NSW HEALTH

Liverpool Hospital Redevelopment - Stage 2

Infrastructure and Ancillary Hospital Works

Project Application and
Environmental Assessment

Appendix P

Geotechnical Assessment Internal Roads

Prepared by: LFA (Pacific) Pty Ltd
and
Capital Insight Pty Ltd

In conjunction with: Jeffrey & Katauskas Pty Ltd

For: Department of Planning

On behalf of : NSW Health

October 2008

REPORT

TO

BOVIS LEND LEASE PTY LTD

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED NEW INTERNAL ROADS

AT

LIVERPOOL HOSPITAL, NSW

9 September 2009

Ref: M21956ZA2rpt

Jeffery and Katauskas Pty Ltd

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EXECUTIVE SUMMARY

The geotechnical investigation was carried out for the proposed new pavements in the eastern and western campuses of Liverpool Hospital, located immediately adjacent to the Main Southern Railway. Nineteen shallow boreholes were drilled to characterise the subgrade conditions and representative samples were obtained for laboratory soaked CBR testing.

From the investigation, poor subgrade conditions including poorly compacted fill and "over-wet" alluvial silty clays, were generally encountered.

We have presented recommendations on appropriate subgrade preparation as well as various pavement layer thickness design options for the proposed asphaltic concrete and concrete pavements.

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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed new internal roads at Liverpool Hospital, NSW. The investigation was commissioned by Bovis Lend Lease Pty Ltd (BLL) Professional Services Agreement (Ref: 115871-PS006). The commission was on the basis of our fee proposal, Ref: PM443ZA dated 14 January 2008.

At the time of preparing this report, the following relevant architectural drawings prepared by Rice Daubney (Project No. 08501) were available from BLL ProjectWeb:

- Drawing No. ZF A 0 0001 ISSUE A dated 25/6/08;
- Drawing No. ZF A 0 0103 ISSUE A dated 25/6/08;
- Drawing No. ZF A 0 0104 ISSUE A dated 25/6/08;
- Drawing No. ZF A 0 0105 ISSUE A dated 25/6/08;
- Drawing No. ZF A 0 0107 ISSUE A dated 25/6/08;
- Drawing No. ZF A 0 0108 ISSUE 00 dated 18/3/08.

A civil design drawing prepared by C&M Consulting Engineers Pty Ltd (Drawing No. ZF-C0-7201 ISSUE 1 dated 25/8/08) was also available from BLL ProjectWeb.

Based on the above drawings, we understand that on-grade asphaltic concrete (AC) and concrete pavements for new roads and car parking areas are proposed immediately either side of the Main Southern Railway, which bisects Liverpool Hospital. The two new pavements areas will be connected by a proposed railway overbridge; refer to previous Jeffery and Katauskas Pty Ltd (J&K) geotechnical investigation report, Ref: M21170ZArpt dated 9 August 2007, which was prepared for Capital Insight Pty Ltd.

From a conversation with Mr Edward Shin of C&M Consulting Engineers Pty Ltd on 5 September 2008 and a subsequent ProjectWeb Correspondence No. 7027 dated

5 September 2008, we understand that the design traffic load for the proposed new pavements is $1x10^5$ Equivalent Standard Axles (ESA). We further understand that site filling to a maximum height of about 1m will be required in some areas to achieve design pavement surface levels.

The purpose of the investigation was to assess the subsurface conditions at nineteen borehole locations and, based on the information obtained, to present our comments and recommendation on earthworks and the proposed pavements. In our fee proposal we had allowed to carry out one AC pavement layer thickness design and one concrete pavement layer thickness design. Additional designs have been carried out. At the request of Mr Chin, we have adhered to the minimum layer thickness requirements of Liverpool City Council (LCC). These requirements are outlined in the LCC publication titled *"New South Wales Development Design Specification D2, Pavement Design"* dated October 2003.

J&K has completed several geotechnical and environmental investigations at Liverpool Hospital. The previous geotechnical investigations are essentially irrelevant to the proposed new internal roads and will therefore not be referred to in this report.

We were also commissioned to carry out a contamination assessment at the site. This work is currently being undertaken by our environmental consulting division, Environmental Investigation Services (EIS). This geotechnical report must be read in conjunction with all previous and future EIS reports.

2 INVESTIGATION PROCEDURE

Prior to the commencement of the fieldwork, a specialist sub-consultant electro-magnetically scanned the borehole locations for buried services.

The fieldwork for the investigation was carried out on 23 & 24 April 2008 and comprised the drilling of nineteen boreholes (R1 to R19), at the locations shown on the attached Figure 1, to depths generally between 1.5m and 1.95m below existing grade. Most of the boreholes were auger drilled using our track mounted JK300 drill rig. Due to the presence of buried services, R1, R2 and R3 were drilled using a hand auger once the pavement was auger drilled using our track mounted drill rig. At R1, R2 and R3, hand auger refusal occurred at depths of 0.085m, 0.2m and 0.12m, respectively.

The relative compaction/strength of the subsoil profile in R4 to R19 was assessed from the Standard Penetration Test (SPT) 'N' values, together with hand penetrometer readings on clayey soils recovered in the SPT split spoon sampler and by tactile examination. At R1, R2 and R3, a Dynamic Cone Penetrometer (DCP) test was attempted to assess the relative compaction/strength of the subsoil profile, however, refusal occurred at depths between 0.11m and 0.28m. Groundwater observations were also made in the boreholes. Further details of the methods and procedures employed in the investigation are presented in the attached Report Explanation Notes.

The borehole locations were set out by tape measurements from existing surface features and apparent site boundaries. The surface reduced levels (RL) indicated on the attached borehole logs were interpolated between spot level heights shown on the previously supplied survey plans prepared by John M Daly & Associates Pty Ltd (Ref: 06321DS, Sheets 1 to 17, Issue A, dated February 2007), and are therefore only approximate. The survey datum is the Australian Height Datum (AHD). Due to the limited extent of the previous survey and that most of the proposed pavement footprint within the western campus has since been stripped, we expect the accuracy of the surface RLs at R1, R2, R3, and at R13 to R19 to be within 0.3m.

Our student geotechnical engineer, under the direction of a Senior Associate, was present full-time during the fieldwork, to set out the borehole locations, nominate testing and sampling, and prepare the attached borehole logs and DCP test results sheet. The Report Explanation Notes define the logging terms and symbols used.

Selected soil samples were returned to a NATA registered laboratory (Soil Test Services Pty Ltd) for Standard compaction and four day soaked CBR testing. The results are summarised in the attached Table A.

3 RESULTS OF THE INVESTIGATION

3.1 Site Description

The proposed new pavements are located in the western and eastern campuses of Liverpool Hospital in relatively flat alluvial topography, immediately outside a meandering bend of the Georges River. The site is bound by Elizabeth Street to the south, Goulburn Street to the west and is bisected by the Main Southern Railway, which is oriented north-east to south-west.

At the time of the fieldwork, the previous buildings and the majority of the concrete pavements within the proposed pavement footprint in the western campus had been demolished and the site had been stripped to approximately 0.5m depth below original surface level. Due to the rainfall period which took place prior and during the fieldwork, the exposed soil subgrade was "boggy" and contained large pools of water. Within the eastern campus, the proposed new pavements are to replace existing AC pavements.

3.2 Subsurface Conditions

Generally, the boreholes encountered pavements and/or fill overlying alluvial silty clays. Neither bedrock nor groundwater were encountered within the 1.95m maximum depth of investigation. Reference should be made to the attached borehole logs and DCP test results sheet for details at each specific location. A summary of the encountered subsurface characteristics is provided below.

Pavements

AC surfacing was encountered in R1, R2, R3 and in R6 to R11 and ranged in thickness between 10mm and 100mm. In R6 to R11, the AC surfacing was supported on a roadbase layer which ranged in thickness between 300mm and 400mm.

Fill

Sandy and/or clayey fill was encountered below the pavements in R1, R2, R3, and R7 to R11, and from the surface in R4, R5, R12, R14, R15 and R19 to depths between at least 0.085m (R1) and at least 1.5m (R4). Inclusions of gravel, ash and brick fragment were encountered in the fill. The shallow fill in R5 resembled imported topsoil. The fill at R5 and R12 was grass covered. Based on the SPT results, the deeper fill in R4, R10, R11 and R12 was assessed to be either poorly or moderately compacted. Hand auger refusal occurred in the fill at R1, R2 and R3 at depths of 0.085m, 0.2m and 0.12m, respectively. R4 was terminated within the fill profile.

Alluvial Silty Clay

Alluvial silty clays of generally medium to high plasticity and of stiff to hard strength were encountered from the surface in R13, R16, R17 and R18 and below the pavements/fill in R5 to R12, R14, R15 and R19, and extended to the borehole termination depths.

Groundwater

The boreholes were "dry" during and on completion of drilling. We note that the groundwater levels may not have stabilised within the limited observation period. No long-term groundwater monitoring was carried out.

3.3 Laboratory Test Results

The four day soaked CBR tests carried out on a clayey fill sample from R12 and on alluvial silty clay samples from R5, R7, R10, R15, R16, R17, R18 and R19 resulted in values between 1.5% and 3.5% when compacted between 90% and 98% of Standard Maximum Dry Density (SMDD) and surcharged with 9kg. Higher sample density ratios could not be achieved at R5, R7, R10, R18 and R19 as the clayey samples were compacted, prior to CBR testing, at their insitu moisture contents which were between 4.4% and 12.5% "wet" of their respective Standard Optimum Moisture Contents (SOMC). The insitu moisture contents of the remaining clayey samples from R12, R15, R16 and R17 were within 2.2% "dry" and 1.6% "wet" of their respective SOMCs.

4 COMMENTS AND RECOMMENDATIONS

4.1 Geotechnical Issues

We consider the following to be the primary geotechnical issues for the proposed new pavements:

- Presence of an "over-wet" clay subgrade.
- Presence of a clay subgrade with some potential for shrink-swell movements with changes in moisture content.
- Low CBR values for the clay subgrade.

The effects of the above geotechnical issues on design and construction are detailed below.

4.2 Site Earthworks

All earthworks recommendations provided for the proposed new pavements should be complemented by reference to AS3798-2007 ("Guidelines on Earthworks for Commercial and Residential Developments").

4.2.1 Site Drainage

The clay subgrade at the site is expected to undergo substantial loss in strength when wet as evident from the low CBR values. Furthermore, the clayey subgrade is expected to have some shrink-swell reactive potential. Therefore, it is important to provide good and effective site drainage both during construction and for long-term site maintenance. The principle aim of the drainage is to promote run-off and reduce ponding. A poorly drained clay subgrade may become untraffickable when wet. The earthworks should be carefully planned and scheduled to maintain good cross-falls during construction.

4.2.2 Site Preparation

Following demolition of the remaining pavements, kerbs and gutters, and removal of all vegetation within the proposed new pavement footprint (including the root balls of any trees), all topsoil, root affected soils and any deleterious or contaminated existing fill should be stripped. Topsoil and root affected soils should be stripped to a nominal average depth of 0.1m.

We note that it is difficult to accurately assess the thickness of AC and depth of topsoil and root affected soils in a 100mm diameter borehole. If considered to be an important contractual issue, we recommend that a number of shallow test pits be excavated in these areas to more accurately confirm the AC and topsoil/root affected soil stripping depth or, alternatively, a geotechnical inspection could be carried out after initial stripping to confirm thicknesses.

Stripped topsoil and root affected soils should be stockpiled separately as they are considered unsuitable for reuse as engineered fill. They may however be reused for landscaping purposes. Reference should be made to the EIS report for guidance on the offsite disposal of soil. Care should be taken during site stripping not to undermine or remove support from any nearby structures or pavements.

4.2.3 Subgrade Preparation

Following stripping we recommend that the soil subgrade be proof rolled with at least eight passes of a static (non-vibratory) smooth drum roller of at least 12 tonnes deadweight. The final pass of proof rolling should be carried out under the direction of an experienced geotechnical engineer for the detection of unstable or soft areas.

Subgrade heaving during proof-rolling may occur in areas where the clays have become "saturated". Heaving should be expected in the vicinity of R5, R7, R10, R18 and R19 where the clay subgrade insitu moisture contents were significantly higher than their respective SOMCs. Similarly, heaving should be expected in the vicinity of R4, R10 and R12 where poorly compacted fill was indicated. Heaving areas should be locally removed down to a stable base and replaced with engineered fill, as outlined in Section 4.2.4 below. Possible alternatives to stripping the full depth of the heaving areas must be provided by the geotechnical engineer during the proof rolling inspection, if appropriate. Nonetheless, a generous time allowance and contingency budget should be allowed for subgrade improvement works.

If soil softening occurs after prolonged periods of rainfall, then the subgrade should be over-excavated to below the depth of moisture softening and replaced with engineered fill. If the clayey subgrade exhibits shrinkage cracking, then the surface should be watered and rolled until the shrinkage cracks are no longer evident.

Engineered fill must be used where site levels need to be raised.

4.2.4 Engineered Fill

General

The stripped sandy and clayey fill and alluvial silty clays are considered suitable for reuse as engineered fill, on condition that they are "clean", and free of organic matter and particle sizes greater than 75mm. All sandy soils must be mixed in with the clayey soils in order to improve the workability of the latter soil type. Based on the laboratory test results, the stripped clayey soils will most likely require "drying out" in order to conform to the moisture specification provided below.

Due to the low CBR characteristics of the clayey soils, we recommend that a continuous select fill layer of imported, durable, well graded crushed sandstone be placed below design subgrade level. The benefit of this select layer is that it will provide a more suitable construction platform during inclement weather periods. Furthermore, the compaction specification and controls for such granular material, as outlined below, are less stringent than for clayey soils. Crushed sandstone will also have a higher CBR value than clayey soils therefore reducing required pavement thicknesses, provided the crushed sandstone is placed and compacted to a sufficient thickness. The actual design CBR for the new pavements should be confirmed by sampling and testing of the imported material prior to placement. The imported material must be free of organic matter and particle sizes greater than 75mm.

Engineered fill comprising the stripped clayey soils should be compacted in maximum 200mm thick loose layers using a large static pad-foot roller to a density ratio strictly between 98% and 102% of SMDD and at a moisture content within 2% of SOMC.

Engineered select fill comprising well graded granular materials, such as imported crushed sandstone, should be compacted in maximum 200mm thick loose layers using a large static pad-foot roller to a minimum density ratio of 100% of SMDD.

Edge Compaction

In order to achieve adequate edge compaction, we recommend that the fill platform extend a horizontal distance of at least 1m beyond the design geometry. If over-filling cannot be accommodated, then further geotechnical advice should be sought.

Trench Backfill

In order to reduce post-construction settlements, backfilling of new service trenches should be carried out using engineered fill. Due to the lower energy output of smaller compaction plant that can be used in trenches, we recommend that the maximum particle size and the placed loose layer thickness be reduced to 40mm and 100mm, respectively. The compaction specifications provided above are applicable for engineered backfill.

Earthworks Inspection and Testing

Density tests should be regularly carried out on the engineered fill to confirm the above specifications are achieved.

- The frequency of density testing for general engineered fill should be at least one test per layer per $1000m^2$ or one test per $200m^3$ distributed reasonably evenly throughout the full depth and area, whichever requires the most tests.
- The frequency of density testing for trench backfill should be at least one test per two layers per 40 linear metres.

Based on the moisture sensitive and low CBR characteristics of the clayey soils, we recommend that Level 1 control of fill placement and compaction, in accordance with AS3798-2007, be carried out. The geotechnical inspection and testing authority (GITA) should be directly engaged by the client and not by the earthworks contractor.

4.3 New Pavements

Based on the results of the investigation, we recommend that the design of the proposed new pavements be based on a CBR value of 2.0% for the compacted clay subgrade.

Due to the low CBR value, and as previously discussed in Section 4.2.4, an engineered select fill layer should be placed below design subgrade level to reduce the thickness of the proposed new pavements. The quality of the crushed sandstone is dependent on availability at the time of construction. A reasonable quality crushed sandstone can be assumed to have a soaked CBR value of at least 20%, when compacted to a minimum density ratio of 100% of SMDD. A poor quality crushed sandstone can be assumed to have a soaked CBR value in the order of 10%, when compacted to a minimum density ratio of 100% of SMDD.

All imported crushed sandstone should be accompanied by appropriate NATA registered laboratory test data, specifically, sieve analysis and CBR test results, and should be inspected by an experienced geotechnical engineer. If such laboratory test data is unavailable then we could provide appropriate representative samples to Soil Test Services Pty Ltd for the testing following our inspection of the material.

4.3.1 Asphaltic Concrete Pavements

Our recommended AC pavement layer thicknesses, on the basis of a subgrade CBR of 2.0% and design traffic load of $1x10^5$ ESAs, are provided below. The designs have been carried out using the computer based CIRCLY (Version 5.0j) program, in accordance with Austroads 2008 (*"Guide to Pavement Technology, Part 2:*

Pavement Structural Design"). For our analyses, we have assumed a subgrade CBR value which increases with depth to 6%.

We have provided three options for the flexible pavement thickness design. For each option, we have provided two sub-options. A cost comparison and an assessment of material availability should be made for each option.

Option 1 – Provision of Crushed Sandstone with CBR≥10%

Pavement Layer	Material Type	Minimum Thickness (mm)	
		Option 1a	Option 1b
Wearing Course	AC10	25	40
Base Course	DGB20	160	160
Select Fill	Crushed Sandstone CBR≥10% at a density ratio≥100% SMDD	270	250
Total Pavement Thickness		455	450

Option 2 – Provision of Crushed Sandstone with CBR≥20%

Pavement Layer	Material Type	Minimum Thickness (mm)	
		Option 2a	Option 2b
Wearing Course	AC10	25	40
Base Course	DGB20	100	100
Select Fill	Crushed Sandstone CBR≥20% at a density ratio≥100% SMDD	250	230
Total Pavement Thickness		375	370

Option 3 - Provision of Crushed Sandstone with CBR≥10% (Limited Source)

Pavement Layer	Material Type	Minimum Thickness (mm)	
		Option 3a	Option 3b
Wearing Course	AC10	25	40
Base Course	DGB20	100	100
Sub-Base Course	DGS40	100	100
Select Fill	Crushed Sandstone CBR≥10% at a density ratio≥100% SMDD	220	190
Total Pavement Thickness		445	430

As can be seen from the tables above, the total pavement thickness reduces by 80mm (ie. Option 1 cf Option 2) if a higher quality crushed sandstone is brought onto site. Where a thin AC surfacing, such as the 25mm thick options provided above, is subjected to heavy traffic and slewing loads, then the AC may be susceptible to breakdown, possibly requiring early maintenance. The above pavement thicknesses assume that good surface and subsurface drainage will be provided.

The following elastic modulus (E) assumptions were made for the AC pavement layer thickness designs:

- AC10 wearing course: E=2500MPa
- Unbound base course layer (DGB20): E=450MPa
- Unbound sub-base course layer (DGS40): E=250MPa

All base materials to be DGB20 in accordance with RTA QA Specification 3051 unbound base. The base course layer should be compacted to at least 98% of Modified Maximum Dry Density (MMDD). All sub-base materials (Option 3 only) to be DGS40 in accordance with RTA QA Specification 3051 unbound base. The sub-base layer should be compacted to at least 95% of MMDD. All select fill materials should be compacted to at least 100% of SMDD, as outlined in Section 4.2.4.

4.3.2 Concrete Pavements

The following assumptions were made for the concrete pavement design:

- An ESA/HVAG (heavy vehicle axle group) damage index value of 0.4; that is. design HVAG of 2.5×10^5.
- A minimum characteristic concrete compressive strength of 32MPa;
- The concrete is reinforced;
- No concrete shoulders.
- A load safety factor of 1.2.

Our recommended concrete pavement thicknesses, on the basis of a subgrade CBR of 2.0% and a design traffic load of 2.5×10^5 HVAGs, are tabulated below. The design has been carried out in accordance with Section 12 of Austroads 2008 ("*Guide to Pavement Technology, Part 2: Pavement Structural Design*").

Pavement Layer	Material Type	Minimum Thickness (mm)
Base Course	Concrete	220
Sub-base Course	Unbound Granular	100
Total Pavement Thickness		320

Depending on the thickness and quality of imported crushed sandstone select fill that may be placed and compacted below design subgrade level, the thickness of the concrete wearing course could be reduced as tabulated below:

Imported Crushed Sandstone CBR Value (%)	Thickness of Crushed Sandstone Select Fill Below Design Subgrade Level (m)	Equivalent Design CBR Value (%)	Concrete Base Course Thickness (mm)
NA	0	2.0	220
10	0.3	3.5	220
10	0.5	5.0	200
20	0.3	4.3	205
20	0.5	6.4	195

As shown above, there is no saving in the concrete thickness by placing a 300mm thick layer of imported CBR 10% crushed sandstone.

The above pavement thicknesses assume that good surface and subsurface drainage will be provided. We have assumed that the reinforcement and joint design will be carried out by others. Nonetheless, in accordance with Section 12.9.5 of Austroads 2008, the minimum steel reinforcing fabric size should be SL92 rather than SL82, which was assumed by C&M Consulting Engineers Pty Ltd in ProjectWeb Correspondence No. 7027.

We recommend that the sub-base course comprise good quality fine crushed rock such as RTA Specification 3051 unbound base (eg. DGB20) or similar quality, and compacted to a minimum density of 98% of MMDD. All select fill materials should be compacted to at least 100% of SMDD, as outlined in Section 4.2.4.

4.3.3 General

Density tests should be regularly carried out on all granular base and sub-base layers to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per 1000m^2, or three tests per layer, or three tests per visit, whichever requires the most tests. Level 2 testing of fill compaction is the minimum permissible in AS3798-2007.

Subsoil drains should be provided along the edges of the proposed pavements, with invert levels of at least 200mm below subgrade level. The drainage trenches should be excavated with a uniform longitudinal fall to appropriate discharge points so as to reduce the risk of water ponding. The subgrade should be graded to promote water flow towards the subsoil drains. Discharge from the subsoil drains should be piped to the stormwater system.

4.4 Additional Geotechnical Input

We summarise below the previously recommended additional work that needs to be carried out:

1 Test pit investigation or geotechnical inspection to more accurately confirm the stripping depth of AC, topsoil and root affected soils, if required.
2 Proof-rolling inspections.
3 Sieve analysis and soaked CBR testing, together with geotechnical inspection of all imported fill materials.
4 Density testing of all engineered fill and granular pavement materials.

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 Jeffery and Katauskas Pty Ltd 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 the proposed new 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 judgement from an experienced engineer. Such judgement 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 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.

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 Jeffery and Katauskas Pty Ltd. 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.

Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

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South-Western Sydney Office Manager

Reviewed By:

Agi Zenon
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For and on behalf of
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SOIL TEST SERVICES

ABN 43 002 145 173

Ref No: M21956ZA2

TABLE A
SUMMARY OF FOUR DAY SOAKED C.B.R.TEST RESULTS

BOREHOLE NUMBER	R5	R7	R10	R12	R15
DEPTH (m)	0.40 - 1.40	0.50 - 1.50	0.80 - 1.50	0.50 - 1.00	0.40 - 1.40
Surcharge (kg)	9.0	9.0	9.0	9.0	9.0
Maximum Dry Density (t/m^3)	1.740 STD	1.653 STD	1.555 STD	1.783 STD	1.695 STD
Optimum Moisture Content (%)	18.1	19.5	20.8	16.7	19.5
Moulded Dry Density (t/m^3)	1.69	1.52	1.40	1.74	1.67
Sample Density Ratio (%)	97	92	90	98	98
Sample Moisture Ratio (%)	124	154	160	109	100
Moisture Contents					
Insitu (%)	22.5	30.0	33.3	18.3	17.3
Moulded (%)	22.5	30.0	33.3	18.3	19.5
After soaking and					
After Test, Top 30mm(%)	27.6	33.3	34.5	20.1	30.5
Remaining Depth (%)	24.9	30.7	34.0	19.5	23.1
Material Retained on 19mm Sieve (%)	0	0	0	0	0
Swell (%)	0.0	0.0	0.0	0.4	3.2
C.B.R. value: @2.5mm penetration					
@5.0mm penetration	3.0	1.5	2.0	3.5	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

NATA

NATA Accredited Laboratory
Number:1327

Approved Signatory
(A.Tatikonda)

Date: 3/9/08

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TABLE A
SUMMARY OF FOUR DAY SOAKED C.B.R.TEST RESULTS

BOREHOLE NUMBER	R16	R17	R18	R19
DEPTH (m)	0.40 - 1.40	0.50 - 1.50	0.00 - 1.00	0.40 - 1.00
Surcharge (kg)	9.0	9.0	9.0	9.0
Maximum Dry Density (t/m^3)	1.619 STD	1.567 STD	1.619 STD	1.561 STD
Optimum Moisture Content (%)	22.8	25.0	22.0	25.0
Moulded Dry Density (t/m^3)	1.59	1.54	1.53	1.46
Sample Density Ratio (%)	98	98	94	93
Sample Moisture Ratio (%)	100	102	120	120
Moisture Contents				
Insitu (%)	22.8	25.4	26.4	30.0
Moulded (%)	22.8	25.4	26.4	30.0
After soaking and				
After Test, Top 30mm(%)	28.6	28.8	28.7	32.8
Remaining Depth (%)	28.3	28.3	27.3	31.8
Material Retained on 19mm Sieve (%)	0	0	0	0
Swell (%)	1.5	1.6	0.0	0.0
C.B.R. value: @2.5mm penetration				
@5.0mm penetration	2.5	2.5	2.5	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

Approved Signatory
(A. Tatikonda)

Date: 3/9/08

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **R1**

1/1

Client: BOVIS LEND LEASE PTY LTD

Project: PROPOSED NEW INTERNAL ROADS

Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2 **Method:** HAND AUGER **R.L. Surface:** ≈ 10.2m

Date: 24-4-08 **Datum:** AHD

Logged/Checked by: A.C./AB

Groundwater Record	SAMPLES ES	SAMPLES U50	SAMPLES DB	SAMPLES DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION					REFER TO DCP TEST RESULTS	0			ASPHALTIC CONCRETE: 80mm.t				
									FILL: Silty sand, fine to medium grained, yellow brown, with a trace of fine grained gravel.	M			HAND AUGER REFUSAL
									END OF BOREHOLE AT 0.085m				
						0.5							
						1							
						1.5							
						2							
						2.5							
						3							
						3.5							

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Borehole No.
R2
1/1

BOREHOLE LOG

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2 **Method:** HAND AUGER **R.L. Surface:** ≈ 10.0m
Date: 24-4-08 **Datum:** AHD
Logged/Checked by: A.C./AJ

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				■	REFER TO DCP TEST RESULTS	0			ASPHALTIC CONCRETE: 80mm.t				
									FILL: Silty sand, fine to medium grained, yellow brown, with fine to coarse grained gravel.	M			
									END OF BOREHOLE AT 0.2m				HAND AUGER REFUSAL
						0.5							
						1							
						1.5							
						2							
						2.5							
						3							
						3.5							

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BOREHOLE LOG

Borehole No. **R3** 1/1

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2 **Method:** HAND AUGER **R.L. Surface:** ≈ 9.8m
Date: 24-4-08 **Datum:** AHD
Logged/Checked by: A.C./AJ

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					REFER TO DCP TEST RESULTS	0			ASPHALTIC CONCRETE: 100mm.t				
									FILL: Silty sand, fine to medium grained, yellow brown.	M			HAND AUGER REFUSAL
									END OF BOREHOLE AT 0.12m				
						0.5							
						1							
						1.5							
						2							
						2.5							
						3							
						3.5							

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Borehole No.
R4
1/1

BOREHOLE LOG

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
R.L. Surface: ≈ 9.9m
Datum: AHD
Logged/Checked by: A.C./AJ

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 sandy clay, medium to high plasticity, grey brown.	MC > PL			APPEARS POORLY COMPACTED
					N = 6 3,3,3	0.5			FILL: Silty gravelly sand, fine to medium grained, dark grey brown, fine to medium grained gravel.	M			
						1							
						1.5			END OF BOREHOLE AT 1.5m				
						2							
						2.5							
						3							
						3.5							

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Borehole No.
R5
1/1

BOREHOLE LOG

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
Logged/Checked by: A.C./AJ
R.L. Surface: ≈ 9.3m
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			0			FILL/TOPSOIL: Silty clay, medium plasticity, dark brown, with root fibres.	MC>PL			GRASS COVER
					CH	SILTY CLAY: high plasticity, orange and grey brown.	MC>PL	VSt	-	ALLUVIAL
		N = 6 1,3,3	0.5						300 330 440	
			1			as above, but red and grey brown.				
		N = 14 4,7,7	1.5						300 260 310	
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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Borehole No.
R6
1/1

BOREHOLE LOG

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 24-4-08
Method: SPIRAL AUGER JK300
R.L. Surface: ≈ 8.7m
Datum: AHD
Logged/Checked by: A.C./AG

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: 100mm.t over ROADBASE: 400mm.t				
		N = 16 6,6,10	0.5		CL	SILTY CLAY: medium plasticity, grey and orange brown.	MC>PL	H	>600 >600 >600	ALLUVIAL
			1							
		N = 16 3,6,10	1.5						550 510 520	
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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BOREHOLE LOG

Borehole No.
R7
1/1

Client: BOVIS LEND LEASE PTY LTD

Project: PROPOSED NEW INTERNAL ROADS

Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2 **Method:** SPIRAL AUGER JK300 **R.L. Surface:** ≈ 9.1m

Date: 24-4-08 **Datum:** AHD

Logged/Checked by: A.C./AG

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		0		ASPHALTIC CONCRETE: 100mm.t over ROADBASE: 300mm.t				
				FILL: Clayey sand, fine to medium grained, yellow and grey brown.	M			
	N = 8 2,3,5	0.5	CL-CH	SILTY CLAY: medium to high plasticity, grey and orange brown.	MC>PL	H	460 460 400	ALLUVIAL
		1						
	N = 16 3,6,10	1.5		SILTY CLAY: medium to high plasticity, grey, red brown and orange brown.			530 520 550	
		2		END OF BOREHOLE AT 1.95m				
		2.5						
		3						
		3.5						

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BOREHOLE LOG

Borehole No. **R8**

1/1

Client: BOVIS LEND LEASE PTY LTD

Project: PROPOSED NEW INTERNAL ROADS

Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2

Date: 24-4-08

Method: SPIRAL AUGER JK300

R.L. Surface: ≈ 9.4m

Datum: AHD

Logged/Checked by: A.C./AG

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			ASPHALTIC CONCRETE: 100mm.t over ROADBASE: 300mm.t				
						FILL: Clayey sand, fine to medium grained, yellow and grey brown.	M			
	DS	N = 12 5,6,6	0.5		CL-CH	SILTY CLAY: medium to high plasticity, grey and yellow brown, with a trace of root fibres.	MC>PL	VSt -H	440 330 270	ALLUVIAL
			1							
	DS	N = 8 2,3,5	1.5			SILTY CLAY: medium to high plasticity, grey, red brown and orange brown.			450 440 340	
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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Borehole No.
R9
1/1

BOREHOLE LOG

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 24-4-08
Method: SPIRAL AUGER JK300
Logged/Checked by: A.C./[illegible]
R.L. Surface: ≈ 9.3m
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			0			ASPHALTIC CONCRETE: 100mm.t over ROADBASE: 300mm.t				
						FILL: Clayey sand, fine to medium grained, yellow and grey brown.	M			
		N = 6 3,3,3	0.5		CL-CH	SILTY CLAY: medium to high plasticity, grey brown.	MC>PL	H	420 430 350	ALLUVIAL
			1							
		N = 15 3,6,9	1.5			SILTY CLAY: medium to high plasticity, grey, red brown and orange brown.			430 500 490	
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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BOREHOLE LOG

Borehole No.
R10
1/1

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 24-4-08
Method: SPIRAL AUGER JK300
R.L. Surface: ≈ 9.6m
Datum: AHD
Logged/Checked by: A.C./AG

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		0		ASPHALTIC CONCRETE: 100mm.t over ROADBASE: 300mm.t				
	N = 7 4,3,3	0.5		FILL: Clayey sand, fine to medium grained, yellow and grey brown.	M			APPEARS POORLY COMPACTED
		1	CL-CH	SILTY CLAY: medium to high plasticity, grey and yellow brown.	MC>PL	VSt	310 340 220	ALLUVIAL
	N = 15 4,7,8	1.5		SILTY CLAY: medium to high plasticity, grey, red brown and yellow brown.		VSt -H	440 380 480	
		2		END OF BOREHOLE AT 1.95m				
		2.5						
		3						
		3.5						

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BOREHOLE LOG

Borehole No.
R11
1/1

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 24-4-08
Method: SPIRAL AUGER JK300
R.L. Surface: ≈ 8.9m
Datum: AHD
Logged/Checked by: A.C./AG

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: 10mm.t over ROADBASE: 390mm.t				
		N = 9 3,3,6	0.5			FILL: Silty sandy clay, low plasticity, grey brown, with fine to medium grained igneous gravel.	MC>PL			APPEARS MODERATELY COMPACTED
		N = 19 5,8,11	1 1.5		CL	SILTY CLAY: medium plasticity, yellow and grey brown.	MC≈PL	H	- 550 >600 >600	ALLUVIAL
			2 2.5 3 3.5			END OF BOREHOLE AT 1.95m				

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BOREHOLE LOG

Borehole No. **R12**
1/1

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 24-4-08
Method: SPIRAL AUGER JK300
R.L. Surface: ≈ 9.8m
Datum: AHD
Logged/Checked by: A.C./A

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: Clayey sand, fine to medium grained, brown, with fine to medium grained igneous gravel and a trace of root fibres.	M			GRASS COVER
		N = 6 1,2,4	0.5			FILL: Silty clay, medium to high plasticity, orange brown.	MC>PL			APPEARS POORLY TO MODERATELY COMPACTED
		N = 8 3,3,5	1.5		CH	SILTY CLAY: high plasticity, yellow brown.	MC>PL	VSt	250 260 360	ALLUVIAL
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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Borehole No.
R13
1/1

BOREHOLE LOG

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
Logged/Checked by: A.C./ AJ
R.L. Surface: ≈ 9.4m
Datum: AHD

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		0	CH	SILTY CLAY: high plasticity, grey and orange brown.	MC>PL	St		ALLUVIAL
	N = 9 1,3,6	0.5					160 160 150	
		1		as above, but with a trace of ironstone gravel.				
	N = 11 1,4,7	1.5				VSt-H	420 390 400	
		2		END OF BOREHOLE AT 1.95m				
		2.5						
		3						
		3.5						

SAMPLES: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No. **R14**
1/1

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
Logged/Checked by: A.C./AJ
R.L. Surface: ≈ 9.4m
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			FILL: Silty clay, medium to high plasticity, dark grey and orange brown, with ash and brick fragments.	MC>PL			
			0.5		CH	SILTY CLAY: high plasticity, grey and orange brown.	MC>PL	VSt	-	ALLUVIAL
		N = 7 1,2,5							260 250 220	
			1			as above, but red and grey brown.				
		N = 10 3,4,6	1.5							
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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BOREHOLE LOG

Borehole No.
R15
1/1

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
Logged/Checked by: A.C./ [illegible]
R.L. Surface: ≈ 9.4m
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			FILL: Silty clayey sand, fine to medium grained, grey brown.	M			
		N = 13 6,6,7	0.5		CL	SILTY CLAY: medium plasticity, grey, red brown and orange brown.	MC≈PL	H	- >600 >600 >600	ALLUVIAL
			1							
		N = 39 9,16,23	1.5			as above, but grey and orange brown.			>600 >600 >600	
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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BOREHOLE LOG

Borehole No.
R16
1/1

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
Logged/Checked by: A.C./
R.L. Surface: ≈ 9.4m
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		CH	SILTY CLAY: high plasticity, grey and orange brown.	MC>PL	VSt		ALLUVIAL
		N = 9 1,4,5	0.5						260 220 230	
			1							
		M = 24 4,9,15	1.5			as above, but with a trace of ironstone gravel.		H	490 490 >600	
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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BOREHOLE LOG

Borehole No.
R17
1/1

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
Logged/Checked by: A.C./
R.L. Surface: ≈ 9.4m
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		CL-CH	SILTY CLAY: medium to high plasticity, orange brown.	MC>PL	VSt		ALLUVIAL
		N = 6 2,2,4	0.5			as above, but grey and red brown, with a trace of root fibres.			300 400 320	
			1							
		N = 22 7,9,13	1.5		CL	SILTY CLAY: medium plasticity, grey and red brown.	MC≈PL	H	>600 >600 >600	
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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Borehole No.
R18
1/1

BOREHOLE LOG

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
R.L. Surface: ≈ 9.8m
Datum: AHD
Logged/Checked by: A.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		CL-CH	SILTY CLAY: medium to high plasticity, orange and grey brown.	MC>PL	VSt		ALLUVIAL
		N = 5 1,2,3	0.5			as above but red brown and grey.			210 260 200	
			1							
		N = 13 2,4,9	1.5				MC≈PL	H	410 480 540	
			2			END OF BOREHOLE AT 1.95m				
			2.5							
			3							
			3.5							

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Borehole No.
R19
1/1

BOREHOLE LOG

Client: BOVIS LEND LEASE PTY LTD
Project: PROPOSED NEW INTERNAL ROADS
Location: LIVERPOOL HOSPITAL, NSW

Job No. M21956ZA2
Date: 23-4-08
Method: SPIRAL AUGER JK300
Logged/Checked by: A.C./ AJ
R.L. Surface: ≈ 9.8m
Datum: AHD

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0		FILL: Silty clay, medium to high plasticity, grey and brown, with ash and brick fragments.				
				CL-CH	SILTY CLAY: medium to high plasticity, orange and grey brown.	MC>PL	St	-	
		N = 4 1,1,3	0.5					170 180 130	ALLUVIAL
			1						
					SILTY CLAY: medium to high plasticity, grey and orange brown.		VSt		
		N = 10 1,3,7	1.5					350 290 300	
			2		END OF BOREHOLE AT 1.95m				
			2.5						
			3						
			3.5						

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

DYNAMIC CONE PENETRATION TEST RESULTS

Client:	BOVIS LEND LEASE PTY LTD		
Project:	PROPOSED NEW INTERNAL ROADS		
Location:	LIVERPOOL HOSPITAL, NSW		
Job No.	M21956ZA2	Hammer Weight & Drop: 9kg/510mm	
Date:	24-4-08	Rod Diameter: 16mm	
Tested By:	A.C.	Point Diameter: 20mm	

Test Location / Depth (mm)	Number of Blows per 100mm Penetration						
	R1	**R2**	**R3**				
0 - 100	EXCAVATED	EXCAVATED	EXCAVATED				
100 - 200	7/10mm	10	16/20mm				
200 - 300	REFUSAL	6/80mm	REFUSAL				
300 - 400		REFUSAL					
400 - 500							
500 - 600							
600 - 700							
700 - 800							
800 - 900							
900 - 1000							
1000 - 1100							
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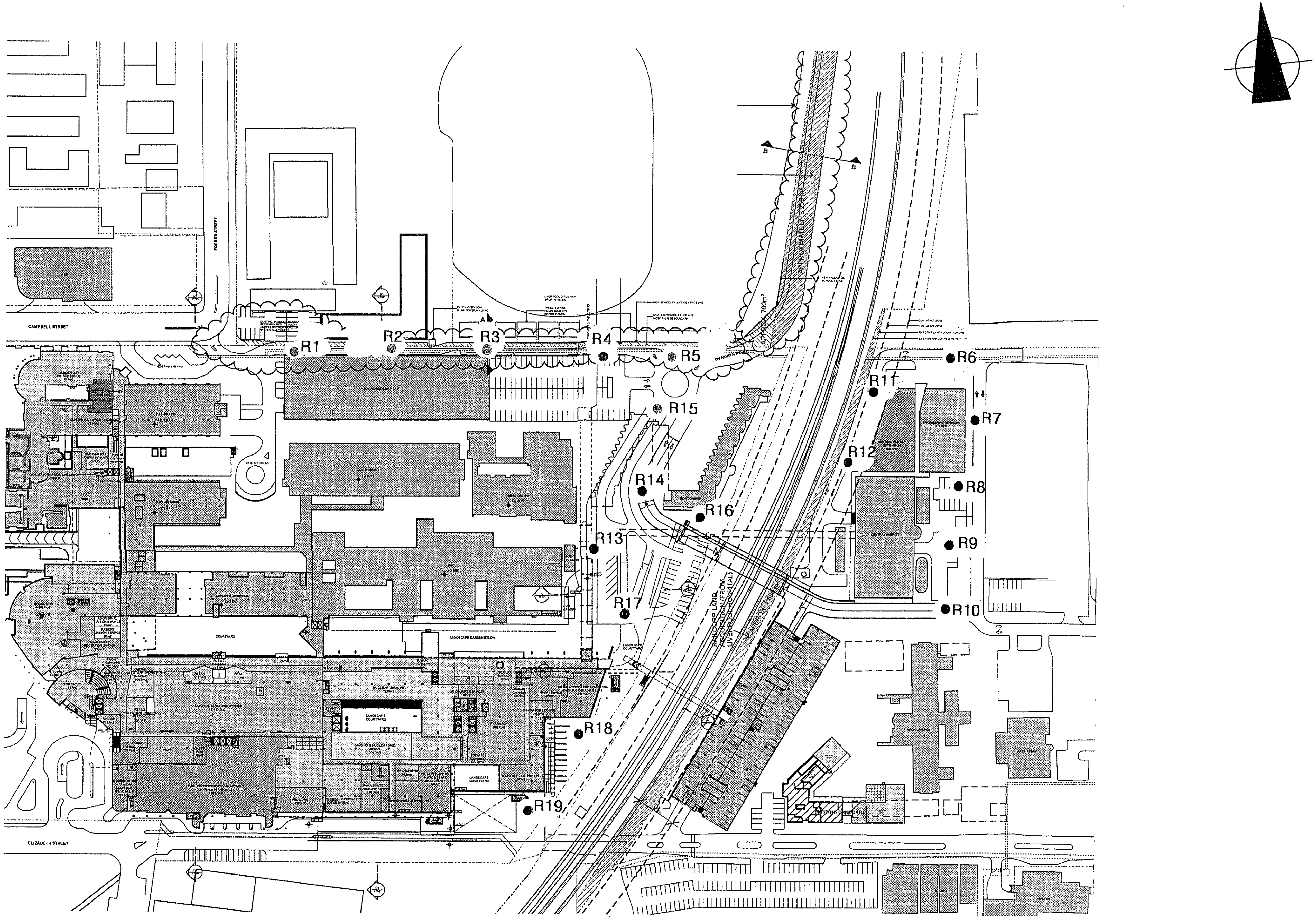
2300 - 2400							
2400 - 2500							
2500 - 2600							
2600 - 2700							
2700 - 2800							
2800 - 2900							
2900 - 3000							

Remarks:
1. The procedure used for this test is similar to that described in AS1289.6.3.2-1997, Method 6.3.2.
2. Usually 8 blows per 20mm is taken as refusal

Ref: Scala3.xls April 99



SCALE (m)

0 100

NOTES:

1. R1 to R3 were completed using a hand auger and Dynamic Cone Penetrometer.
2. R4 to R19 were completed using our track mounted JK300 drill rig.

BOREHOLE LOCATION PLAN

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

Report No. M21956ZA2 **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

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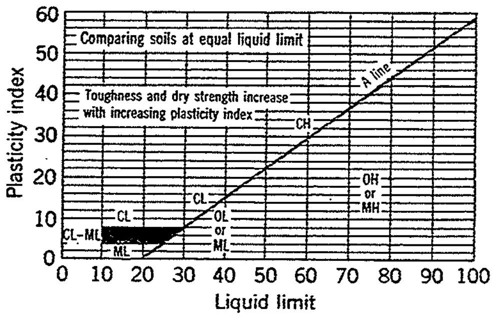
UNIFIED SOIL CLASSIFICATION TABLE

Major divisions			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	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	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics		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	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*)		$C_U = \frac{D_{60}}{D_{10}}$ 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

Identification Procedures on Fraction Smaller than 380 μm Sieve Size

Major divisions		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils More than half of material is *smaller* than 75 μm sieve size	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
		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	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	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	Example:
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	*Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
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 (e.g. 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.

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LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		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	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. '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	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.

LOG COLUMN	SYMBOL	Density Index (I_D)	Range (%)	SPT 'N' Value Range (Blows/300mm)
Density Index/ Relative Density (Cohesionless Soils)	VL	Very Loose	<15	0-4
	L	Loose	15-35	4-10
	MD	Medium Dense	35-65	10-30
	D	Dense	65-85	30-50
	VD	Very Dense	>85	>50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.		

LOG COLUMN	SYMBOL	DEFINITION
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

Ref: Standard Sheets/Log Symbols
November 2007

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LOG SYMBOLS

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	