines’ at joints.

Concrete pavements should be provided with effective shear connection at joints by using dowels or keys. Concrete pavements should be used in areas where heavy vehicles manoeuvre (such as garbage bin and truck unloading areas).

Subsoil drains should be provided along the perimeter of pavements, with inverts not less than 0.2m below clay subgrade level. The drainage trench should be excavated with a longitudinal fall to appropriate discharge points, so as to reduce the risk of water ponding. The pavement subgrade should be graded to promote water flow or infiltration towards subsoil drains.

4.9 Further Geotechnical Input

The following summarises the further geotechnical input which is required and which has been detailed in the preceding sections of this report:

- Geotechnical footing inspections.
- Monitoring of groundwater seepage into bulk excavation.
- Proof-rolling inspections.
- Proof-testing of anchors, if appropriate.
- Density testing of pavement layers.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

A waste classification will need to be assigned to any soil excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous Waste. If the natural soil has been stockpiled, classification of this soil as Excavated Natural Material (ENM) can also be undertaken, if requested. However, the criteria for ENM are more stringent and the cost associated with attempting to meet these criteria may be significant. Analysis takes seven to 10 working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) should be expected. We strongly recommend that this issue is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE A
MOISTURE CONTENT, ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client:	JK Geotechnics	**Ref No:**	26305Z
Project:	Proposed Residential Aged Care Facility (RACF)	**Report:**	A
Location:	238 Mona Vale Road, St Ives, NSW	**Report Date:**	13/03/2013
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AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	DEPTH m	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %	PLASTICITY INDEX %	LINEAR SHRINKAGE %
102	0.50-0.95	26.6	52	22	30	14.5
104	0.50-0.95	25.8	49	21	28	14.0
104	4.50-4.95	25.8				
104	10.00-10.50	11.6				
104	11.50-12.00	7.9				
106	1.50-1.95	23.4	55	21	34	15.0
106	2.40-3.00	5.4				
106	5.50-6.00	6.7				

Notes:
- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions
- Date of receipt of sample: 05/03/2013

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
FOUR DAY SOAKED CALIFORNIA BEARING RATIO TEST REPORT

Client:	JK Geotechnics	**Ref No:**	26305Z
Project:	Proposed Residential Aged Care Facility (RACF)	**Report:**	B
Location:	238 Mona Vale Road, St Ives, NSW	**Report Date:**	13/03/2013
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BOREHOLE NUMBER	101
DEPTH (m)	0.10 - 1.30
Surcharge (kg)	9.0
Maximum Dry Density (t/m^3)	1.50 STD
Optimum Moisture Content (%)	26.2
Moulded Dry Density (t/m^3)	1.39
Sample Density Ratio (%)	93
Sample Moisture Ratio (%)	125
Moisture Contents	
Insitu (%)	33.4
Moulded (%)	32.8
After soaking and	
After Test, Top 30mm(%)	33.0
Remaining Depth (%)	31.8
Material Retained on 19mm Sieve (%)	0
Swell (%)	0.0
C.B.R. value: @5.0mm penetration	2.0

NOTES:
- Refer to appropriate Borehole logs for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1
- Date of receipt of sample:5/3/13

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Authorised Signature / Date
(A. Tatikonda) 13/3/13

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **101**

Client: BUPA
Project: PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)
Location: 238 MONA VALE ROAD, ST IVES, NSW

Job No. 26305Z
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 150.3m
Date: 28-2-13
Datum: AHD
Logged/Checked by: D.S./A.Z.

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION	DS		0			FILL: Silty sandy gravel, fine to medium grained igneous and alluvial river gravel, light grey brown and dark brown, trace of ash.				
	ES, DB	N = 11 4,5,6			CH	SILTY CLAY: high plasticity, orange brown, trace of fine to medium grained ironstone gravel and ash.	MC>PL	VSt	270 270 320	
			1			SILTY CLAY: high plasticity, light grey mottled red brown, with fine to medium grained ironstone gravel.		H		
	DS	N = 22 8,8,14							450 500 500	
			2							
	DS	N = 22 10,10,12	3						550 560 550	
			4							
AFTER 5 HRS	DS	N = 20 7,10,10							470 470 480	
			5							
	DS	N > 12 10,12/ 30mm REFUSAL	6						500 300 310	
						END OF BOREHOLE AT 6.45m				HAND SLOTTED TEMPORARY PVC STANDPIPE INSTALLED TO 6.45m
			7							

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BOREHOLE LOG

Borehole No.
101
2/2

Client: BUPA
Project: PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)
Location: 238 MONA VALE ROAD, ST IVES, NSW

Job No. 26305Z
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 150.3m
Date: 28-2-13
Datum: AHD
Logged/Checked by: D.S./A.Z.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						8							DEPTH
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No.
102
1/1

Client: BUPA
Project: PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)
Location: 238 MONA VALE ROAD, ST IVES, NSW

Job No. 26305Z
Date: 28-2-13
Method: SPIRAL AUGER JK305
Logged/Checked by: D.S./A.Z.
R.L. Surface: ≈ 151.3m
Datum: AHD

Groundwater Record	Samples (ES/U50/DB/DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION	ES		0			FILL: Silty sandy clay, medium plasticity, dark brown, with fine to medium grained river stone gravel.	MC>PL			
	ES, DS	N = 9 3,4,5			CL	SILTY CLAY: medium plasticity, orange brown and light brown, trace of fine grained ironstone gravel.	MC>PL	St	150 180 150	
	DS	N = 10 3,4,6	1		CH	SILTY CLAY: high plasticity, light grey mottled orange brown, trace of fine to medium grained ironstone gravel.			180 190 200	
AFTER 4 HRS			2							
	DS	N = 19 7,8,11	3			SILTY CLAY: high plasticity, light grey, with fine to medium grained ironstone gravel.		H	450 450 500	
	DS	N = 17 5,7,10	4					VSt	250 250 300	
			5							
			6			END OF BOREHOLE AT 6.0m				HAND SLOTTED TEMPORARY PVC STANDPIPE INSTALLED TO 6m DEPTH
			7							

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **103**
1/1

Client: BUPA
Project: PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)
Location: 238 MONA VALE ROAD, ST IVES, NSW

Job No. 26305Z **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 151.2m
Date: 28-2-13 **Datum:** AHD
Logged/Checked by: D.S./A.Z.

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES		0			FILL: Gravel, fine to medium grained crushed concrete, light grey.	M			
						FILL: Silty sand, fine to medium grained, dark grey.				
	ES, DS	N = 10 3,4,6			CH	SILTY CLAY: high plasticity, orange brown.	MC>PL	VSt	350 350 350	
			1							
	DS	N = 14 7,6,8							330 350 350	
			2							
ON COMPLETION & AFTER 3.25 HRS						SILTY CLAY: high plasticity, orange brown mottled red brown and light grey, with fine to medium grained ironstone gravel.		St-VSt		
	DS	N = 11 4,5,6	3						250 210 300	
			4							
▶	DS	N = 10 4,5,5						St	180 180 200	
			5							
			6			END OF BOREHOLE AT 6.0m				
			7							

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **104**
1/2

Client: BUPA
Project: PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)
Location: 238 MONA VALE ROAD, ST IVES, NSW

Job No. 26305Z **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 150.8m
Date: 28-2-13 **Datum:** AHD
Logged/Checked by: D.S./A.Z.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION	ES		0	Fill		FILL: Silty sand, fine to medium grained, dark grey, with fine to medium grained river stone gravel, ash and slag.				
	ES, DS	N = 11 4,5,6			CH	SILTY CLAY: high plasticity, orange brown, with fine to medium grained ironstone gravel.	MC<PL	St-VSt		TOO FRIABLE FOR HP TESTING
			1				MC≈PL			
	DS	N = 12 3,5,7							170 200 220	
			2							
	DS	N = 24 8,11,13	3			SILTY CLAY: high plasticity, orange brown mottled red brown and light grey, with fine to medium grained ironstone gravel.	MC>PL	H	450 450 450	
▼ AFTER 2 HRS			4							
	DS	N = 17 7,8,9						VSt	380 380 380	
			5							
	DS							St	150 150 150	
			6		-	SANDSTONE: fine to medium grained, light grey.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
			7							

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **104**

Client: BUPA
Project: PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)
Location: 238 MONA VALE ROAD, ST IVES, NSW

Job No. 26305Z
Date: 28-2-13
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 150.8m
Datum: AHD
Logged/Checked by: D.S./A.Z.

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						SANDSTONE: fine to medium grained, light grey.	XW	EL		
			8							
			9				DW-SW	L-M		LOW TO MODERATE RESISTANCE
			10			SANDSTONE: fine to medium grained, light grey, with iron indurated seams.				MODERATE RESISTANCE WITH BANDED HIGH RESISTANCE
			11							
			12			END OF BOREHOLE AT 12.0m				
			13							
			14							

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BOREHOLE LOG

Borehole No.
105
1/1

Client: BUPA
Project: PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)
Location: 238 MONA VALE ROAD, ST IVES, NSW

Job No. 26305Z
Date: 28-2-13
Method: SPIRAL AUGER JK305
Logged/Checked by: D.S./A.Z.
R.L. Surface: ≈ 151.2m
Datum: AHD

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION	ES		0			FILL: Silty clay, low plasticity, red brown, with fine to medium grained river stone gravel, trace of ash.	MC<PL			
					CH	SILTY CLAY: high plasticity, orange brown, with fine to medium grained ironstone gravel.	MC<PL	H		
	ES, DS	N = 12 5,6,6							450 500 500	
			1							
						SILTY CLAY: high plasticity, light grey, with fine to medium grained ironstone gravel.				
	DS	N = 20 7,8,12							550 500 550	
			2							
	DS	N = 26 9,12,14	3						>600 >600 >600	
			4							
	DS	N = 20 8,10,10							450 480 500	
			5							
▼ AFTER 1 HR										
			6			END OF BOREHOLE AT 6.0m				
			7							

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
106
1/1

Client: BUPA

Project: PROPOSED RESIDENTIAL AGED CARE FACILITY (RACF)

Location: 238 MONA VALE ROAD, ST IVES, NSW

Job No. 26305Z

Date: 28-2-13

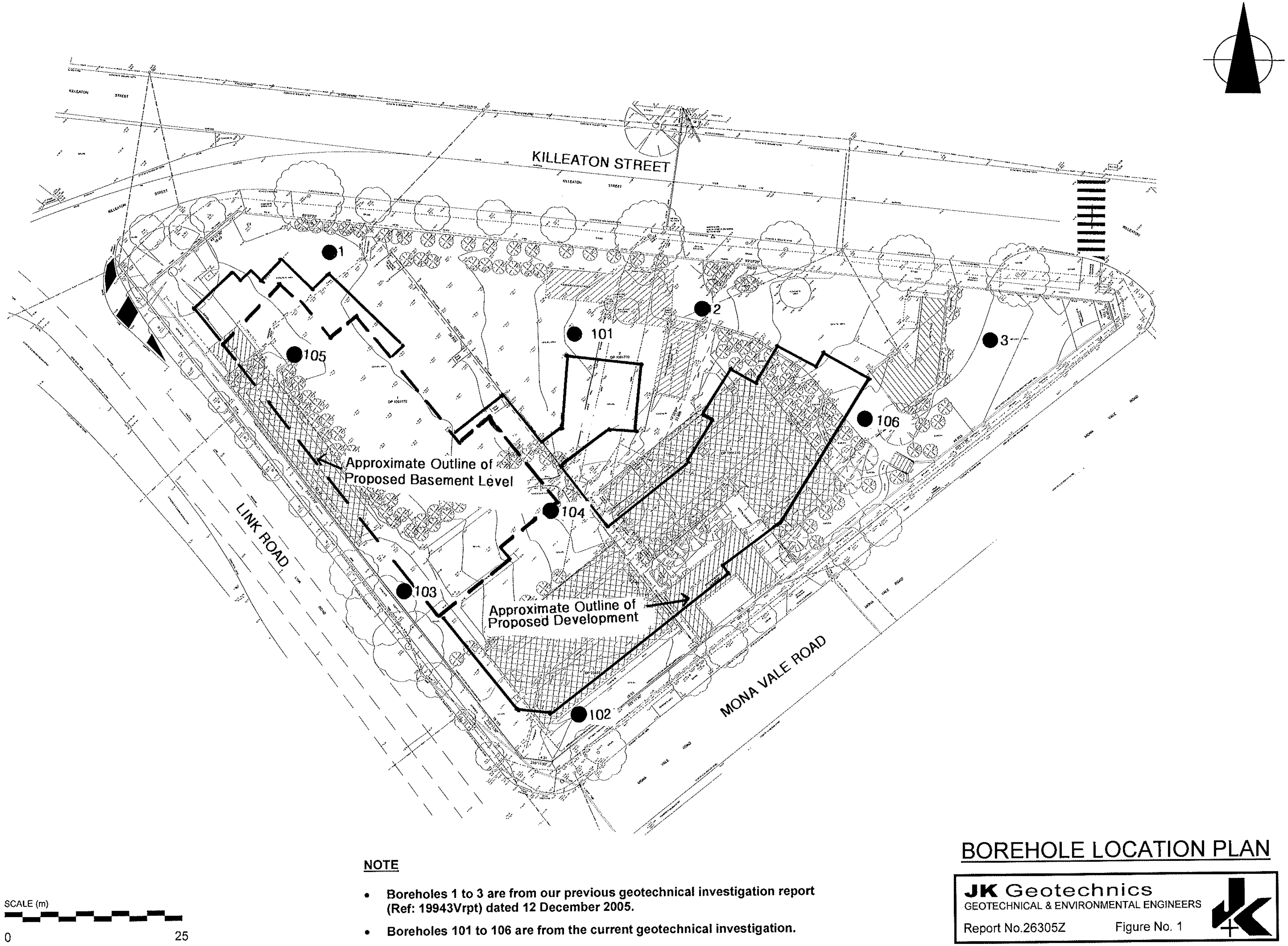
Method: SPIRAL AUGER JK305

R.L. Surface: ≈ 151.4m

Datum: AHD

Logged/Checked by: D.S./A.Z.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Silty sand, fine to medium grained, with fine to medium grained river stone gravel, ash and slag.	D			
		N = 14 4,6,8			CH	SILTY CLAY: high plasticity, orange brown.	MC>PL	VSt	260 300 220	
		N = 18 7,9,9	1			SILTY CLAY: high plasticity, light grey, with fine to medium grained ironstone gravel.	MC<PL	H	550 >600 >600	
			2		-	SANDSTONE: fine to medium grained, light grey, with clay seams.	XW	EL		BANDED VERY LOW 'TC' BIT RESISTANCE
						SANDSTONE: fine to medium grained, light grey, with L-M strength iron indurated seams.				BANDED LOW TO MODERATE RESISTANCE
			5			SANDSTONE: fine to medium grained, light grey, with M strength iron indurated bands.	DW	L		MODERATE RESISTANCE
						as above, but with M-H strength iron indurated bands.				MODERATE TO HIGH RESISTANCE
			6			END OF BOREHOLE AT 6.0m				
			7							



NOTE

- **Boreholes 1 to 3 are from our previous geotechnical investigation report (Ref: 19943Vrpt) dated 12 December 2005.**
- **Boreholes 101 to 106 are from the current geotechnical investigation.**

BOREHOLE LOCATION PLAN

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS
Report No.26305Z Figure No. 1

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

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

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

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

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

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

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

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

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

SAMPLING

Sampling is carried out during drilling or from other excavations 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, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained 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 used are given on the attached logs.

INVESTIGATION METHODS

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

Test Pits: These are normally excavated with a 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 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

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

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

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

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

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

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

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

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

The test results are reported in the following form:

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

  N = 13
  4, 6, 7

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

  N>30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

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

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by 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 as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- 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.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

  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 occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

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

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

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

GROUNDWATER

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

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

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

FILL

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

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

LABORATORY TESTING

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

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 (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical 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 be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that 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 Institution 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 to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed <u>or</u> where only a limited investigation has been completed <u>or</u> where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or

iii) full time engineering presence on site.

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

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

ROCK

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

DEFECTS AND INCLUSIONS

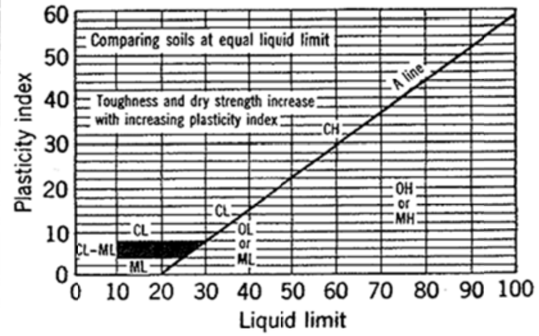
- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)				Group Symbols a	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria	
Coarse-grained soils More than half of material is *larger* than 75 μm sieve size[b] (The 75 μm sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures			Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures			Atterberg limits above "A" line, with *PI* greater than 7
	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines			$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures			Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures			Atterberg limits below "A" line with *PI* greater than 7

Fine-grained soils More than half of material is *smaller* than 75 μm sieve size	Identification Procedures on Fraction Smaller than 380 μm Sieve Size				Group Symbols	Typical Names	Information Required for Describing Soils
		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)			
	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines).
2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

LOG SYMBOLS

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

LOG SYMBOLS continued

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

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

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

ABBREVIATIONS USED IN DEFECT DESCRIPTION

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

APPENDIX A

Borehole Logs from Previous Geotechnical Investigation

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **1**
1/2

BOREHOLE LOG

Client:
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: CNR. LINK AND MONA VALE ROADS, ST IVES, NSW

Job No. 19943V
Date: 2-12-05
Method: SPIRAL AUGER JK300
Logged/Checked by: J.C./
R.L. Surface: ≈ 151.0m
Datum: AHD

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0		-	CONCRETE: 60mm.t	MC>PL	-	-	NO REINFORCEMENT OBSERVED
						FILL: Silty clay, high plasticity, brown, with ironstone gravel and ceramic fragments.				
					CH	SILTY CLAY: high plasticity, light grey mottled orange brown, with ironstone gravel.	MC≈PL	St- VSt	-	
	DS	N = 10 1,4,6							280 370 400	
			1							
	DS	N = 19 5,8,11						VSt -H	420 340 550	
			2							
			3							
	DS	N = 15 4,6,9						VSt	390 340 360	
			4							
	DS	N = 17 4,7,10						VSt -H	420 340 330	
			5							
			6							
	DS	N = 21 4,9,12							>600 >600 >600	
						SILTY CLAY: high plasticity, light grey and light brown mottled red brown, with ironstone gravel.	MC<PL	H		
AFTER 4 HRS ▼			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 1

2/2

Client:

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LINK AND MONA VALE ROADS, ST IVES, NSW

Job No. 19943V | **Method:** SPIRAL AUGER JK300 | **R.L. Surface:** ≈ 151.0m

Date: 2-12-05 | **Datum:** AHD

Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						SILTY CLAY: high plasticity, light grey and light brown mottled red brown, with ironstone gravel.	MC<PL	H		
	DS	N = 27 7,12,15				as above, but light grey and red brown.			>600 >600 >600	
			8			SILTY CLAY: high plasticity, light grey with a trace of fine to medium grained sand.				
	DS	N > 20 6,15, 5/50mm REFUSAL	9						>600 >600 >600	
	DS		10		-	SANDSTONE: fine to medium grained, red brown.	DW	M-H	-	VERY LOW TO LOW 'TC' BIT RESISTANCE MODERATE RESISTANCE HIGH RESISTANCE
			11			END OF BOREHOLE AT 10.5m				PRACTICAL 'TC' BIT REFUSAL
			12							
			13							
			14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **2**
1/1

Client:
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: CNR. LINK AND MONA VALE ROADS, ST IVES, NSW

Job No. 19943V
Date: 2-12-05
Method: SPIRAL AUGER JK300
Logged/Checked by: J.C./
R.L. Surface: ≈ 150.5m
Datum: AHD

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty clay, high plasticity, dark brown, with igneous gravel.	MC>PL			GRAVEL COVER
	DS	N = 7 2,3,4			CH	SILTY CLAY; high plasticity, light brown mottled orange brown, with ironstone gravel.	MC≈PL	VSt	380 360 380	
			1							
ON COMPLETION & AFTER 2 HRS	DS	N = 10 3,5,5					MC>PL		240 200 240	
			2							
	DS	N = 11 3,4,7	3						230 240 260	
			4							
	DS	N = 14 5,7,7				as above, but orange brown.			520 320 260	
			5		-	SANDSTONE: fine to medium grained, red brown, iron indurated.	DW	M-H	-	PRACTIAL 'V' BIT REFUSAL HIGH 'TC' BIT RESISTANCE
	DS		6			END OF BOREHOLE AT 6.0m				PRACTICAL 'TC' BIT REFUSAL
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

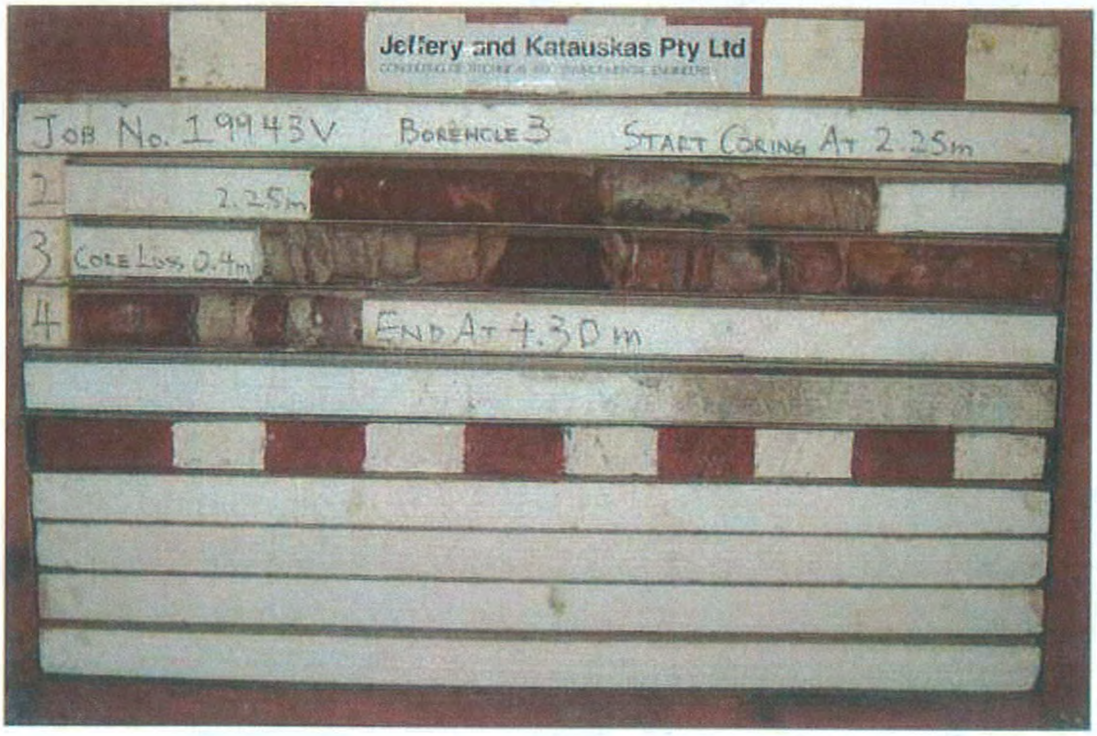
BOREHOLE LOG

Borehole No. **3**
1/2

Client:
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: CNR. LINK AND MONA VALE ROADS, ST IVES, NSW

Job No. 19943V **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 151.4m
Date: 2-12-05 **Datum:** AHD
Logged/Checked by: J.C./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			ASPHALTIC CONCRETE: 30mm.t over FILL: Gravel, medium to coarse grained igneous, dark grey, with sand.	D / MC≈PL			
		N = 5 2,2,3			CH	FILL: Silty clay, high plasticity, dark brown and grey. SILTY CLAY: high plasticity, light brown mottled orange brown, with ironstone gravel.	MC≈PL	VSt-H	290 450 500	
		SPT 8/80mm.	1							
					-	SANDSTONE: fine to medium grained, red brown, iron indurated bands.	DW	M / M-H	-	'V' BIT REFUSAL. MODERATE 'TC' BIT RESISTANCE HIGH RESISTANCE
			2			REFER TO CORED BOREHOLE LOG				PRACTICAL 'TC' BIT REFUSAL
			3							
			4							
			5							
			6							
			7							


Jeffery and Katauskas Pty Ltd
JOB No. 19943V
BOREHOLE 3
START CORING AT 2.25m
2
2.25m
3
CORE LOSS 0.4m
4
END AT 4.30m

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **3**

CORED BOREHOLE LOG

Client:

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: CNR. LINK AND MONA VALE ROADS, ST IVES, NSW

Job No. 19943V | **Core Size:** NMLC | **R.L. Surface:** ≈ 151.4m

Date: 2-12-05 | **Inclination:** VERTICAL | **Datum:** AHD

Drill Type: JK300 | **Bearing:** = | **Logged/Checked by:** J.C./ Y

Water Loss/Level	Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Description (Specific)
	1–2	START CORING AT 2.25m			
FULL RETURN		SANDSTONE: fine to medium grained, dark brown and red brown.	DW	H	- J, 30°, P, R - Bo, 5°, P, S - CS, 130mm.t
		as above, but light grey.	SW	M	
	3	CORE LOSS 0.4m			
		SANDSTONE: fine to medium grained, light grey.	SW	L-M	
	4	as above, but dark red brown.		H	- Be, 0°, P, S - CS, 70mm.t - XWS, 40mm.t - CS, 50mm.t - CS, 30mm.t
	5–8	END OF BOREHOLE AT 4.3m			

APPENDIX B

Envirolab
'Certificate of Analysis'
No 87176

ENVIROLAB SERVICES

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

CERTIFICATE OF ANALYSIS 87176

Client:
Environmental Investigation Services
PO Box 976
North Ryde BC
NSW 1670

Attention: David Schwarzer

Sample log in details:

Your Reference:	**26305Z, St Ives**	
No. of samples:	3 Soils	
Date samples received / completed instructions received	12/03/13	/ 12/03/13

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	19/03/13	/ 18/03/13
Date of Preliminary Report:	Not issued	

NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025. **Tests not covered by NATA are denoted with *.**

Results Approved By:

Nick Sarlamis
Inorganics Supervisor

Miscellaneous Inorg - soil				
Our Reference:	UNITS	87176-1	87176-2	87176-3
Your Reference	-------------	BH103	BH105	BH101
Depth	------------	4.5-4.95	4.5-4.95	6-6.18
Date Sampled		28/02/2013	28/02/2013	28/02/2013
Type of sample		Soil	Soil	Soil
Date prepared	-	15/03/2013	15/03/2013	15/03/2013
Date analysed	-	15/03/2013	15/03/2013	15/03/2013
pH 1:5 soil:water	pH Units	4.8	4.5	4.8
Chloride, Cl 1:5 soil:water	mg/kg	18	24	33
Sulphate, SO4 1:5 soil:water	mg/kg	22	17	11

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA 22nd ED, 4500-H+.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 22nd ED, 4110 -B.

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			15/03/2013	[NT]	[NT]	LCS-1	15/03/2013
Date analysed	-			15/03/2013	[NT]	[NT]	LCS-1	15/03/2013
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-1	101%
Chloride, Cl 1:5 soil:water	mg/kg	2	Inorg-081	<2	[NT]	[NT]	LCS-1	105%
Sulphate, SO4 1:5 soil:water	mg/kg	2	Inorg-081	<2	[NT]	[NT]	LCS-1	110%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NA: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike : A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample) : This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

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

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

Spikes for Physical and Aggregate Tests are not applicable.

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

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable.