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REPORT
on
GEOTECHNICAL INVESTIGATION

PROPOSED AUSTRALIAN HEARING HUB
CNR UNIVERSITY AVENUE AND MACQUARIE DRIVE
MACQUARIE PARK

Prepared for
MACQUARIE UNIVERSITY

Project 71683.00
April 2010

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REPORT ON GEOTECHNICAL INVESTIGATION
PROPOSED AUSTRALIAN HEARING HUB
CNR UNIVERSITY AVENUE AND MACQUARIE DRIVE, MACQUARIE PARK

1. INTRODUCTION

This report presents the results of a geotechnical investigation undertaken for the proposed Australian Hearing Hub (AHH) within the Macquarie University campus, at the corner of University Avenue and Macquarie Drive, Macquarie Park. The investigation was commissioned by Coffey Projects (Australia) Pty Ltd on behalf of Macquarie University.

It is understood that the AHH development will include construction of a new six-storey research/commercial building with two levels of basement carparking. The basement floor level varies from RL65.5 to RL66.5 m and will mostly require excavation to depths of approximately 6 m to 8 m. The western end of the basement extends into a local high spot and will require excavation to depths of approximately 9.5 m. It is understood that column working loads may be in the order of 7500 kN. Site investigation was carried out to provide information on subsurface conditions for the design and planning of excavations, retaining walls and foundations.

The field work for the investigation included the drilling of seven rock cored boreholes, nine shallow augered boreholes and the installation of three groundwater monitoring wells for sampling and measurement of groundwater levels. Laboratory testing of selected soil and rock core samples was undertaken, followed by engineering analysis and reporting. Details of the field work are given in the report, together with comments on design and construction practice.

Douglas Partners Pty Ltd (DP) have also carried out a Targeted Phase 2 Contamination Assessment (Project No. 71683.01, dated April 2010) on the site in conjunction with the geotechnical investigation, the results of which have been reported separately.

2. SITE DESCRIPTION

The site of the proposed development is situated on the southern side of the Macquarie University campus in Macquarie Park and is located on the north-eastern corner of the intersection between University Avenue and Macquarie Drive. The site is an irregular-shaped lot and covers an area of approximately 7200 m^2.

The site is located on a low hill which slopes at approximately 3 degrees towards the east and south-east. A local high spot is located on the western end of the site with a surface level of approximately RL76 m relative to Australian Height Datum (AHD), however, the ground surface on the majority of the site typically varies from between RL 74 to RL 72 m.

At the time of the investigation the site was mostly occupied by two three-storey concrete carparks with surrounding footpaths and grass covered areas. Western Road currently runs through the western end of the site. Batter slopes approximately 1 m to 2 m high are located along the eastern and southern sides of the site. The batters generally exposed ripped shale and clay filling over natural clay and weathered shale. Weathered shale was also exposed on the mound on the western end of the site.

The site is bounded by roadways to the north, south and west which are generally set back approximately 10 m to 15 m from the site boundaries. Undeveloped grassed areas and on-grade carparking are generally located on the properties to the south and west of the site.

On the property to the east of the site there is a three-storey concrete carpark which is set back approximately 10 m from the common boundary.

To the north of the site, on the northern side of Macquarie Drive, there is a construction site for the Macquarie University Library. Bulk earthworks have been completed and construction of the structure has commenced.

3. BACKGROUND

DP previously carried out a geotechnical investigation (Project 45140, dated October 2007) for the new library to the north of the site. DP subsequently carried out the design of the soil nail support system in consultation with the structural engineers for the project and then carried out detailed inspections of the excavation and soil nail wall installation. Relevant information from DPs involvement on this project is included in this report.

DP also previously carried out a geotechnical investigation (Project 45298, dated March 2008) for the Cochlear Global Headquarters to the south-east of the site, which is currently under construction. The investigation included the installation of a groundwater monitoring well (BH1/45298) towards the south-eastern corner of the AHH site, as indicated on Drawing 1 in Appendix A. Groundwater was not encountered within a depth of 8 m in this monitoring well at the time of the previous investigation.

4. GEOLOGY

Reference to the Sydney 1:100 000 Geological Series Sheet 9130 indicates that the site is located close to the boundary between Hawkesbury Sandstone and Ashfield Shale. The boundary is often marked by a thin (typically less than 6 m) transitional unit known as the Mittagong Formation.

Ashfield Shale typically comprises dark grey to black shale, siltstone and laminite which weathers to a residual clay profile of medium to high plasticity. Hawkesbury Sandstone typically comprises medium to coarse grained quartz sandstone with some shale bands or lenses.

The Mittagong Formation generally comprises quartz sandstone similar to, but finer grained than the underlying Hawkesbury Sandstone, with interbedded siltstone and shale bands and laminations.

The geological mapping was confirmed by the field work which identified shallow residual soils overlying shale, siltstone and laminite.

5. FIELD WORK METHODS

The field work included seven rock cored boreholes (BH1 to BH7 inclusive) drilled to depths of about 12 m and nine augered boreholes (BH8 to BH16) drilled to depths of 0.6 m to 3.5 m. Boreholes 1 to 11 were drilled using a bobcat or truck-mounted drilling rig and BH12 to 16 were drilled using a 2-tonne excavator with an auger attachment.

The boreholes were drilled using spiral augers and rotary washboring within the soil and extremely weathered rock to depths of 0.6 m to 3.5 m. BH1 to BH7 were then cased and continued into the underlying rock using diamond core drilling techniques to obtain continuous core samples of the bedrock.

Standard Penetration Tests (SPTs) were carried out at a depth 1.0 m in some of the boreholes to sample the soil and extremely weathered rock and to assess the in-situ strength of the materials. Disturbed soil samples were also retrieved from the boreholes during drilling for identification and laboratory testing of selected samples.

The rock cores were returned to the DP office where they were logged by a geologist, the cores photographed and Point Load Strength Index (Is_{50}) tests carried out on selected samples of the rock core.

Groundwater monitoring wells (50 mm diameter slotted PVC) were installed in BH 1, 3 and 8 to depths of 12.0 m, 12.0 m and 3.5 m respectively to allow for the measurement of the groundwater level during the investigation period and for sampling of the groundwater for the contamination assessment. No long term monitoring of groundwater levels was carried out.

The borehole locations are shown on Drawing 1 in Appendix A.

The ground surface level at each of the borehole locations was interpolated from spot heights relative to AHD shown on the survey plan (Project No. 30431, dated 31/3/10) by Lockley Land Title Solutions Pty Ltd.

6. FIELD WORK RESULTS

Details of the subsurface conditions encountered are given in the borehole logs in Appendix B, together with colour photographs of the rock core samples and notes defining classification methods and descriptive terms.

The boreholes encountered a subsurface profile typically comprising pavements and/or shallow filling over stiff to hard residual clay to depths of 0.2 m to 2.2 m over weathered bedrock. The bedrock generally comprised extremely low to very low then very low to low strength shale and siltstone to depths of 3 m to 6 m, grading to medium to high then high strength siltstone and laminite. The rock sequence was somewhat variable and included higher and lower strength bands down to depths of 7.0 m to 10.0 m where more uniform high strength rock was encountered. The laminite included thick bands of fine grained sandstone at some locations. An interpreted geotechnical model is presented in Section 9.

No free groundwater was observed during augering of the boreholes (i.e. within depths of 0.6 m to 3.5 m) and the use of water during wash boring and coring within the bedrock prevented the measurement of groundwater below this depth. The water level within the groundwater monitoring wells was measured on 16 April 2010 at depths of 10.5 m (RL63.5 m) in BH1 and 11.5 m (RL60.0 m) in BH3. The groundwater well in BH8 was dry to a depth of 3.5 m on 16 April 2010. The water levels were measured following development of the wells on 12 April 2010 as part of the contamination assessment.

7. LABORATORY TEST RESULTS

One sample of silty clay from BH7 (0.7-0.8 m) was tested in the DP laboratory to determine the four-day soaked Californian Bearing Ratio (CBR) value and four samples of soil and weathered rock were tested at an external laboratory to assess aggressivity (pH, chloride and sulphate content). The results of the laboratory testing are included in Appendix C and summarised in Tables 1 and 2.

Table 1 – Summary of Laboratory Test Results

Borehole	Depth (m)	Material	W_f (%)	OMC (%)	MDD (t/m^3)	Swell (%)	4-day soaked CBR (%)
BH7	0.7-0.8m	Silty Clay	17.6	20	1.67	3.5	2

W_f = Field Moisture Content OMC = Optimum Moisture Content
MDD = Maximum Dry Density CBR = Californian Bearing Ratio

The relatively low CBR value of 2% indicates that the clay soils lose substantial strength upon saturation.

Table 2 – Summary of Laboratory Chemical Analysis

Borehole	Depth (m)	Material	pH	Chloride, Cl^- (mg/L)	Sulphate, SO_4^{2-} (mg/L)
BH2	0.5-0.7	Filling : sand	8.6	6.5	91
BH4	0.6-0.8	Shale	4.4	17	40
BH5	0.8-1.0	Shale	6.5	18	17
BH7	0.8-1.0	Silty Clay	4.3	37	130

Based on the results of the pH, sulphate and chloride test results and reference to Table 6.4.2(C) of AS 2159 – 2009, the site soils and shale may be assumed to have a 'mild' to 'moderate' exposure classification with respect to buried, reinforced concrete, structural elements.

8. POINT LOAD STRENGTH TESTS

Selected samples of the rock core were tested in the laboratory to determine the Point Load Strength Index (Is_{50}) values. The results of the testing are shown on the bore logs at the appropriate depths.

It is noted that Is_{50} tests are not readily carried out on extremely low to very low strength rock and hence strength classification for the weaker rock is based on visual/tactile assessments of the rock core. The Is_{50} values for the various rock strata are described below together with the estimated unconfined compressive strength (UCS) which is based on a UCS:Is_{50} ratio of 1:20.

The Is_{50} values for the rock cores generally ranged from 0.3 MPa to 2.0 MPa, corresponding to a low to high strength classification (estimated UCS ranging from 6 MPa to 40 MPa). Higher Is_{50} values of up to 3.4 MPa were measured on some high to very strength rock cores at some locations.

9. INTERPRETED GEOTECHNICAL MODEL

Two geotechnical cross sections (Sections A-A' and B-B') showing the interpreted subsurface profile between the boreholes are shown on Drawings 2 and 3 in Appendix B. The sections show interpreted geotechnical divisions of underlying soil and rock together with the extent of the proposed basement excavations. A summary of the depths (and reduced level) to the top of the various rock strata encountered in the rock core boreholes is provided in Table 3. It should be noted that the rock profile has been divided into generalised strength layers and some lower and higher strength bands of rock are encountered within these layers at some locations. Reference should be made to the borehole logs for more detailed information and descriptions of the rock. The orientations of the cross-sections are shown on Drawing 1.

The interpreted geotechnical model for the site is outlined below:

- the existing carpark pavements comprise a 50-80 mm thick layer of asphaltic concrete (AC) over road base to a depth of 0.2-0.3 m.

- below the pavements and topsoil, ripped shale and clay filling is generally encountered to depths of approximately 0.5 m to 1.0 m. Sandy filling is present at some locations.
- a thin layer of stiff to hard residual clay underlies the filling at some locations to depths of approximately 1 m to 2 m (i.e. BH1, 6 and 7).
- weathered bedrock is encountered below the filling and clay at depths of approximately 0.5 m to 2.0 m. The bedrock generally comprises extremely low to very low then very low to low strength shale and siltstone (Ashfield Shale) to depths of 3 m to 6 m grading to medium to high then high strength siltstone and laminite (possibly Mittagong Formation). The rock sequence is somewhat variable and includes higher and lower strength bands and fragmented and highly fractured zones down to depths of 7.0 m to 10.0 m, where more uniform slightly fractured and unbroken, high strength rock was encountered. The laminite includes thick bands of fine grained sandstone at some locations. The rock included numerous moderately and steeply dipping joints with dips ranging from 30 degrees below horizontal to sub-vertical.
- groundwater seepage should be expected near the interface of the residual clay and rock surface and may also occur within fractured zones and joints within the underlying rock profile. Inspections during excavation on the adjacent Library site suggest that seepage, if encountered, will be minimal. Groundwater seepage flows are likely to increase following periods of extended wet weather.

Table 3 – Summary of Depths (and Reduced Level) to Top of Various Rock Strata in Rock Cored Boreholes

Borehole	Surface RL (AHD)	Depth & Reduced Level to Top of Various Rock					
		EL-VL Shale/ Siltstone	VL-L Siltstone/ Laminite**	L-M Siltstone/ Laminite**	M Siltstone/ Laminite**	M-H Siltstone/ Laminite**	H Siltstone/ Laminite**
1	74.0	2.2 (71.8)	-	6.2 (67.8)	8.5 (65.5)	-	10.0 (64.0)
2	74.2	0.8 (73.4)	2.8 (71.8)	6.0 (68.2)	7.9 (66.3)	-	9.8 (64.4)
3	71.5	0.2 (71.3)	3.9 (67.6)	-	4.9 (66.6)	-	7.9 (63.6)
4	70.7	0.5 (70.2)		3.6 (67.1)	7.0 (63.7)	-	7.6 (63.1)
5	73.3	0.3 (73.0)	-	3.0 (70.3)	4.1 (69.2)	6.0 (67.3)	7.1 (66.2)
6	73.0	1.2 (71.8)	6.3 (66.7)	-	7.1 (65.9)	-	8.1 (64.9)
7	70.0	1.9 (68.1)	3.0 (67.0)	-	-	5.3 (64.7)	7.0 (63.0)

Notes: Bracketed numbers are the Reduced Level (to AHD) for the top of the stratum
EL = extremely low strength rock M = medium strength rock
VL = very low strength rock H = high strength rock
L = low strength rock
** Laminite includes thick bands on fine grained sandstone at some locations and bands of lower and higher strength rock are generally encountered throughout the upper rock sequence. Refer to the borehole logs for more detailed information.

10. COMMENTS

10.1 Proposed Development

Based on architectural drawings dated 14 April 2010 by Perumal Pedavoli Pty Ltd, it is understood that the AHH development will include construction of a new six-storey research/commercial building with two levels of basement carparking. The basement floor level steps down to the south from RL66.5 to RL65.5 and will mostly require excavation to depths of approximately 6 m to 8 m. The western end of the basement extends into a local high spot and will require excavation to depths of approximately 9.5 m. It is understood that column working loads may be in the order of 7500 kN.

10.2 Site Preparation and Earthworks

10.2.1 Excavation Conditions

The investigation indicates that excavation for the basements will require the removal of soil and extremely low to low strength rock to depths of approximately 3 m to 6 m followed by low to medium strength then medium and high strength rock in the lower half of the basement. It is important to note that the upper layers of weathered rock contains bands of medium to high strength rock and ironstone. Slightly fractured to unbroken, high strength rock is expected towards the base of the excavation in the western end of the basement.

Excavation of soil and extremely low to low strength rock should be achievable using conventional earthmoving equipment, however the assistance of rock hammering or ripping will probably be required for effective removal of medium to high strength bands within the weathered rock sequence. Excavation of low to medium strength rock may require moderate ripping with a heavy bulldozer whilst excavation of medium and high strength rock will require heavy ripping with a large bulldozer. Productivity within medium to high strength rock is likely to be low (even with large dozers) and therefore some pre-splitting or rock hammering may be necessary to improve efficiency. The slightly fractured to unbroken rock, where encountered, may be effectively unrippable in which case large hydraulic rock breakers in conjunction with heavy ripping will be required to remove this material, particularly for detailed excavation of services and footings. Rock saws may also be used around the perimeter of the excavation to reduce vibrations and reduce over-break of the rock.

The excavation rate that can be achieved within the medium to high strength rock varies considerably and is dependent upon the degree of jointing in the rock, the rock strength, the type of machinery being used and the skill of the operator. Some of these factors vary between individual contractors and it is therefore recommended that bulk excavation tenderers be required to make their own assessment of the equipment required to carry out the work. Contractors may inspect the rock core samples at the DP office in West Ryde prior to submitting final tenders (rock cores are generally kept for 6 months after drilling unless longer holding times are requested).

10.2.2 Disposal of Excavated Material

All excavated materials will need to be disposed of in accordance with the current *Waste Classification Guidelines* (DECC, April 2008). Reference should be made to the DP Targeted Phase 2 Contamination Assessment report for details on the contamination status and waste classification of site soils.

10.2.3 Groundwater Seepage

Groundwater was measured in the groundwater monitoring wells at RL60.0 to RL63.5 which is at least 2 m below the proposed basement level. It is anticipated that the measured groundwater is probably associated with seepage flows along the interface of residual clay and bedrock and minor seepage through fractures and joints in the rock. The permanent groundwater table was not encountered within the two level basement excavation on the adjacent Library site.

During construction, it is anticipated that groundwater seepage will be relatively minor and should be readily controlled by perimeter drains connected to a "sump-and-pump" dewatering system. A drained basement will require permanent subfloor drainage below the basement floor slab connected to a sump and pump dewatering system.

10.2.4 Dilapidation Surveys

Consideration should be given to undertaking dilapidation surveys on surrounding buildings and pavements before the commencement of any excavation work in order to document any existing defects so that any claims for damage due to construction related activities can be accurately assessed.

10.2.5 Vibrations

It is anticipated that the proposed rock excavation will result in vibration of the surrounding ground, however, given that adjacent buildings are generally set back 10 m or more from the basement footprint and are generally well constructed, it is anticipated that the risk of damage resulting from vibrations would be low. Where impact breakers are required in the vicinity of adjacent structures it would be prudent to monitor and limit vibrations on these structures. Generally, a maximum peak particle velocity of 8 mm/sec (in any component direction) at the foundation level of adjacent structures is suggested for both structural and human comfort considerations.

10.3 Excavation Support

Vertical excavations within the soils and extremely low to low strength rock and also highly fractured medium to high strength rock will require both temporary and permanent lateral support during and after excavation. Due to the deeply weathered rock profile and the close proximity of the excavation to the site boundaries, it will generally be necessary to provide shoring/support over the full depth of the excavation. Some unsupported vertical excavation in medium to high strength rock may be possible towards the base of the excavation on the western part of the site.

It is understood that a permanent soil nail support system is proposed to support the basement excavation. Comments on the design and construction of a soil nail support system are provided in the following sections. There are a number of other alternatives to providing retaining support and advice on alternative systems can be provided upon request. Alternatives such as anchored soldier pile walls are generally associated with lower wall movements and are generally used where there are movement sensitive buildings or structures adjacent to the excavation.

10.3.1 Batter Slopes and Vertical Rock Faces

Suggested temporary batter slopes for unsupported excavation are shown in Table 4. These batters are subject to assessment of jointing in the rock by a geotechnical engineer. If adverse jointing is present in the rock then flatter batters or stabilisation may be required.

Table 4 – Recommended Maximum Batter Slopes

Material	Temporary Batter Slope (H:V)
Filling or natural clay soils	1.5:1
Shale/Siltstone : Extremely low to very low strength	1:1
Siltstone/laminite : Low to medium strength	0.5:1
Laminite: Medium to high strength	Vertical*

Notes: *Vertical excavation is subject to jointing and geotechnical inspection

Excavations in slightly fractured to unbroken, medium or greater strength laminite may be self-supporting (subject to joint orientation) and may be cut vertically. It is anticipated that the extent

of vertical rock excavation on the site will be limited and may only be possible on the western end of the site below about RL67.5 (refer to BH5). The extent of vertical rock excavation will need to be assessed as the excavation proceeds. All vertical rock faces must be progressively inspected by a geotechnical engineer at 1.5 m depth intervals to check for adversely inclined joints and to assess whether additional stabilisation measures are required. Stabilisation of vertical rock faces may include shotcrete of fractured or highly weathered zones or rock bolts/soil nails where adverse joints form potentially unstable wedges of rock. All rock faces will require shotcrete protection in the long term to prevent weathering and fretting.

10.3.2 Soil Nail Support System

It is understood that a permanent soil nail and shotcrete wall is being considered for support of the excavation. Soil nailing is an established method of providing lateral support for excavated slopes in soil and weak rock. It involves the progressive installation of passive tensile reinforcement into the ground to essentially form a reinforced mass gravity structure. Soil nail walls are generally associated with higher lateral movements than anchored soldier pile walls and are suitable where there are no movement sensitive structures within the zone of influence of the excavation. In order to avoid the soil and weak rock between the reinforcement points becoming unstable some form of facing (typically reinforced shotcrete) needs to be installed.

The design of the soil nail system must consider both the internal and external stability of the reinforced volume. Internal stability refers to the ability of the reinforcing elements to transfer tensile forces into the surrounding soil/rock mass. External stability involves assessment of bearing capacity and tilt failure, sliding and slip circle failure.

It is suggested that the soil nail and shotcrete wall should be progressively constructed with bench heights of no more than 1.5 m in soil and 2 m in weak rock. Excavation should not proceed below the upper bench level until the soil nails and shotcrete are installed and the grout/shotcrete has been given sufficient time to reach the design strength.

Permanent soil nails will require adequate corrosion protection. As a minimum, it is suggested that corrosion protection should include allowance for galvanised bars within a fully grouted drill hole and also corrugated sheathing along the full length of the soil nail.

Soil nail lengths generally vary from 0.6 to 1.0 times the height of the excavation, however, this is subject to detailed design and analysis. Based on experience with the adjacent Library site, it

is anticipated that the design of the soil nail and shotcrete wall could include 4 m to 6 m long, galvanised N20 to N24 bars, which are installed on a vertical and horizontal grid spacing of 1 m to 1.3 m. Drilled holes typically vary from 100 mm to 150 mm in diameter. It is anticipated that the reinforced shotcrete facing may vary from 150 mm to 200mm thick.

10.3.3 Design

The design of the soil nail support system may be based on the parameters provided in Table 5. Active earth pressures (Ka) may be used where some wall movement is acceptable, and at rest earth pressures (Ko) should be used where wall movement is to be minimised.

Table 5 – Recommended Design Parameters for Soil Nail Support System

Material	Unit Weight (kN/m^3)	Earth Pressure Coefficient		Effective Cohesion c' (kPa)	Effective Friction Angle
		Active (Ka)	At Rest (Ko)		
Filling	20	0.4	0.6	2	25
Residual Clay	20	0.3	0.5	5	20
Shale/Siltstone : Extremely low to very low strength	20	0.25	0.4	10	25
Siltstone/laminite : Low to medium strength	22	0.2	0.3	30	25
Laminite: Medium to high strength	22	0.1	0.2	50	25

All surcharge loads should be allowed for in the soil nail design including building footings, inclined slopes behind the wall, traffic and construction related activities.

The design of the permanent support will also need to consider the possibility that 45° joints in the rock will daylight near the base of the shoring wall leading to wedges of rock which need to be supported by the permanent soil nail support system. This will require soil nails with their bond lengths formed in rock behind a line projected up at 45° from the base of the shoring. As a guide, the support system should be designed to withstand a horizontal force per unit width of $4.2H^2$ (kN) where H is the height of the excavation in metres. This approximation of the horizontal force required to support a 45 degree wedge is based on a soil nail/anchor inclination of 10° below horizontal, an average bulk weight of 21 kN/m^3, and friction angle of 25° and

cohesion of 0 kPa along the failure plane. Given that there is a low probability that a joint would run the full length and height of the excavation it suggested that this design may be carried out using a factor of safety of 1.1.

Shoring walls should be designed for full hydrostatic pressures unless drainage of the ground behind impermeable walls can be provided. Drainage could comprise 150 mm wide strip drains pinned to the face at 2-3 m centres behind the shotcrete facing. The base of the strip drains should extend out from the shotcrete wall to allow any seepage to flow into a perimeter toe drain which is connected to a sump dewatering system.

The design of permanent soil nails may be carried out on the basis of the maximum allowable bond stresses given in Table 6.

Table 6 – Bond Stresses for Soil Nail Design

Material Description	Maximum Allowable Bond Stress (kPa)
Residual Clay	50
Shale/Siltstone : Extremely low to very low strength	100
Silstone/laminite : Low to medium strength	200
Laminite: Medium to high strength	600

The parameters given in Table 6 assume that drilled holes are clean and adequately flushed. Lift-off tests should be carried out to confirm the bond capacities. Higher bond stress values may be adopted if trial anchors are used to prove higher capacities.

10.4 Foundations

Following bulk excavation it is anticipated that medium to high strength siltstone/laminite will be exposed at or close to the lowest basement level across most of the site. Along the eastern side of the site, it is expected that medium to high strength silststone/laminite may be approximately 1 m to 1.5 m below the bulk excavation.

All structural loads should be uniformly supported on underlying bedrock for which pad footings should generally be appropriate. Deepened pad footings or bored piles may be used to reach the underlying high strength laminite for higher load carrying capacities.

Recommended maximum allowable pressures and modulus values for the various foundation materials are presented in Table 7. These parameters apply to the design of spread foundations, such as pads or strip footings, and rock socketed bored piles.

Table 7 – Recommended Design Parameters and Modulus Values for Foundation Design

Foundation Stratum	Maximum Allowable Pressure		Elastic Modulus (MPa)
	End Bearing (kPa)	Shaft Adhesion (kPa)	
Siltstone/laminite: medium to high strength	3500	350	500
Laminite: high strength	6000	600	1000

Foundations proportioned on the basis of the above parameters would be expected to experience total settlements of less than 1% of the footing width (or pile diameter) under the applied working load, with differential settlements between adjacent columns expected to be less than half of this value.

All footings should be inspected by a geotechnical engineer to confirm that foundation conditions are suitable for the design parameters.

Spoon testing should be undertaken in at least one-third of high level footings which are proportioned on the basis of allowable bearing pressures of greater than 3500 kPa. For spread footings designed using allowable bearing pressures of 6000 kPa, spoon testing should be undertaken in at least half of all footing locations. The purpose of spoon testing is to check that no significant weak seams exist below the base of the footing within a depth equal to 1.5 times the least footing dimension. If the testing identifies the presence of weak seams then the footing will either have to be deepened or widened to reduce the actual bearing pressure.

10.5 Pavements & Floor Slabs

During construction of pavements and access roads outside the basement area it is recommended that all topsoil, organic and deleterious material should be stripped and stockpiled separately for disposal or use in landscaping areas. Proof rolling of the exposed subgrade should be carried out under the supervision of a geotechnical engineer to detect any soft or heaving areas. Any soft spots detected during proof rolling would need to be stripped to a stiff base and replaced with engineered filling.

Engineered filling should be placed in maximum 200 mm thick loose layers and compacted to a minimum dry density ratio of 98% Standard compaction with moisture contents within 2% of optimum moisture content (OMC). The compaction should be increased to a dry density ratio of 100% Standard compaction within 0.3 m of the subgrade surface. The existing filling, clay and excavated rock on site should generally be suitable for re-use as engineered filling provided it has a maximum particle size of 70 mm and moisture content within 2% of OMC (where possible, preference should be given to the use of granular material).

Subject to the subgrade preparation outlined above, the design of pavements on engineered filling or clay subgrade may be based on a CBR value of 2%. Design of pavements on weathered rock may be based on a CBR value of 5% for extremely low to very low strength rock and 10% for low strength rock or better. These CBR values assume all pavements are protected by adequate surface and subsoil drainage to minimise the risk of water infiltration and softening of pavement materials.

11. LIMITATIONS

Douglas Partners (DP) has prepared this report for the Australian Hearing Hub project within the Macquarie University campus at the corner of University Avenue and Macquarie Drive, Macquarie Park in accordance with the consultancy agreement between Douglas Partners Pty Ltd and Macquarie University. This report is provided for the exclusive use of the Macquarie University for the specific project and purpose as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party.

The results provided in the report are considered to be indicative of the sub-surface conditions on the site only to the depths investigated at the specific sampling and/or testing locations, and only at the time the work was carried out. DP's advice is based on observations, measurements, tests or derived interpretations. The accuracy of the advice provided by DP in this report may be limited by unobserved features and variations in ground conditions across the site in areas between test locations and beyond the site boundaries or by variations with time. The advice may be limited by restrictions in the sampling and testing which was able to be carried out, as well as by the amount of data that could be collected given the project and site constraints. Actual ground conditions and materials behaviour observed or inferred at the test locations may differ from those which may be encountered elsewhere on the site. Should variations in subsurface conditions be encountered, then additional advice should be sought from DP and, if required, amendments made.

This report must be read in conjunction with the attached "Notes Relating to This Report" and any other attached explanatory notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions from review by others of this report or test data, which are not otherwise supported by an expressed statement, interpretation, outcome or conclusion stated in this report. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

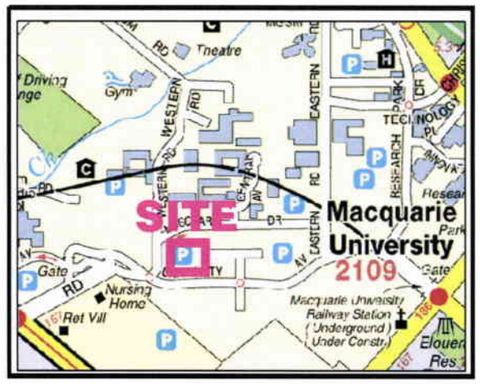
DOUGLAS PARTNERS PTY LTD

Reviewed by

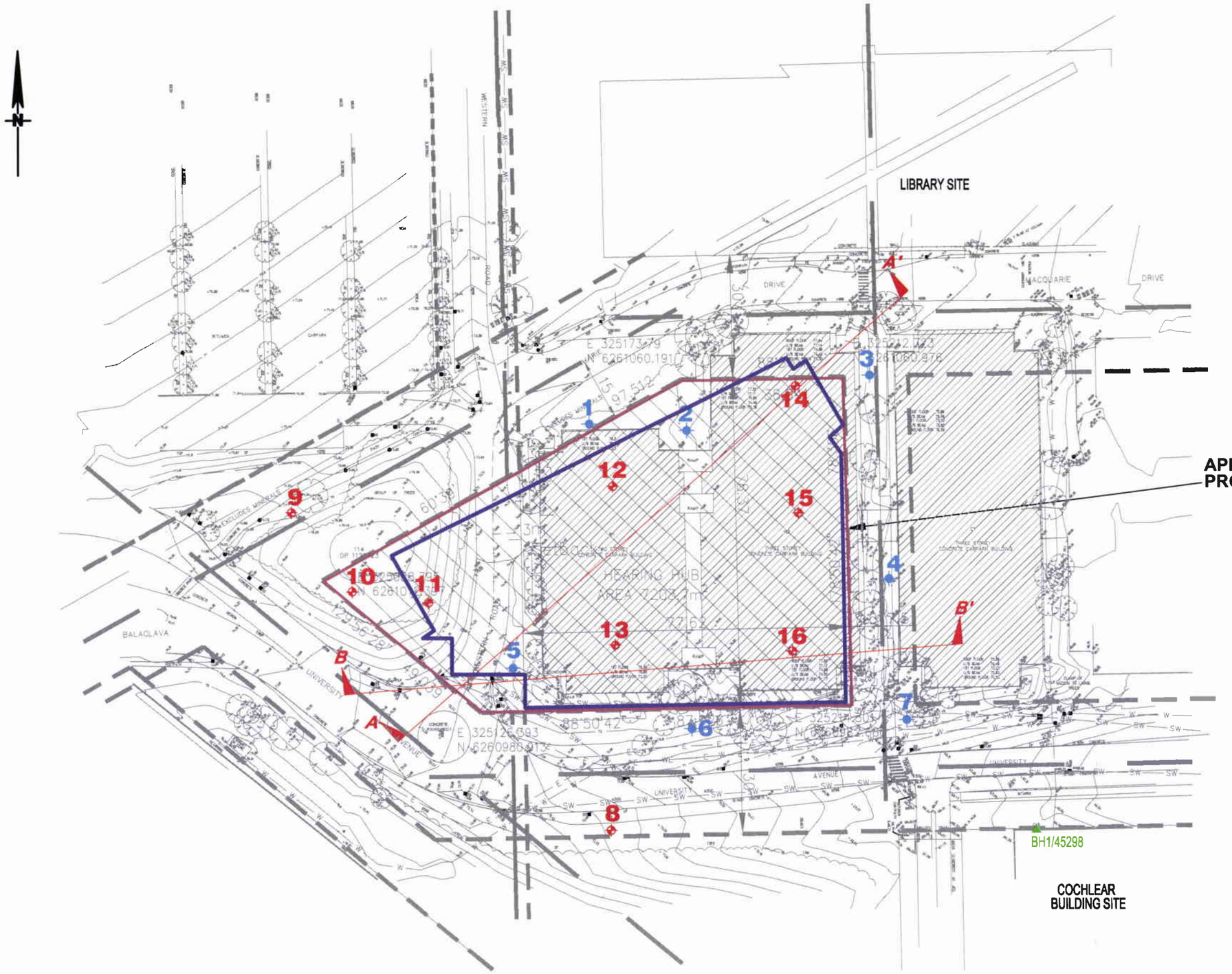
Scott Easton
Senior Associate

Fiona MacGregor
Principal

APPENDIX A
Drawing No. 1 to 3



LOCALITY PLAN



LEGEND

- AUGERED BORE LOCATION
- CORED BORE LOCATION
- PREVIOUS BOREHOLE FOR COCHLEAR SITE (MARCH 2008)

SCALE 0 10 20 30 40 50m 1:1000

REFER TO DRAWINGS 2 & 3 FOR GEOTECHNICAL CROSS-SECTIONS A-A' AND B-B'

Douglas Partners Geotechnics · Environment · Groundwater	CLIENT: Macquarie University		TITLE: Location of Boreholes Australian Hearing Hub Cnr University Ave & Macquarie Dr., MACQUARIE PARK	PROJECT No: 71683
	DRAWN BY: PSCH	SCALE: As shown		DRAWING No: 1
	APPROVED BY: STE	DATE: 19.4.2010		REVISION: A
		OFFICE: Sydney		

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A

A'

APPROXIMATE EXISTING GROUND SURFACE

APPROXIMATE OUTLINE OF PROPOSED BUILDING

FILLING

SHALE/SILTSTONE: EL-VL

SILTSTONE: VL-L SOME L-M BANDS

SILTSTONE: L-M

SILTSTONE/LAMINITE: M-H

*Includes thick bands of sandstone

LAMINITE: H

*Includes thick bands of sandstone

RL 66.5 PROPOSED BASEMENT 1

RL 66.5 PROPOSED BASEMENT 2

5 (Bottom Depth 12 m)

13 (EL, Bottom Depth 0.6 m)

12 (EL, Bottom Depth 1 m)

2 (9,23/150mm refusal; Bottom Depth 11.9 m)

14 (EL, Bottom Depth 0.8 m)

3 (Bottom Depth 12 m)

ELEVATION (AHD)

DISTANCE ALONG PROFILE (m)

NOTE: Subsurface conditions are accurate at the borehole locations only and variations between boreholes may be expected

CROSS-SECTION A-A'

LEGEND

- Asphaltic Concrete
- CORE LOSS
- Concrete
- Filling
- Laminite
- Sandstone fine grained
- Shale
- Siltstone

ROCK STRENGTH
EL - Extremely Low
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High

SOIL CONSISTENCY
st - stiff
vst - very stiff
h - hard

TESTS / OTHER
N - Standard penetration test value
- Water level

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CLIENT: Maquarie University		TITLE: GEOTECHNICAL CROSS SECTION A-A'	PROJECT No: 71683
DRAWN BY: LD	SCALE: 1: 500 (H) 1: 100 (V)	Australian Hearing Hub	DRAWING No: 2
APPROVED BY: STE	DATE: 20.04.2010	University Avenue, Macquarie Park	REVISION: A

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B

B'

APPROXIMATE EXISTING GROUND SURFACE

APPROXIMATE OUTLINE OF PROPOSED BUILDING

5

13

6

16

4

FILLING

FILLING CLAY

SHALE/SILTSTONE EL-VL

SILTSTONE: L-M

SILTSTONE/LAMINITE: M-H

LAMINITE: VL-L with H bands

LAMINITE: H

LAMINITE: H

*Includes thick bands of sandstone

*Includes thick bands of sandstone

RL 66.5

PROPOSED BASEMENT 2 (Southern side)

Bottom Depth 0.6 m

Bottom Depth 1.2 m

Bottom Depth 12 m

Bottom Depth 11.85 m

Bottom Depth 12.2 m

ELEVATION (AHD)

DISTANCE ALONG PROFILE (m)

CROSS-SECTION B-B'

NOTE: Subsurface conditions are accurate at the borehole locations only and variations between boreholes may be expected

LEGEND

- Asphaltic Concrete
- CORE LOSS
- Concrete
- Filling
- Laminite
- Sandstone fine grained
- Shale
- Siltstone
- Silty Clay

ROCK STRENGTH
EL - Extremely Low
VL - Very Low
L - Low
M - Medium
H - High
VH - Very High

SOIL CONSISTENCY
st - stiff
vst - very stiff
h - hard

TESTS / OTHER
N - Standard penetration test value
Water level

Douglas Partners
Geotechnics · Environment · Groundwater

CLIENT: Maquarie University			TITLE: **GEOTECHNICAL CROSS SECTION B-B'** **Aaustralia Hearing Hub** **University Avenue, Macquarie Park**
DRAWN BY: LD	SCALE: 1: 500 (H) 1: 100 (V)	OFFICE:	
APPROVED BY: STE		DATE: 20.04.2010	

PROJECT No: 71683
DRAWING No: 3
REVISION: A

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APPENDIX B
Notes Relating to this Report
Results of Field Work

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Geotechnics · Environment · Groundwater

NOTES RELATING TO THIS REPORT

Introduction

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

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

Description and Classification Methods

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

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

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

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

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

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

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

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

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

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

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

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow

sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is 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.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining 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 6.3.1.

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

The test results are reported in the following form.

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

  as 4, 6, 7
  N = 13

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

  as 15, 30/40 mm.

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

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end 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 friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

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

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

q_c (MPa) = (0.4 to 0.6) N (blows per 300 mm)

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

q_c = (12 to 18) c_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on

soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is 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.

Bore Logs

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

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

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

- In low permeability soils, ground water although present, 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. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

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

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 condition, 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 depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

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

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those 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 than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the 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.

Site Inspection

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

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DESCRIPTION AND CLASSIFICATION OF ROCKS FOR ENGINEERING PURPOSES

DEGREE OF WEATHERING

Term	Symbol	Definition
Extremely Weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly Weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.
Moderately Weathered	MW	Rock substance affected by weathering to the extent that staining or discolouration of the rock substance usually by limonite has taken place. The colour of the fresh rock is no longer recognisable.
Slightly Weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh Stained	Fs	Rock substance unaffected by weathering, but showing limonite staining along joints.
Fresh	Fr	Rock substance unaffected by weathering.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index ($I_{S(50)}$) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by Australian Standard 4133.4.1 - 1993.

Term	Symbol	Field Guide*	Point Load Index $I_{S(50)}$ MPa	Approx Unconfined Compressive Strength q_u ** MPa
Extremely low	EL	Easily remoulded by hand to a material with soil properties	<0.03	< 0.6
Very low	VL	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; too hard to cut a triaxial sample by hand. SPT will refuse. Pieces up to 3 cm thick can be broken by finger pressure.	0.03-0.1	0.6-2
Low	L	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long 40 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.	0.1-0.3	2-6
Medium	M	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.	0.3-1.0	6-20
High	H	Can be slightly scratched with a knife. A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow, rock rings under hammer.	1 - 3	20-60
Very high	VH	Cannot be scratched with a knife. Hand specimen breaks with pick after more than one blow, rock rings under hammer.	3 - 10	60-200
Extremely high	EH	Specimen requires many blows with geological pick to break through intact material, rock rings under hammer.	>10	> 200

Note that these terms refer to strength of rock material and not to the strength of the rock mass, which may be considerably weaker due to rock defects.

* The field guide assessment of rock strength may be used for preliminary assessment or when point load testing is not able to be done.

** The approximate unconfined compressive strength (q_u) shown in the table is based on an assumed ratio to the point load index of 20:1. This ratio may vary widely.

STRATIFICATION SPACING

Term	Separation of Stratification Planes
Thinly laminated	<6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	>2 m

DEGREE OF FRACTURING

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks. The orientation of rock defects is measured as an angle relative to a plane perpendicular to the core axis. Note that where possible, recordings of the actual defect spacing or range of spacings is preferred to the general terms given below.

Term	Description
Fragmented	The core consists mainly of fragments with dimensions less than 20 mm.
Highly Fractured	Core lengths are generally less than 20 mm - 40 mm with occasional fragments.
Fractured	Core lengths are mainly 40 mm - 200 mm with occasional shorter and longer sections.
Slightly Fractured	Core lengths are generally 200 mm - 1000 mm with occasional shorter and longer sections.
Unbroken	The core does not contain any fracture.

ROCK QUALITY DESIGNATION (RQD)

This is defined as the ratio of sound (i.e. low strength or better) core in lengths of greater than 100 mm to the total length of the core, expressed in percent. If the core is broken by handling or by the drilling process (i.e. the fracture surfaces are fresh, irregular breaks rather than joint surfaces) the fresh broken pieces are fitted together and counted as one piece.

SEDIMENTARY ROCK TYPES

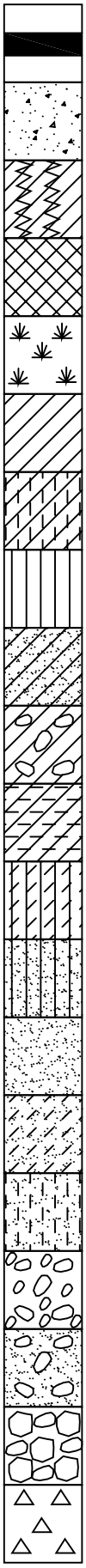
This classification system provides a standardised terminology for the engineering description of sandstone and shales, particularly in the Sydney area, but the terms and definitions may be used elsewhere when applicable.

Rock Type	Definition
Conglomerate	More than 50% of the rock consists of gravel-sized (greater than 2 mm) fragments
Sandstone:	More than 50% of the rock consists of sand-sized (0.06 to 2 mm) grains
Siltstone:	More than 50% of the rock consists of silt-sized (less than 0.06 mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of clay or sericitic material and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay-sized particles and the rock is laminated.

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, eg. clayey sandstone, sandy shale.

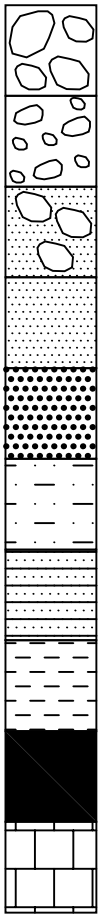
GRAPHIC SYMBOLS FOR SOIL & ROCK

SOIL



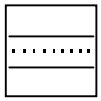
BITUMINOUS CONCRETE
CONCRETE
TOPSOIL
FILLING
PEAT
CLAY
SILTY CLAY
SILT
SANDY CLAY
GRAVELLY CLAY
SHALY CLAY
CLAYEY SILT
SANDY SILT
SAND
CLAYEY SAND
SILTY SAND
GRAVEL
SANDY GRAVEL
COBBLES/BOULDER
TALUS

SEDIMENTARY ROCK

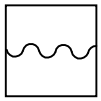


BOULDER CONGLOMERATE
CONGLOMERATE
CONGLOMERATIC SANDSTONE
SANDSTONE FINE GRAINED
SANDSTONE COARSE GRAINED
SILTSTONE
LAMINITE
MUDSTONE, CLAYSTONE, SHALE
COAL
LIMESTONE

SEAMS

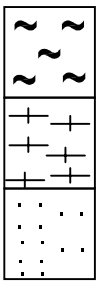


SEAM >10mm



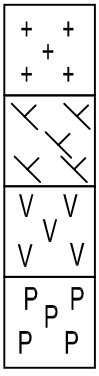
SEAM <10mm

METAMORPHIC ROCK



SLATE, PHYLLITE, SCHIST
GNEISS
QUARTZITE

IGNEOUS ROCK



GRANITE
DOLERITE, BASALT
TUFF
PORPHYRY

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Macquarie University Hearing Hub **Macquarie Park**	**Project** **71683**	**April** **2010**	**BH 1**

BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 74.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 71683
DATE: 09 Apr 10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
74	0.05	TOPSOIL - dark grey brown, silty clay topsoil with some grass rootlets, moist							A/E			
		CLAY - stiff, brown clay with a trace of ironstone gravel, moist							A/E			
73	1 1.0	CLAY - stiff, mottled orange and light grey clay, moist							A/E S			2,6,8 N = 14
72	2 2.2	SHALE - extremely low to very low strength, grey brown shale with ironstone bands						Note: Unless otherwise stated, rock is fractured along rough planar bedding planes	R			
71	3 3.5	SHALE/SILTSTONE - extremely low and very low strength, extremely and highly weathered, fragmented to fractured, light grey and grey brown, shale/siltstone with some clay bands and medium strength bands						3.5-4.76m: fragmented rock with clay bands	C	100	0	
70	4							4.76-5.6m: highly weathered rock with ironstone & clay bands	C	100	0	
69	5 5.6							5.6m: CORE LOSS: 550mm	C	100	94	
68	6 6.15	SILTSTONE - medium strength, highly weathered, fragmented to fractured, grey brown siltstone with some extremely low and very low to low strength bands						6.15-7.33m: B0°- 5° (numerous), ironstained, healed & fragmented into 0.01 to 0.05m intervals 6.4-6.73m: (x2) J30°-35°, ironstained & clay smear	C	81	20	PL(A) = 0.6MPa PL(A) = 0.4MPa
67	7 7.45	LAMINITE - low to medium strength, highly to moderately weathered, fractured to slightly fractured, grey brown laminite (approximately 20% fine grained sandstone laminations) with some extremely low strength bands						7.45m: J50°, undulating, curved, rough 7.65m: J45°, smooth 7.78m: J90°, partially healed 8.0-8.3m: clay band 8.3-8.5m: J, subvertical, ironstained, rough				PL(A) = 0.3MPa
66	8 8.5	LAMINITE - medium strength, fresh stained, slightly fractured, grey brown laminite (approximately 20- 40% fine grained sandstone laminations and bands)						8.64m: J85°, smooth 8.85m: J90°, smooth 9.11m: B0°, clay veneer 9.4m: J25°, rough 9.46-9.60m: (x3) B0°-10°, ironstained 9.76m: J20°, smooth	C	100	94	PL(A) = 0.3MPa PL(A) = 0.4MPa
65	9					16-04-10						

RIG: Bobcat **DRILLER:** Steve S **LOGGED:** SI **CASING:** Uncased

TYPE OF BORING: Solid flight auger to 2.5m; Rotary to 3.5m; NMLC-Coring to 12.15m

WATER OBSERVATIONS: No free groundwater observed whilst augering. Water in standpipe at 9.2m on 16/4/10

REMARKS: E = Environmental sample. 10% water loss from 11.0m. Standpipe installed to 12.0m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 74.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 71683
DATE: 09 Apr 10
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
64	10.0	LAMINITE - high strength, fresh, slightly fractured, light grey and grey, laminite (approximately 50% fine grained sandstone laminations and bands)						10.08m: J35°, healed 10.42m: B0°, 10mm clay	C	100	94	PL(A) = 1.9MPa
63	11							10.95m: J40°	C	100	94	PL(A) = 1.9MPa
62	12							11.46m: B0°, 10mm clay 11.58m: B0°, 10mm clay				PL(A) = 1.5MPa
	12.15	Bore discontinued at 12.15m										
61	13											
60	14											
59	15											
58	16											
57	17											
56	18											
55	19											

RIG: Bobcat **DRILLER:** Steve S **LOGGED:** SI **CASING:** Uncased

TYPE OF BORING: Solid flight auger to 2.5m; Rotary to 3.5m; NMLC-Coring to 12.15m

WATER OBSERVATIONS: No free groundwater observed whilst augering. Water in standpipe at 9.2m on 16/4/10

REMARKS: E = Environmental sample. 10% water loss from 11.0m. Standpipe installed to 12.0m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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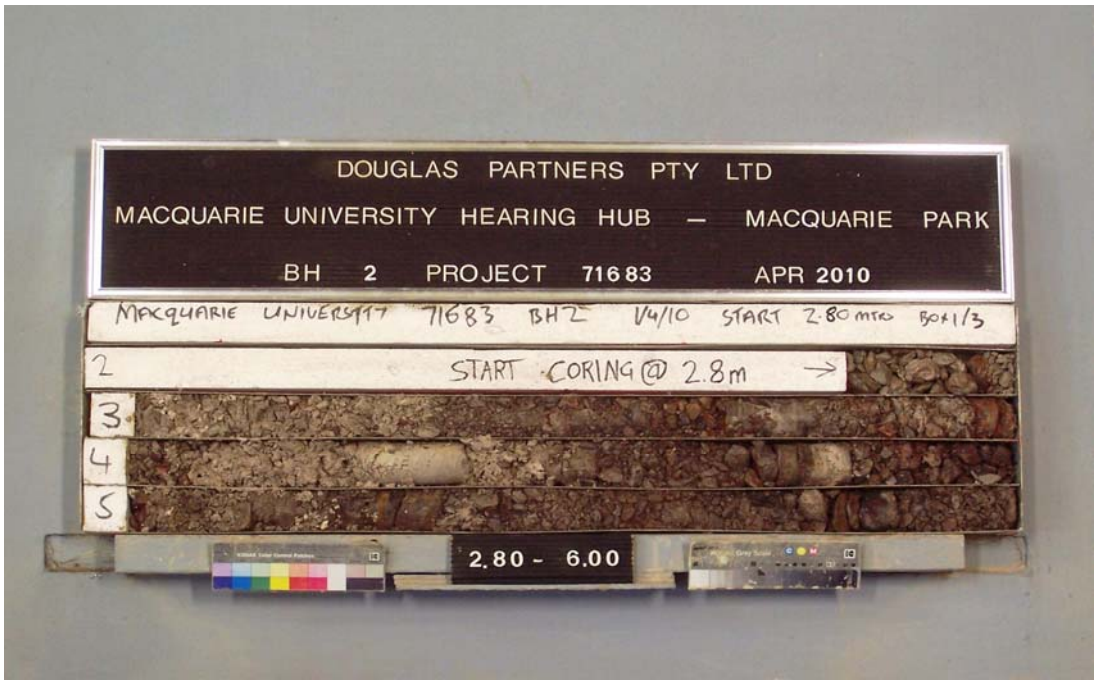

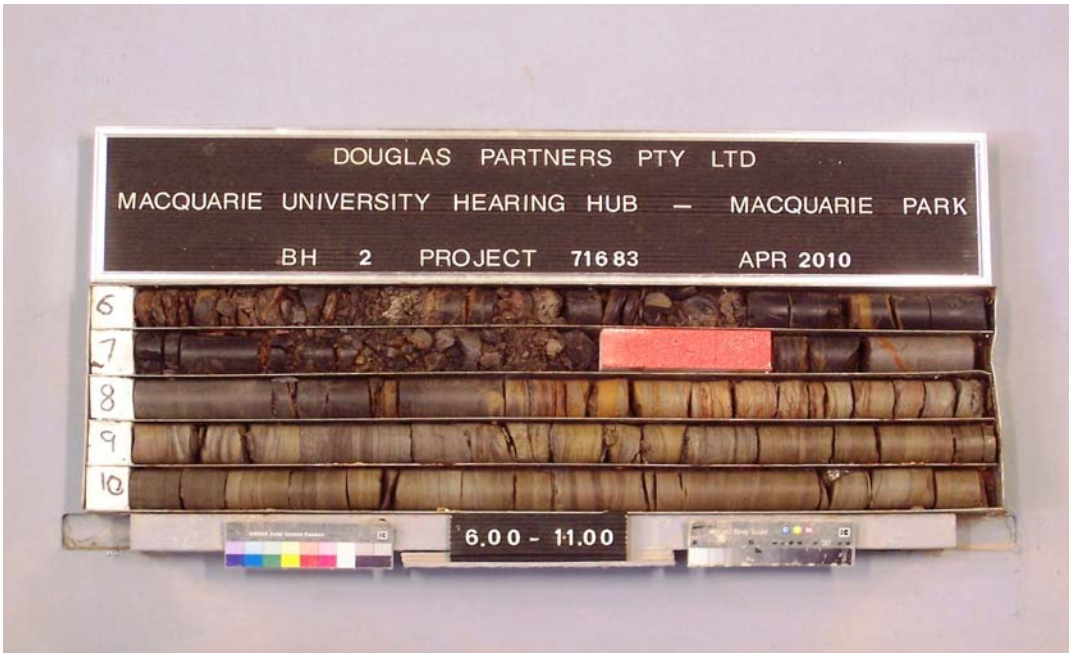

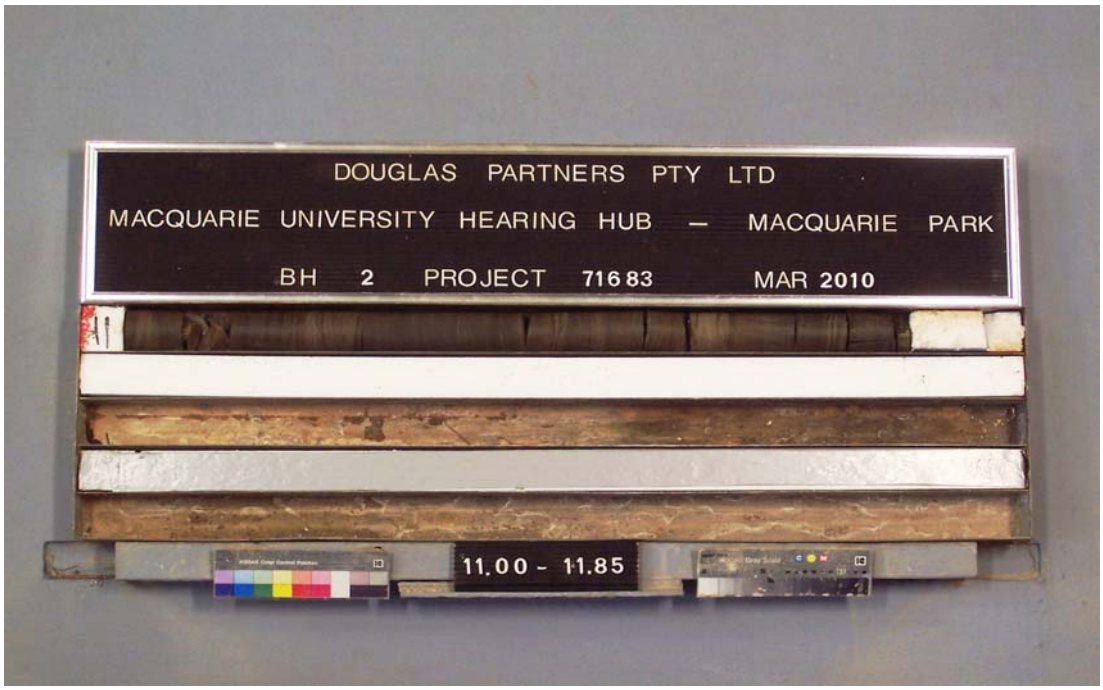

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 74.2 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 71683
DATE: 01 Apr 10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
74	0	FILLING - brown, silty sand filling with some gravel, humid							A/E*			
									A/E			
	0.8	SHALE - very low strength, light grey shale							E			
73	1								A S			9,23/150mm refusal
								Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10° or joints				
72	2											
	2.8	SILTSTONE - alternate bands of very low to low and low to medium strength, extremely to highly weathered, fragmented, light grey and grey brown siltstone with some medium strength ironstone bands						2.8-6.35m: fragmented into 0.01 to 0.02m intervals, ironstained, highly weathered rock	C	100	0	
71	3											
70	4								C	100	0	PL(A) = 0.3MPa
69	5											
												PL(A) = 0.7MPa
	6.0	SILTSTONE - low to medium and medium strength, highly to moderately weathered, fragmented and highly fractured, dark grey and brown siltstone with some very low to low strength bands						6.25-6.35m: crushed rock with clay 6.35-6.71m: fragmented into 0.02m intervals, B0°, ironstained	C	88	0	PL(A) = 0.6MPa
68	6											
								7.15-7.55m: fragmented, ironstained & clay bands 7.25m: J70°, ironstained 7.55m: CORE LOSS: 200mm				PL(A) = 0.4MPa
67	7											
	7.5											
	7.85	SANDSTONE - medium strength, moderately to slightly weathered then fresh, fractured to slightly fractured, light grey and grey brown, fine grained sandstone with approximately 20% siltstone bands and laminations						7.85m: J45°, slightly curved, rough 8.15m: J40°, smooth 8.2-8.92m: (x8) B0°- 5°, ironstained	C	100	34	PL(A) = 0.5MPa
66	8											PL(A) = 0.7MPa
								9m: B0°, 10mm clay band 9.1m: J20°, clay smear 9.40-9.86m: (x6) B0°- 10°, clay smear				PL(A) = 0.6MPa
65	9											
	9.8	SANDSTONE - see next page										PL(A) = 0.8MPa

RIG: DT 100 **DRILLER:** Younan **LOGGED:** Mikhail/SI **CASING:** HQ to 2.0m

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 2.0m; Rotary to 2.8m; NMLC-Coring to 11.9m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample
*Denotes field replicate sample BD2/010410 collected

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 74.2 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 71683
DATE: 01 Apr 10
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
64		SANDSTONE - high strength, fresh, slightly fractured, light grey to grey, fine grained sandstone with approximately 20% siltstone bands and laminations *(continued)*						10.48m: B0°, 5mm clay 10.8m: J50°, rough, undulating				PL(A) = 1.1MPa
63	11 11.0	SILTSTONE - high strength, fresh, slightly fractured, grey siltstone with approximately 20% fine grained sandstone bands and laminations						11.1m: J45°, rough, undulating 11.58m: B0°, clay veneer 11.8m: J85°, rough	C	100	99	PL(A) = 1.8MPa
62	11.9 12	Bore discontinued at 11.9m										
61	13											
60	14											
59	15											
58	16											
57	17											
56	18											
55	19											

RIG: DT 100 **DRILLER:** Younan **LOGGED:** Mikhail/SI **CASING:** HQ to 2.0m

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 2.0m; Rotary to 2.8m; NMLC-Coring to 11.9m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample
*Denotes field replicate sample BD2/010410 collected

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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Macquarie University Hearing Hub **Macquarie Park**	**Project** **71683**	**April** **2010**	**BH 3**

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 71.5 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 71683
DATE: 08 Apr 10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.12	CONCRETE										
	0.2	FILLING - brown silty clay filling with gravel										
71		SHALE - very low strength, light grey brown shale							A/E			
	1								A/E			
70	1.4	SHALE - very low strength, light grey brown shale with some ironstone bands						Note: Unless otherwise stated, rock is fractured along rough planar dipping 0°- 10° or joints	A			
	2								R			
69	2.5	SILTSTONE - extremely low to very low then very low strength, extremely and highly weathered, fragmented and highly fractured, light grey and grey brown siltstone						2.9-3.6m: fragmented, ironstained	C	81	0	
68	3.6							3.6m: CORE LOSS: 250mm				
	4								C	100	10	
67	4.87							4.4m: J50°, rough 4.4-4.55m: drilling induced break				
	5							4.63-4.71m: (x2) B0°- 5°, ironstained 4.71-4.87m: fragmented, ironstained				PL(A) = 0.6MPa
66	4.93	LAMINITE - medium strength, highly to moderately then slightly weathered, fractured to slightly fractured, light grey to grey and red brown laminite with some very low strength bands (50% siltstone and 50% fine grained sandstone)						4.87m: CORE LOSS: 60mm 5.08m: J30°, ironstained 5.2-5.3m: (x2) B0°, clay smear 5.42m: B5, 5mm clay 5.54m: J45°, ironstained, rough 5.63m: B10°, ironstained, clay band 5.74m: B0°, ironstained 5.92m: J80°, healed 6.07-6.78m: (x6) B0°- 5°, ironstained & clay veneer				PL(A) = 0.7MPa
	5.73											PL(A) = 1.8MPa
	6	SANDSTONE - high then medium strength, moderately to slightly weathered, fractured then slightly fractured, light grey brown to red brown, fine to medium grained sandstone							C	98	66	
65												
	7											PL(A) = 0.6MPa
	7.1	LAMINITE - medium strength, fresh stained, slightly fractured, light grey to grey and brown laminite (approximately 25% fine grained sandstone laminations and bands). Some very low strength bands										PL(A) = 0.9MPa
64	7.9							7.78m: B5°, clay band				PL(A) = 1.4MPa
	8	SANDSTONE - high strength, fresh stained to fresh, slightly fractured, light grey to grey, fine grained sandstone with siltstone laminations and bands. Some very low strength bands						8.1m: B5°, ironstained 8.22m: J85°, rough 8.25m: J50°- 75°, curved, rough 8.46m: B0°, 10mm clay 8.51m: J35°, rough 8.74m: B0°, 10mm clay	C	100	85	PL(A) = 1.2MPa
63	8.9											
	9											PL(A) = 1.4MPa
62		LAMINITE - high strength, fresh, slightly fractured, light grey and grey, laminite with occasional very low strength bands (approximately 50% fine grained sandstone bands and laminations)							C	100	86	
								9.88m: B0°, 10mm clay				

RIG: Bobcat **DRILLER:** Steve S **LOGGED:** SI **CASING:** HW to 1.5m

TYPE OF BORING: Diatube to 0.12m; Solid flight auger to 1.5m; Rotary to 2.5m; NMLC-Coring to 12.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering. Water in standpipe at 11.5m on 16/4/10

REMARKS: E = Environmental sample. Standpipe installed to 12.0m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 71.5 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 71683
DATE: 08 Apr 10
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
61		LAMINITE - high strength, fresh, slightly fractured, light grey and grey, laminite with occasional very low strength bands (approximately 50% fine grained sandstone bands and laminations) *(continued)*						10.06m: B0°, 15mm clay				PL(A) = 1.9MPa
	11							10.6m: J45°, rough, undulating 10.95m: J70°, rough	C	100	86	PL(A) = 3.4MPa
60						16-04-10		11.2-11.94m: (x7) B0°-5°, clay veneer				PL(A) = 1.1MPa
	12 12.0	Bore discontinued at 12.0m										
59	13											
58	14											
57	15											
56	16											
55	17											
54	18											
53	19											
52												

RIG: Bobcat **DRILLER:** Steve S **LOGGED:** SI **CASING:** HW to 1.5m

TYPE OF BORING: Diatube to 0.12m; Solid flight auger to 1.5m; Rotary to 2.5m; NMLC-Coring to 12.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering. Water in standpipe at 11.5m on 16/4/10

REMARKS: E = Environmental sample. Standpipe installed to 12.0m

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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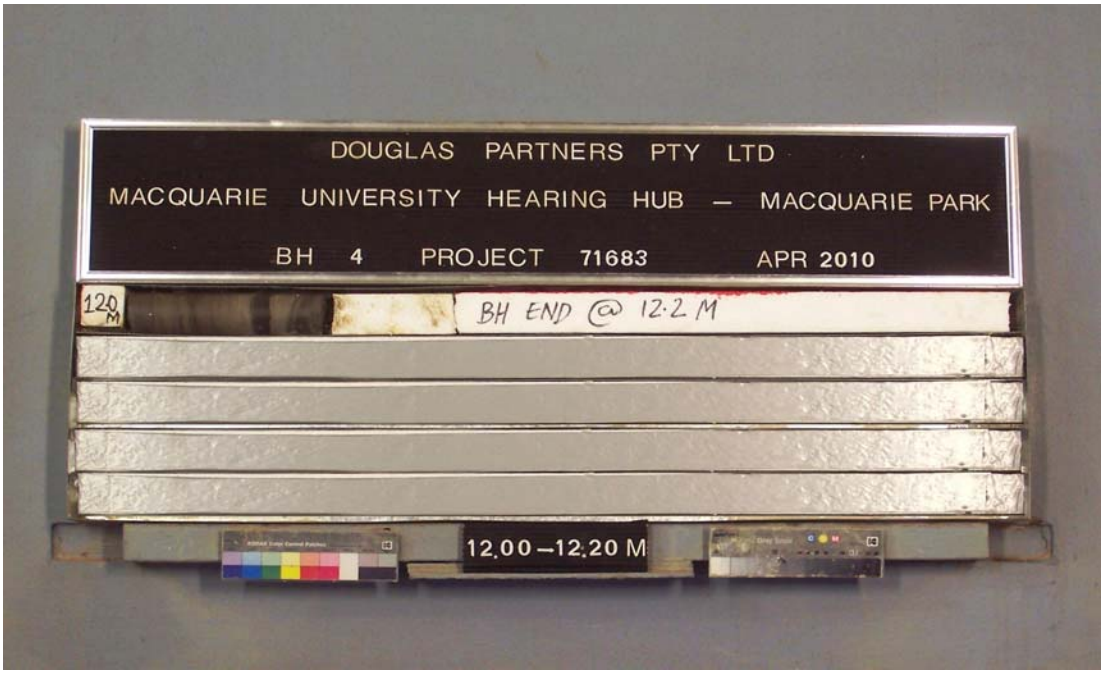

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 70.7 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 71683
DATE: 07 Apr 10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
	0.1	CONCRETE										
		FILLING - brown, sandy gravel filling with some clay, damp							A/E			
	0.5	SHALE - extremely low to very low strength, light grey shale							A/E			
70	1											
69	2							Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping at 0°-10° or joints	R			
	2.5	SILTSTONE - extremely low to very low strength, extremely to highly weathered, light grey and red brown, siltstone with some clay bands and medium strength ironstone bands							C	100	0	
68	3							3.3m: J75°, rough				
	3.55	SANDSTONE - low strength, highly to moderately weathered, fragmented and highly fractured, light grey and red brown, fine grained sandstone with some siltstone bands and high strength ironstone bands						3.55-5.0m: fragmented, ironstained				PL(A) = 1MPa
67	4											PL(A) = 1.3MPa
66	5											
	5.0	LAMINITE - alternate bands of very low and high strength, slightly weathered, highly fractured, light grey and brown laminite (approximately 50% fine grained sandstone laminations and bands)						5.0-5.85m: B0° (numerous), fragmented into 0.05 to 0.15m intervals with clay bands	C	100	19	PL(A) = 1.7MPa
65	6							5.85-7.58m: B0° (numerous), ironstained & clay veneer, fragmented into 0.01 to 0.09mm intervals				
64		6.45m: grey and dark grey with increasing siltstone laminations						6m: J80°, smooth 6.2m: J85°, ironstained				PL(A) = 1.3MPa
	7											PL(A) = 2.6MPa
	7.0	LAMINITE - medium strength, slightly weathered, fractured, light grey to grey laminite (approximately 50% fine grained sandstone laminations and bands)										
63	7.55	LAMINITE - high strength, fresh, slightly fractured, light grey and grey laminite (approximately 50% fine grained sandstone laminations and bands)						7.66m: B5°, ironstained 7.92m: B0°, clay smear, ironstained	C	100	60	PL(A) = 1.4MPa
62	8											
	9							9.2-9.45m: (x3) B0°, clay veneer				
61								9.59m: J60°, rough	C	100	100	PL(A) = 1.2MPa

RIG: Bobcat **DRILLER:** Salib **LOGGED:** Mikhail/SI **CASING:** HW to 1.5m

TYPE OF BORING: Diatube to 0.1m; 100mm diameter solid flight auger (TC-bit) to 1.5m; Rotary to 2.5m; NMLC-Coring to 12.2m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

Douglas Partners
Geotechnics · Environment · Groundwater

BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 70.7 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 71683
DATE: 07 Apr 10
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
60	11	LAMINITE - high strength, fresh, slightly fractured, light grey and grey laminite (approximately 50% fine grained sandstone laminations and bands) *(continued)*						10.45m: J45°, rough	C	100	100	PL(A) = 2.1MPa PL(A) = 2.5MPa
59	12							11.79m: B0°, clay smear 11.99m: B0°, clay band				PL(A) = 2.7MPa
	12.2	Bore discontinued at 12.2m										
58	13											
57	14											
56	15											
55	16											
54	17											
53	18											
52	19											
51												

RIG: Bobcat **DRILLER:** Salib **LOGGED:** Mikhail/SI **CASING:** HW to 1.5m

TYPE OF BORING: Diatube to 0.1m; 100mm diameter solid flight auger (TC-bit) to 1.5m; Rotary to 2.5m; NMLC-Coring to 12.2m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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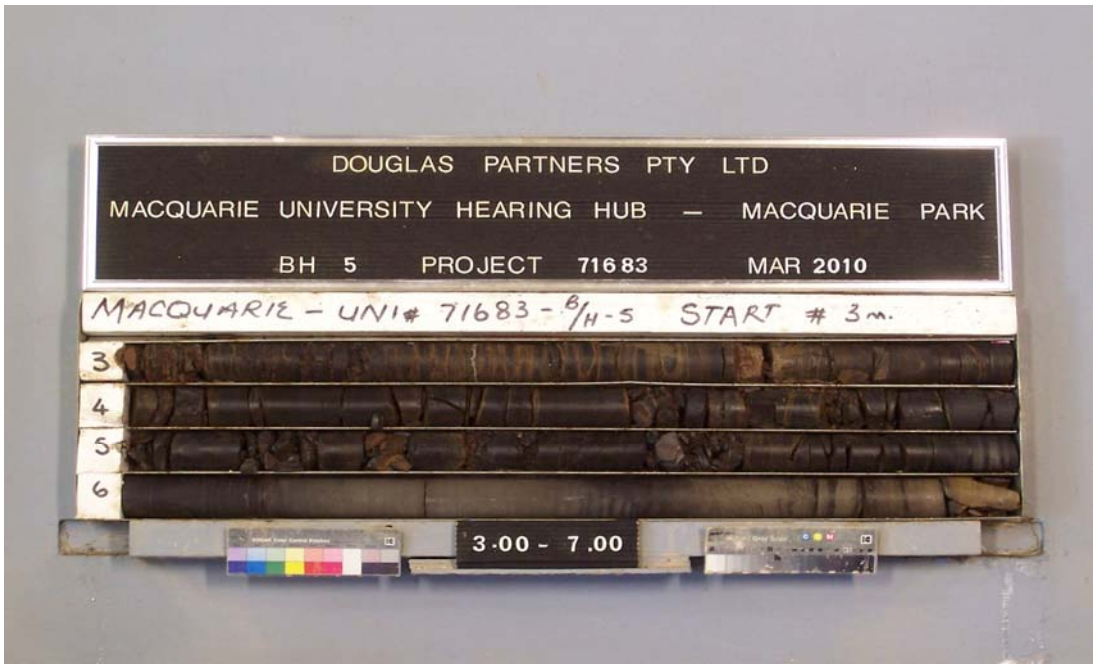
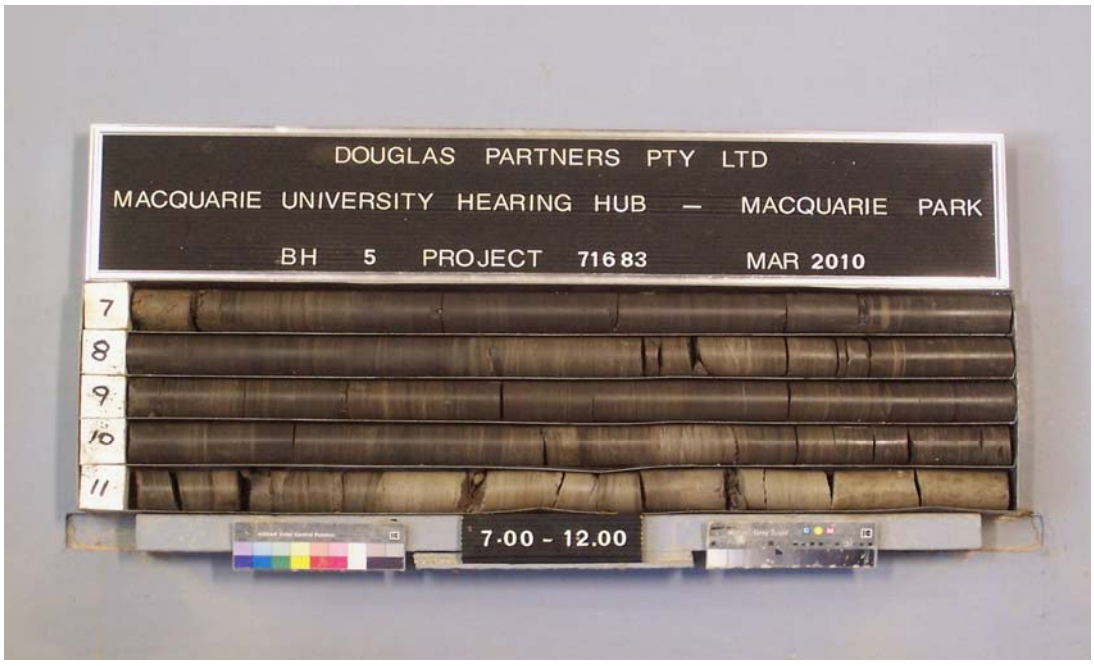

DOUGLAS PARTNERS PTY LTD
MACQUARIE UNIVERSITY HEARING HUB – MACQUARIE PARK
BH 5 PROJECT 71683 MAR 2010
MACQUARIE – UNI# 71683 - B/H-5 START # 3m.
3
4
5
6
3.00 - 7.00


DOUGLAS PARTNERS PTY LTD
MACQUARIE UNIVERSITY HEARING HUB – MACQUARIE PARK
BH 5 PROJECT 71683 MAR 2010
7
8
9
10
11
7.00 - 12.00

BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 73.3 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 71683
DATE: 29 Mar 10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
73	0.3	FILLING - brown and grey, sand filling with some crushed shale gravel, humid							E			
		SHALE - very low strength, light grey *shale*							A			
72	1											
71	2							Note: Unless otherwise stated, rock, is fractured along rough planar bedding dipping at 0°-10° or joints				
70	3	3.0 SILTSTONE - low to medium strength, moderately to slightly weathered, fragmented and highly fractured, grey and brown siltstone						3.0-3.55m: fragmented, partially healed, ironstained 3.12m: J80°, partially healed, ironstained, rough 3.39m: B0°, 2mm clay 3.55m: (x2) J25°, 85°, ironstained	C	100	0	PL(A) = 0.9MPa
69	4	4.1 SILTSTONE - medium to high strength, fresh stained, highly fractured and fractured, grey to dark grey siltstone						3.55-3.85m: B0°- 5°, ironstained, partially healed 3.85m: J20°, ironstained 4.33m: J70°- 90°, curved, rough 4.39-4.86m: B0°- 5°, ironstained & fragmented into 0.01 to 0.03mm	C	100	21	PL(A) = 1MPa
68	5							4.9m: J15°, ironstained 4.96m: B25°, smooth 5.0-5.32m: B0°- 20°, ironstained & fragmented 0.01 to 0.1mm intervals 5.32m: J50°, ironstained 5.38-5.42m: crushed rock 5.44-5.80m: B/J0°- 15°, ironstained & fragmented into 0.01 to 0.06mm intervals 5.85m: J25°, smooth 6.63m: J90°, healed 6.90-6.95m: (x2) J80°-85°, slightly curved, parallel, ironstained 7.05m: J35°, some crushed rock fragments 7.21m: J55°, healed 8.4-11.16m: (x8) B0°-10°, clay veneer				PL(A) = 0.8MPa PL(A) = 0.8MPa
67	5.85	SILTSTONE & SANDSTONE - medium then high strength, fresh, slightly fractured, grey siltstone and fine grained sandstone							C	100	85	PL(A) = 2MPa
66	7	7.1 LAMINITE - high strength, fresh stained then fresh, slightly fractured, light grey and grey, laminite (approximately 50% fine grained sandstone laminations and bands)										PL(A) = 1.5MPa
65	8								C	100	70	
64	9								C	100	95	PL(A) = 2.1MPa

RIG: Bobcat **DRILLER:** Steve S **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary to 3.0m; NMLC-Coring to 12.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 73.3 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 71683
DATE: 29 Mar 10
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
63		LAMINITE - high strength, fresh stained then fresh, slightly fractured, light grey and grey, laminite (approximately 50% fine grained sandstone laminations and bands) *(continued)*										PL(A) = 1.2MPa
	11								C	100	95	
62	11.27	SANDSTONE - high strength, fresh, fractured and slightly fractured, light grey, fine grained sandstone						11.23m: B0°, 10mm clay 11.38m: J25°, rough 11.52m: B10°- 15°, 5mm clay 11.64m: B0°, 30mm clay				PL(A) = 2.6MPa
	12 12.0	Bore discontinued at 12.0m										
61	13											
60	14											
59	15											
58	16											
57	17											
56	18											
55	19											
54												

RIG: Bobcat **DRILLER:** Steve S **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary to 3.0m; NMLC-Coring to 12.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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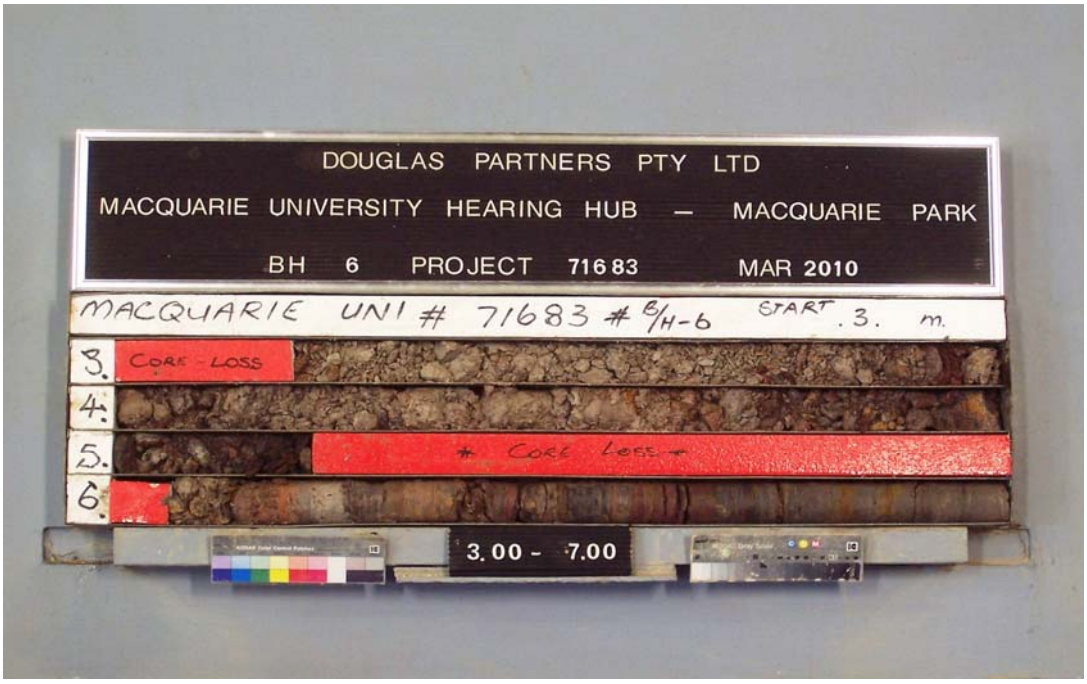
DOUGLAS PARTNERS PTY LTD
MACQUARIE UNIVERSITY HEARING HUB – MACQUARIE PARK
BH 6 PROJECT 71683 MAR 2010
MACQUARIE UNI # 71683 # B/H-6 START .3. m.
3. CORE LOSS
4.
5. * CORE LOSS *
6.
3.00 - 7.00


DOUGLAS PARTNERS PTY LTD
MACQUARIE UNIVERSITY HEARING HUB – MACQUARIE PARK
BH 6 PROJECT 71683 MAR 2010
7.
8.
9.
10.
11.
11.85m
7.00 - 11.85

BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 73.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 71683
DATE: 01 Apr 10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
73		FILLING - brown, silty sand filling with some clay, humid							A/E			
	0.7								A/E			
72	1	SILTY CLAY - very stiff, light grey and orange brown, silty clay, M<Wp, high plasticity							A/E			
	1.2	SHALE - extremely low strength, light grey shale							S			5,10,14 N = 24
71	2	- becoming very low strength at 1.8m						Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping at 0°-10° or joints				
70	3								R			
	3.0	SILTSTONE - extremely low to very low strength, extremely to highly weathered, fragmented, light grey and brown, siltstone with some medium strength ironstone bands						3m: CORE LOSS: 200mm	C	80	0	
69	4											
68	5								C	60	0	
	5.22							5.22m: CORE LOSS: 850mm				
67	6											
	6.3	LAMINITE - very low and low strength, highly weathered, fragmented to highly fractured, grey brown laminite with medium to high strength ironstone bands						6.07-7.17m: B0°, numerous, ironstained				PL(A) = 1MPa
66	7											
	7.05	LAMINITE - medium strength, slightly weathered, fractured to slightly fractured, grey laminite with approximately 20% fine grained sandstone laminations 7.4-7.65m: very low strength band						7.21-8.1m: B0°, numerous clay smear/bands	C	100	45	PL(A) = 0.9MPa
65	8											
	8.13	LAMINITE - high strength, slightly weathered then fresh, slightly fractured and unbroken, light grey to grey laminite (approximately 30% fine grained sandstone laminations and bands)						8.3m: B0°, clay smear 8.43m: J25°, clay band				PL(A) = 1.9MPa
								8.71m: B0°, clay band & rock fragments 8.86m: B0°, ironstained				
64	9								C	100	95	PL(A) = 1.1MPa
								9.61m: J30°, rough 9.69-11.70m: (x4) B0°-5°, clay veneer				

RIG: Bobcat **DRILLER:** Salib **LOGGED:** Mikhail/SI **CASING:** HW to 3.0m

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 2.5m; Rotary to 3.0m; NMLC-Coring to 11.85m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep
		▼	Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 73.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 71683
DATE: 01 Apr 10
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
63		LAMINITE - high strength, slightly weathered then fresh, slightly fractured and unbroken, light grey to grey laminite (approximately 30% fine grained sandstone laminations and bands) *(continued)*										PL(A) = 1.7MPa
62	11								C	100	95	
	11.85											PL(A) = 1.8MPa
61	12	Bore discontinued at 11.85m										
60	13											
59	14											
58	15											
57	16											
56	17											
55	18											
54	19											

RIG: Bobcat **DRILLER:** Salib **LOGGED:** Mikhail/SI **CASING:** HW to 3.0m

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 2.5m; Rotary to 3.0m; NMLC-Coring to 11.85m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 70.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 7
PROJECT No: 71683
DATE: 31 Mar 10
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
70		FILLING - brown, silty clay filling with some sand and gravel, M<Wp							A/E			
	0.7	SILTY CLAY - very stiff, orange brown and red brown, silty clay with a trace of ironstone gravel, M<Wp, high plasticity							A/E			
69	1	- becoming light grey and orange brown from 1.2m							B			
	1.9	SHALE - very low strength, light grey shale							A/E			
68	2								S			5,10,14 N = 24
								Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping at 0°-10° or joints				
67	3								R			
	3.0	SANDSTONE - alternate bands of very low to low and medium strength, highly weathered, fragmented and highly fractured, light grey brown, fine grained sandstone with some high strength ironstone bands						3m: CORE LOSS: 120mm 3.12-3.73m: fragmented, slightly ironstained, clay smear	C	88	0	
66	4							4.1m: J, subvertical, ironstained, rough				PL(A) = 2.6MPa
	4.25	LAMINITE - very low to low strength, highly weathered, fragmented and fractured, grey laminite some high strength bands (approximately 20% fine grained sandstone laminations)						4.4-4.8m: fragmented into 0.01 to 0.05mm intervals, clay smear, ironstained				PL(A) = 1.4MPa
65	5							4.9m: B0°, 50mm clay band 5.16m: B0°, 50mm clay band 5.24m: B0°, ironstained 5.35-5.906m: (x7) B0°, clay smear	C	100	35	PL(A) = 1.8MPa
	5.25	LAMINITE - high strength, slightly weathered, fractured to slightly fractured, light grey and grey, laminite with some very low strength bands (approximately 30% fine grained sandstone laminations and bands)						6.08m: B0°, ironstained 6.08-6.15m: fragmented 6.41-6.73m: (x7) B0°, 2-5mm clay bands				PL(A) = 1.1MPa
64	6							6.86-6.97m: (x3) B0°, 5mm clay bands				
63	7							7.22-7.39m: (x6) B0°- 5°, ironstained				PL(A) = 1.3MPa
	7.0	LAMINITE - high strength, fresh stained, slightly fractured, light grey and grey, laminite (approximately 20% fine grained sandstone laminations)										
62	8							8.18m: J25°, rough				PL(A) = 1.8MPa
	8.55	LAMINITE - *medium* then medium to high strength, fresh, fractured to slightly fractured, light grey to grey, laminite (approximately 40-50% fine grained sandstone laminations and bands)						8.53m: B0°, ironstained, 10mm clay band 8.73m: B0°, clay smear	C	100	91	
61	9											PL(A) = 0.5MPa
								9.87m: J35°, healed				

RIG: Bobcat **DRILLER:** Steve S **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary to 3.0m; NMLC-Coring to 12.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: 15% water loss from 9.5m. M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

Douglas Partners
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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 70.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 7
PROJECT No: 71683
DATE: 31 Mar 10
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00)	Discontinuities (B - Bedding J - Joint S - Shear D - Drill Break)	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
60		LAMINITE - medium then medium to high strength, fresh, fractured to slightly fractured, light grey to grey, laminite (approximately 40-50% fine grained sandstone laminations and bands) *(continued)*						10.3-10.4m: (x2) J85° & 70°, rough, ironstained 10.7m: J45°- 90°, curved, ironstained, rough				PL(A) = 1MPa
59	11							11.18m: J35°, rough 11.22m: J45°, 10mm crushed rock, undulating, rough 11.3-11.4m: (x2) B0°- 5°, clay smear 11.4m: J, subvertical 11.68m: B5°, clay smear & J550°, healed 11.9m: J45°, undulating, rough	C	100	79	
	11.45	SANDSTONE - very high strength, fresh, slightly fractured, light grey, fine grained sandstone with some siltstone laminations										PL(A) = 3.1MPa
58	12 12.0	Bore discontinued at 12.0m										
57	13											
56	14											
55	15											
54	16											
53	17											
52	18											
51	19											

RIG: Bobcat **DRILLER:** Steve S **LOGGED:** SI **CASING:** HW to 2.5m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary to 3.0m; NMLC-Coring to 12.0m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: 15% water loss from 9.5m. M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

Douglas Partners
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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 72.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH 90°/--

BORE No: 8
PROJECT No: 71683
DATE: 29 Mar 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
72	0.0	FILLING - brown, silty sand filling with some clay, humid		E*	0.0				0.3m stickup
	0.3	SILTY CLAY - stiff to very stiff, light grey and orange brown, silty clay, M<Wp, high plasticity			0.2				Bentonite pellet plug
71	1			E	0.4		pp = 200kPa		
	1.1	SHALE - very low strength, light grey shale			0.6				Backfilled with 20mm pea gravel
70	2								Machine slotted PVC screen
69	3								
	3.5	Bore discontinued at 3.5m - target depth reached							End cap
68	4								
67	5								
66	6								
65	7								
64	8								
63	9								

RIG: DT 100 **DRILLER:** R Ennis **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 3.5m

WATER OBSERVATIONS: No free groundwater observed whilst augering. Standpipe installed and dry on 16/4/10

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample
*Denotes field replicate sample BD2/290310 collected

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

Douglas Partners
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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 74.5 AHD
EASTING:
NORTHING:
DIP/AZIMUTH 90°/--

BORE No: 9
PROJECT No: 71683
DATE: 29 Mar 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
74	0.1	TOPSOIL - brown, silty sand topsoil with some clay, a trace of gravel and rootlets, humid		E	0.0 0.1				
		FILLING - brown, silty clay filling with some sand and gravel, M<Wp		E	0.4 0.6				
73	0.9	SHALE - very low strength, light grey shale							
72	2.0	Bore discontinued at 2.0m - target depth reached							
71									
70									
69									
68									
67									
66									
65									

RIG: DT 100 **DRILLER:** R Ennis **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 2.0m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 76.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 10
PROJECT No: 71683
DATE: 29 Mar 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
76	0.0	FILLING - brown, silty sand filling with some clay, humid		E	0.0				
					0.2				
	0.3	SILTY CLAY - stiff to very stiff, light grey and orange brown, silty clay, M<Wp, high plasticity							
75	1			E	0.6		pp = 200kPa		1
					0.8				
	1.4	SHALE - very low strength, light grey shale							
74	2								2
	2.0	Bore discontinued at 2.0m - target depth reached							
73	3								3
72	4								4
71	5								5
70	6								6
69	7								7
68	8								8
67	9								9

RIG: DT 100 **DRILLER:** R Ennis **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 2.0m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U$_x$	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 75.9 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 11
PROJECT No: 71683
DATE: 29 Mar 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
75	0.1	TOPSOIL - brown, silty sand topsoil with some clay and trace of rootlets, humid		E	0.0 0.1				
	0.6	FILLING - brown, silty clay filling with some sand and gravel		E	0.4 0.6				
	1	SILTY CLAY - stiff, light grey and orange brown, silty clay, M<Wp, high plasticity		A/E	0.9 1.0				1
	1.3	SHALE - very low strength, light grey shale							
	1.5	Bore discontinued at 1.5m - target depth reached							
74	2								2
73	3								3
72	4								4
71	5								5
70	6								6
69	7								7
68	8								8
67	9								9
66									

RIG: DT 100 **DRILLER:** R Ennis **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 1.5m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: M = Moisture content; Wp = Plastic Limit. E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 73.5 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 12
PROJECT No: 71683
DATE: 06 Apr 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
73	0.08	ASPHALTIC CONCRETE		E	0.1				
	0.2	FILLING - grey, sandy gravel (roadbase) filling, humid			0.2				
		FILLING - brown and grey, silty clay filling with some gravel, humid		E	0.4 0.5				
	0.8	SHALE - extremely low strength, light grey shale		E	0.8				
72	1.0	Bore discontinued at 1.0m - target depth reached			1.0				
71	2								
70	3								
69	4								
68	5								
67	6								
66	7								
65	8								
64	9								

RIG: 2T excavator **DRILLER:** Brad **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 1.0m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U$_x$	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 73.2 AHD
EASTING:
NORTHING:
DIP/AZIMUTH 90°/--

BORE No: 13
PROJECT No: 71683
DATE: 06 Apr 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
73	0.08	ASPHALTIC CONCRETE							
	0.3	FILLING - grey, sandy gravel (roadbase) filling, humid		E	0.2				
					0.3				
		SHALE - extremely low strength, light grey shale		E	0.4				
	0.6	Bore discontinued at 0.6m - target depth reached			0.6				
72	1								1
71	2								2
70	3								3
69	4								4
68	5								5
67	6								6
66	7								7
65	8								8
64	9								9

RIG: 2T excavator **DRILLER:** Brad **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 0.6m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 72.3 AHD
EASTING:
NORTHING:
DIP/AZIMUTH 90°/--

BORE No: 14
PROJECT No: 71683
DATE: 06 Apr 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
72	0.06	ASPHALTIC CONCRETE		E	0.1				
	0.3	FILLING - grey, sandy gravel (roadbase) filling, humid			0.2				
		SHALE - extremely low strength, light grey shale		E	0.5				
	0.8				0.6				
71	1	Bore discontinued at 0.8m - target depth reached							
70	2								
69	3								
68	4								
67	5								
66	6								
65	7								
64	8								
63	9								

RIG: 2T excavator **DRILLER:** Brad **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 0.8m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U$_x$	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 72.0 AHD
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 15
PROJECT No: 71683
DATE: 06 Apr 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
72	0.05	ASPHALTIC CONCRETE		E	0.1				
	0.3	FILLING - grey, sandy gravel (roadbase) filling, humid		E	0.2				
	0.5	FILLING - brown, silty clay filling with some gravel, humid			0.3				
	0.8	SILTY CLAY - stiff to very stiff, light grey and brown, silty clay with a trace of ironstone gravel, M<Wp, medium plasticity			0.4				
71	1.0	SHALE - extremely low strength, light grey shale							
		Bore discontinued at 1.0m - target depth reached							
70	2								
69	3								
68	4								
67	5								
66	6								
65	7								
64	8								
63	9								

RIG: 2T excavator **DRILLER:** Brad **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 1.0m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U,	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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BOREHOLE LOG

CLIENT: Maquarie University
PROJECT: Australian Hearing Hub
LOCATION: University Avenue, Macquarie Park (Macquarie University)

SURFACE LEVEL: 71.8 AHD
EASTING:
NORTHING:
DIP/AZIMUTH 90°/--

BORE No: 16
PROJECT No: 71683
DATE: 06 Apr 10
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
71	0.07	ASPHALTIC CONCRETE							
	0.2	FILLING - grey, sandy gravel (roadbase) filling, humid		E	0.2 0.3				
	0.5	FILLING - brown, silty clay filling with some gravel, humid		E	0.5 0.6				
	0.8	SILTY CLAY - stiff to very stiff, light grey and brown, silty clay with a trace of ironstone gravel, M<Wp, medium plasticity							
	1.2	SHALE - extremely low strength, light grey shale							
		Bore discontinued at 1.2m - target depth reached							

RIG: 2T excavator **DRILLER:** Brad **LOGGED:** Mikhail **CASING:** Uncased

TYPE OF BORING: 100mm diameter solid flight auger (TC-bit) to 1.2m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: E = Environmental sample

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials: SE
Date: 27/4/10

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APPENDIX C
Laboratory test Results

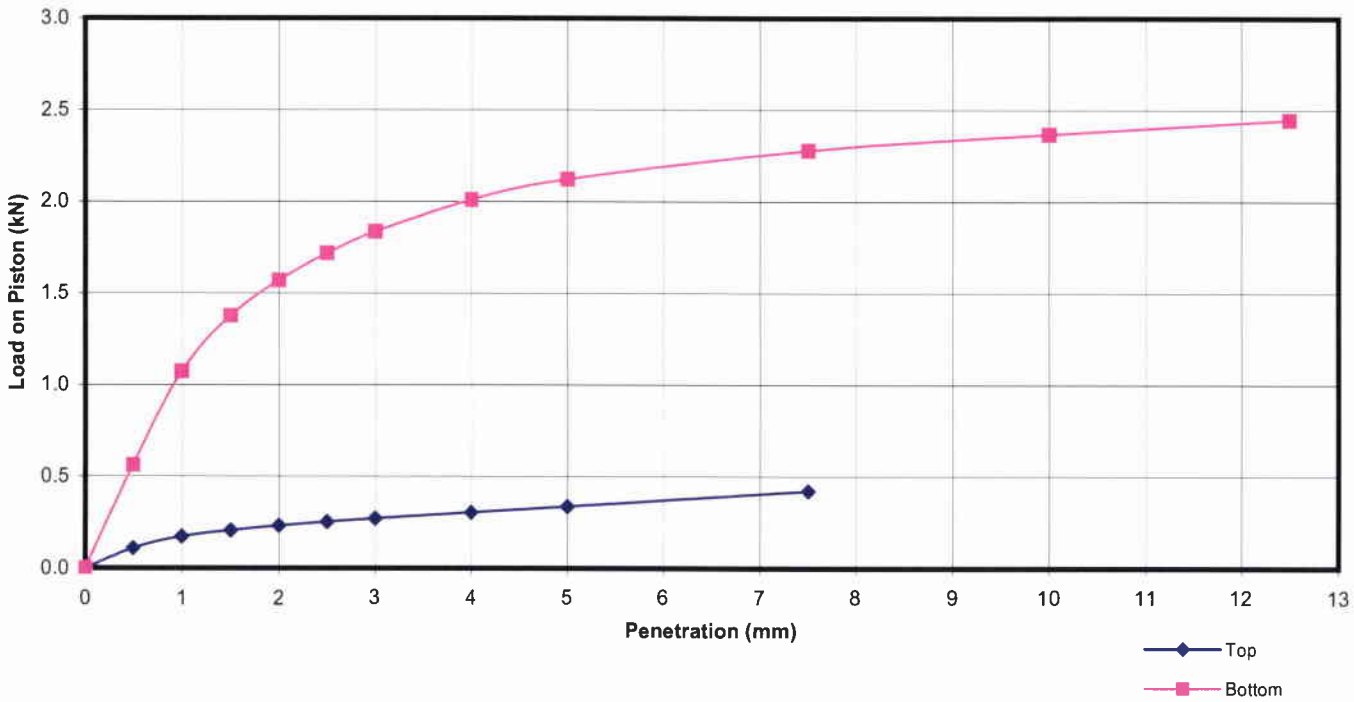
Douglas Partners
Geotechnics · Environment · Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
PO Box 472
West Ryde NSW 1685
Australia

96 Hermitage Road
West Ryde NSW 2114
Phone ***(02) 9809 0666***
Fax: *(02) 9809 4095*
sydney@douglaspartners.com.au

RESULT OF CALIFORNIA BEARING RATIO TEST

Client :	MACQUARIE UNIVERSITY	**Project No. :**	71683
		Report No. :	S10-061 A
Project :	MACQUARIE UNIVERSITY HEARING HUB	**Report Date :**	14/04/2010
		Date Sampled :	07/04/2010
Location :	UNIVERSITY AVE, MACQUARIE UNIVERSITY	**Date of Test:**	09/04/2010
Test Location :	BH 7		
Depth / Layer :	0.7-0.8m	**Page:**	1 of 1



Description: SILTY CLAY - Orange brown and red brown silty clay with a trace of ironstone gravel

Test Method(s): AS 1289.6.1.1-1998, AS 1289.2.1.1-2005

Sampling Method(s): Sampled by engineering department **Percentage > 19mm:** 0.0%

LEVEL OF COMPACTION: 99% of STD MDD **SURCHARGE:** 4.5 kg **SWELL:** 3.5%
MOISTURE RATIO: 103% of STD OMC **SOAKING PERIOD:** 4 days

CONDITION		MOISTURE CONTENT %	DRY DENSITY t/m^3
At compaction		20.8	1.66
After soaking		25.4	1.60
After test	Top 30mm of sample	29.0	-
	Remainder of sample	22.8	-
Field values		17.6	-
Standard Compaction		20.1	1.67

RESULTS		
TYPE	**PENETRATION**	**CBR (%)**
TOP	**2.5 mm**	**2.0**
	5.0 mm	**1.5**
BOTTOM	**2.5 mm**	**13**
	5.0 mm	**11**

NATA
TECHNICAL COMPETENCE

NATA Accredited Laboratory Number: 828
This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO IEC 17025

Approved Signatory:

Tested:	AJ
Checked:	NW

Norman Weimann
Laboratory Manager

Douglas Partners
Geotechnics · Environment · Groundwater

Douglas Partners Pty Ltd
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Australia

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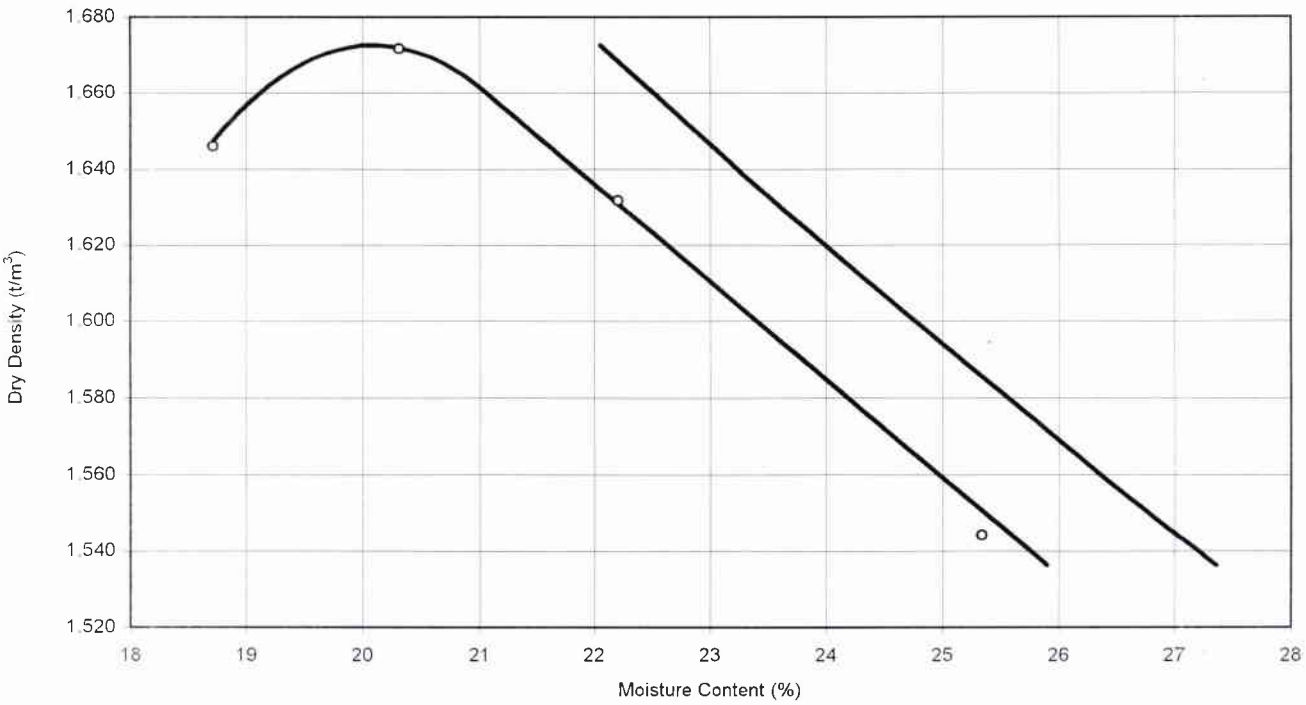
Fax: (02) 9809 4095
sydney@douglaspartners.com.au

RESULTS OF COMPACTION TEST

Client :	MACQUARIE UNIVERSITY	**Project No. :**	71683
		Report No. :	S10-061 A2
Project :	MACQUARIE UNIVERSITY HEARING HUB	**Report Date :**	09/04/10
Location :	UNIVERSITY AVE, MACQUARIE UNIVERSITY	**Date of Test:**	09/04/10
		Page:	1 of 1



Sample Details **Location:** BH 7
Depth: 0.7 - 0.8m

Particles > 19mm: 0%

Description: SILTY CLAY - Orange brown and red brown silty clay with a trace of ironstone gravel

Maximum Dry Density:	**1.67 t/m^3**
Optimum Moisture Content:	**20.0 %**

Remarks:

Test Methods: STD AS 1289.5.1.1, AS 1289.2.1.1

Sampling Methods: Sampled by engineering department

NATA
TECHNICAL COMPETENCE

NATA Accredited Laboratory Number: 828
This Document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025

Approved Signatory:

Tested:	AJ
Checked:	NW

Norman Weimann
Laboratory Manager

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 39633

Client:
Douglas Partners
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Scott Easton

Sample log in details:

Your Reference:	**71683, Macquarie University**
No. of samples:	4 Soils
Date samples received:	07/04/10
Date completed instructions received:	07/04/10

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:	14/04/10
Date of Preliminary Report:	Not Issued
Issue Date:	12/04/10

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

Results Approved By:

Jacinta Hurst
Operations Manager

Miscellaneous Inorg - soil					
Our Reference:	UNITS	39633-1	39633-2	39633-3	39633-4
Your Reference	----------	BH2/0.5-0.7	BH5/0.8-1.0	BH7/0.8-1.0	BH4/0.6-0.8
Date Sampled	----------	1/04/2010	29/03/2010	31/03/2010	7/04/2010
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	09/04/2010	09/04/2010	09/04/2010	09/04/2010
Date analysed	-	09/04/2010	09/04/2010	09/04/2010	09/04/2010
pH 1:5 soil:water	pH Units	8.6	6.5	4.3	4.4
Chloride, Cl 1:5 soil:water	mg/kg	6.5	18	37	17
Sulphate, SO4 1:5 soil:water	mg/kg	91	17	130	40

Method ID	Methodology Summary
LAB.1	pH - Measured using pH meter and electrode in accordance with APHA 20th ED, 4500-H+.
LAB.81	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 21st 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	-			09/04/2010	[NT]	[NT]	LCS-1	09/04/2010
Date analysed	-			09/04/2010	[NT]	[NT]	LCS-1	09/04/2010
pH 1:5 soil:water	pH Units		LAB.1	[NT]	[NT]	[NT]	LCS-1	99%
Chloride, Cl 1:5 soil:water	mg/kg	2	LAB.81	<2.0	[NT]	[NT]	LCS-1	96%
Sulphate, SO4 1:5 soil:water	mg/kg	2	LAB.81	<2.0	[NT]	[NT]	LCS-1	97%

Report Comments:

Asbestos was analysed by Approved Identifier: Not applicable for this job
INS: Insufficient sample for this test NT: Not tested PQL: Practical Quantitation Limit <: Less than >: Greater than
RPD: Relative Percent Difference NA: Test not required LCS: Laboratory Control Sample NR: Not requested

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 batches of 20. The duplicate sample RPD and matrix spike recoveries for the sample batch were within laboratory acceptance criteria.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes and LCS: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable. Surrogates: 60-140% is acceptable for general organics and 10-140% for SVOC and speciated phenols.