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Geotechnics | Environment | Groundwater

Report on
Preliminary Geotechnical Investigation

Proposed Hospital Upgrade
Bowral & District Hospital, Mona Road, Bowral

Prepared for
Health Infrastructure

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	Signature	Date
Author	Arthur Castrissios	7.10.16
Reviewer	for G.W. McIntosh	7.10.16

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Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
1/1 Luso Drive
Unanderra NSW 2526
PO Box 486
Unanderra NSW 2526
Phone (02) 4271 1836
Fax (02) 4271 1897

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Report on Preliminary Geotechnical Investigation
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1. Introduction

This report presents the results of a preliminary geotechnical investigation carried out for a proposed upgrade to the Bowral & District Hospital at Mona Road, Bowral. The work was commissioned by Health Infrastructure, the project planners and undertaken in liaison with TSA Management Pty Ltd, the project managers for the developers.

It is understood that an upgrade of the hospital is proposed and will include the construction of new buildings and car park areas in the northern section of the site. Site investigation was therefore undertaken to provide information on subsurface conditions and to assist in the conceptual planning and design of site preparation measures, foundations, retaining walls, ground slabs and pavements.

The investigation comprised borehole drilling with in-situ testing and sampling followed by laboratory testing of selected samples, engineering analysis and reporting. Details of work undertaken and the results obtained are given in the report, together with comments relating to design and construction practice.

Preliminary site layout option drawings were provided by the client for the investigation. This report supersedes a draft document (Project 89199) dated 20 September 2016 and all previous verbal advice and written correspondence.

2. Site Description and Regional Geology

The proposed upgrade is to be located in the northern section of the grounds of Bowral & District Hospital (Lot 4 in DP858938), accessed from the southern side of Bowral Street at Bowral. Maximum north-south and east-west dimensions of the development area are approximately 90 m and 100 m respectively. Surface levels fall in the northerly direction (ie towards Bowral Street) at grades of 1 in 35 to 1 in 60 with an overall difference in level estimated to be about 2 m from the highest point of the development footprint to the lowest. The site is bounded to the north by Bowral Street, to the west by Southern Highlands Private Hospital, to the south by existing hospital buildings and to the east by lightly grassed hospital grounds. At the time of the investigation, the building footprint comprised a single level hospital building and asphalt paved car park. The remainder of the footprint was lightly grassed. Various observations made during the investigation are shown on the colour photoplates in Appendix B.

Reference to the 1:100,000 Southern Coalfield Regional Geology Sheet (Ref 1) indicates that the site is underlain by rocks belonging to the Wianamatta Group of Triassic age. This formation typically comprises shale, laminate and siltstone. The results of the field investigation were consistent with the broad-scale geological mapping with sandstone or shale intersected in seven of the eight boreholes.

3. Field Work

3.1 Methods

The field work comprised the drilling of four boreholes (Bores 1 – 4) to depths of 0.2 – 1.1 m with a Kubota KX018-4 mini-excavator and four further boreholes (Bores 101 – 104) to depths of 1.5 – 6.0 m with either a DT100 truck-mounted or Bobcat-mounted drilling rig.

Bores 1 – 4 were advanced through the overburden soils using a 450 mm diameter power auger. Bores 3 and 4 were continued below 1.2 m depth using a 150 mm diameter power auger to refusal depths of 4.0 m and 2.5 m respectively. The boreholes were logged by a geotechnical engineer who collected disturbed and bulk samples at regular depth intervals to assist in strata identification and for possible laboratory testing.

Bores 101 – 104 were advanced through the overburden soils using 150 mm diameter solid flight augers or washboring to refusal depths of 1.5 – 3.0 m. Disturbed samples and standard penetration tests (SPTs) were taken at regular depth intervals to assist in strata identification and for possible laboratory testing. Details of the SPT procedure are given in the accompanying notes in Appendix B, with the penetration 'N' values given on the borehole logs. Bores 101, 103 and 104 were continued below auger or casing refusal depth of 1.8 – 3.0 m using NMLC (50 mm diameter) diamond core drilling equipment to recover core samples of the bedrock to the termination depths of 4.7 – 6.0 m.

Dynamic cone penetrometer tests (DCP, AS1289 6.3.2) were undertaken adjacent to Bores 1, 3 and 4 to depths of 1.2 m and at an additional location (P105) to 2.4 m depth to assess the consistency of the near-surface soils.

The approximate locations of the field tests are shown on Drawing 1 (Appendix B). The surface levels to Australian Height Datum (AHD) were determined from web-based mapping. The co-ordinates to Map Grid of Australian (MGA) were determined using a hand-held GPS receiver. The levels and co-ordinates are therefore approximately only.

3.2 Results

The subsurface conditions encountered during the investigation are given on the borehole logs in Appendix B. These should be read in conjunction with the accompanying notes defining classification method and descriptive terms. Geotechnical sections are included in Appendix B.

Slightly variable conditions were encountered underlying the site, with the succession of strata broadly summarised as follows:

ASPHALTIC CONCRETE:	15 – 20 mm thick pavement wearing course in Bores 1 – 3 and 103;
TOPSOIL/ TOPSOIL FILLING:	to 0.1 m depth in Bores 4, 101, 102 and 104;

FILLING: of variable composition and consistency to depths of 0.2 – 0.5 m in Bores 2, 3, 103 and 104, and to the limit of investigation at 1.0 m in Bore 1.

SILTY CLAY: typically stiff to very stiff (but soft and saturated at 1.2 m depth in Bore 4), to depths of 1.5 – 3.3 m in Bores 3, 4 and 101 – 104;

BEDROCK: variably extremely low to low strength sandstone and shale, becoming extremely low to medium strength at auger refusal at depths of 1.5 – 4.0 m. In Bore 101, 103 and 104, the recovered core typically comprised extremely low strength shale becoming low strength below depths of 4.3 – 4.5 m and continuing to the termination depths of 4.7 – 6.0 m. Weathered rock was also inferred by DCP refusal at 2.4 m depth in P105.

The depths and levels at which the various grades of rock were encountered are summarised in Table 1.

Table 1: Rock Depth Summary

Pit/ Bore No	Surface RL (m, AHD)	Top of ELS Rock		Top of VLS - LS Rock		Top of LS - MS Rock	
		Depth (m)	RL (m)	Depth (m)	RL (m)	Depth (m)	RL (m)
1	680.0	NE	-	NE	-	NE	-
2	680.5	NE	-	NE	-	0.2	680.3(1)
3	680.1	NE	-	2.8	677.3	4.0(2)	676.1
4	679.6	2.3	677.3	NE	-	2.5(2)	677.1
101	679.0	3.3	675.7	3.8	675.2	4.3	674.7
102	680.0	NE	-	NE	-	1.5(2)	678.5
103	680.2	2.7	677.5	NE	-	3.9	676.3
104	680.8	2.8	678.0	4.1	676.7	NE	-
105	671.6	2.4(3)	679.2	NE	-	NE	-

Where: ELS = extremely low strength VLS - LS = Very low strength to low strength
LS - MS = Low to medium strength NE = Not encountered

Note: (1) Possible boulder in filling
(2) Inferred by auger refusal
(3) Inferred by DCP refusal

Free groundwater was observed at depths of 1.1 m (RL 679) and 1.2 m (RL 678.4) in Bores 3 and 4 respectively during drilling. No free groundwater was observed in the remaining boreholes during auger drilling. It is noted that the use of water as a drilling fluid precluded groundwater observations whilst coring. Furthermore, all boreholes were backfilled following the field work which precluded long term monitoring of groundwater level. Groundwater levels are dependent on preceding climatic conditions and soil permeability and can therefore fluctuate with time.

4. Laboratory Testing

Selected samples from the boreholes were tested in the DP laboratory for measurement of field moisture content, compaction properties, California bearing ratio, Shrink-Swell Index and undrained triaxial shear using modified stage testing techniques. The detailed test report sheets are given in Appendix C, with the results summarised in Table 2.

Table 2: Results of Laboratory Testing (Mechanical)

Bore No	Depth (m)	FMC (%)	OMC (%)	MDD (t/m^3)	CBR (%)	Cu$^{(1)}$ (kPa)	Iss (%/ΔpF)	Material
3	0.5 – 0.7	19.3	18.8	1.82	6			Silty Clay
4	0.5 – 0.7	27.6	19.3	1.73	11			Silty Clay
102	0.5 – 0.9	21.9				76		Silty Clay
103	0.5 – 0.9	21.4				58	0.3	Silty Clay

Where:
FMC = Field moisture content
OMC = Optimum moisture content
MDD = Maximum dry density
CBR = California bearing ratio

Note (1) : Average of 50 kPa, 100 kPa and 200 kPa confining pressure

The CBR results are slightly higher than anticipated which is likely due to the relatively high sand and silt content within the overall clay matrix. Whilst the results are an accurate determination of a small, remoulded laboratory sample, it is considered that they overstate the in-situ strength of the subgrade. As such, some downgrading has been undertaken for design purposes.

The results of the strength testing indicated that the clay samples tested are of *'stiff'* consistency and confirm the field logging. The Shrink-Swell result indicates that the sample tested is of low plasticity and as such, would be slightly susceptible to shrinkage and swelling movements with changes in soil moisture content.

Two samples from the boreholes (Bores 102 & 102) were despatched to Envirolab Services Pty Ltd for measurement of pH, electrical conductivity, chloride and sulfate concentrations. The detailed test report sheets are given in Appendix C with the results summarised in Table 3.

Table 3: Results of Laboratory Testing (Chemical)

Bore No.	Depth (m)	pH	EC (μS/cm)	Cl^- (mg/kg)	SO_4^{2-} (mg/kg)	Material
102	1.0	6.2	1.2	10	<10	Silty Clay
103	2.5	5.9	49	17	<10	Silty Clay

Where
EC = Electrical conductivity
Cl^- = Chloride concentration
SO_4^{2-} = Sulfate concentration

Reference to AS2159 – 2009 (Ref 2) indicates that the samples tested can be classified as *'non aggressive'* to concrete and steel.

Point load strength index ($Is_{(50)}$) tests were carried out on selected samples of the rock core. The results of these tests are included on the borehole logs and indicate unconfined compressive strength (UCS) of the rock in the range 2 – 18 MPa. These values are generally indicative of low to medium strength rock and are based on a UCS:$Is_{(50)}$ correlation factor of 20.

5. Proposed Development

It is understood that the first stage of the Bowral Hospital Upgrade will comprise partial demolition of existing structures following by the construction of a new 3-storey hospital building, associated accessways and car parks. As conceptual design was yet to commence at the time of this report, the recommendations given within must be considered as being preliminary in nature. It is understood that cut and fill depths of around 1.5 m will be required to create a building platform at RL680 m AHD.

From information provided by Enstruct, consulting structural and civil engineers, working column loads are envisaged to be in the range 2000 kN for an on-grade floor slab to 3000 kN for suspended slab construction. A design traffic loading of 1 x 10^5 Equivalent Standard Axles (ESA) has been nominated by Enstruct for pavement thickness design purposes.

Confirmation of the appropriateness of the recommendations given within should be sought from DP once preliminary designs are available.

6. Comments

6.1 Site Classification

Due to the presence of filling of variable composition and consistency to depths in excess of 0.4 m (in part) and variable strength of the natural clay, the site (at the time of the investigation) is classified as Class P in accordance with the requirements of AS 2870 – 2011 *"Residential Slabs and Footings"* (Ref 3). The main requirement of a Class P site is for design to be undertaken by a suitably qualified structural engineer with design based on engineering principles.

Notwithstanding the P classification, the underlying stiff clay profile would be equivalent to Class M (moderately reactive) conditions. It is noted however that classification is based on the subsurface conditions at the time of the investigation and is independent of proposed construction and site works, and is aimed at classifying the site from the reactivity viewpoint only. Following earthworks under controlled conditions (refer Section 6.2), the resulting site classification would be primarily dependent on the shrink-swell capacity of the fill materials. For example, fill materials placed to depths of up to 1.5 m would need to have a Shrink-swell Index no greater than 2.5%/ΔpF to achieve an M classification. Alternatively, upper Shrink-swell limits of 3.5%/ΔpF and 4.6%/ΔpF would result in H1 and H2 classifications respectively.

6.2 Site Preparation

In order to provide a platform suitable for floor slab construction and pavements, the following site preparation measures are suggested:

- strip all surface vegetation, organic topsoils and other deleterious materials (such as the existing filling) to expose the underlying natural clays. Due to the variable consistency of the existing filling, care must be exercised to separate the deleterious materials (eg: topsoils, vegetation, oversize fractions etc) from suitable parts of the filling, which could be re-used within the structural platform;
- test roll the stripped surface in the presence of a geotechnical engineer to identify weak subgrade areas;
- where encountered, weak subgrade areas should be treated by over-excavation and replacement with approved materials;
- place approved filling (such as clay soils won from cut and selected existing shaly clay filling) in horizontal layers of maximum 300 mm loose thickness;
- compact of each layer to achieve a minimum of 98% Standard maximum dry density with placement moisture contents maintained within ± 2% of Standard optimum. In pavement areas, the upper 0.5 m of any filling and subgrade is to be compacted to achieve at least 100% standard maximum dry density.

The placement of structural filling should be undertaken under Level 1 conditions as defined in AS3798 – 2007 (Ref 4)

The soils clay soils underlying the site will not be able to stand vertically without support. Where space permits it will be practicable to batter the sides of the excavation and in this regard, it is suggested that maximum temporary batters of 1:1 (H:V) be adopted for preliminary design purposes. Permanent cut and fill batters should be formed no steeper than 3:1 (horizontal:vertical) with erosion protection measures put in place as soon as practical following construction.

6.3 Excavation Conditions

On the basis that cut depths will be less than 1.5 m, existing filling and residual clays will mainly be encountered. Accordingly, few difficulties are foreseen in excavation of the overburden soils using conventional earthmoving equipment. Some heavy ripping, possibly in conjunction with percussion assistance should be anticipated in the vicinity of Bore 2 where auger refusal occurred (possible on weathered rock or rocky filling) at a depth of 0.2 m.

For service trench excavation, the presence of shallow groundwater seepage may require localised dewatering via sump and pump techniques, together with shoring or battering. In particular, it is noted that free groundwater was observed at depths of 1.1 m in Bore 3 and 1.2 m in Bore 4 during drilling.

6.4 Disposal of Excavated Materials

Under the Protection of the Environment and Operations Act (1997), the burden of proof that materials received by a landfill or fill site meet the environmental criteria for proposed land use rests on the waste/fill receiving site. Inspection and testing will need to be carried out to classify the spoil in accordance with the Waste Classification Guidelines (2014) prior to removal from site. The type and extent of testing undertaken would depend on final use or destination of the spoil and requirements of the receiving site. As a minimum, allowance should be made during bulk excavation to stockpile fill materials separately from the underlying residual soils and rock to enable the best possible waste classification of the natural soils/rock to be achieved.

As a geo-environmental consultant, Douglas Partners Pty Ltd has the capabilities to assist excavation contractors in classifying materials and negotiating disposal, if required.

6.5 Retaining Walls

Where proposed, it is suggested that earth pressures on cantilever retaining walls due to the retained soils be based on a triangular pressure distribution calculated as follows:

$$\sigma_z = \gamma.Ka.z$$

where σ_z = horizontal pressure at depth z

γ = unit weight of retained soil (20 kN/m^3)

Ka = active earth pressure coefficient
= 0.35 for stiff to very stiff clays and compacted filling
= 0.15 for weathered sandstone/siltstone.

The above parameters assume level backfill behind the wall with no surcharge loading from water pressure, traffic or adjacent footings. In addition, allowance should be made for the following factors in the design of retaining walls:

- backfilling of the void between the wall and the slope should be undertaken using imported sandy or granular material with provision of an adequate drainage medium behind the retaining wall connected into a drainage pipe at the base of the wall;
- capping of the backfill (where exposed) with compacted clay or concrete to prevent surface runoff entering the backfill;
- provision of an open drain to collect and divert surface runoff from above the wall (where appropriate);
- any additional surcharge loads;
- a factor of safety of 1.5.

6.6 Foundations

Consideration has initially been given to the use of high level footings (such as pad/strip footings or a raft slab) founded in the upper residual clay, however their use is not recommended. Due to the loads proposed, settlement (both total and differential) would be beyond tolerable limits for the structure. Accordingly, it is suggested that all footings found on a uniform bearing stratum of low to medium strength rock. The main advantage with founding on rock is that settlements (both total and differential) would be negligible under the anticipated loads.

It is noted that due to the presence of seepage at relatively shallow depths, allowance should be made for the inclusion of temporary or permanent casing to mitigate groundwater inflow and provide sidewall stability in the overburden soils. Socket adhesion is to be neglected over those sections which are cased. Side adhesion should also be neglected in the overburden clays.

Based on the results of the field investigation, footings could be proportioned using the following (working stress) parameters

• Base bearing pressure on very low to low strength rock	800 kPa
• Allowable shaft adhesion in extremely low to very low strength rock (compression)	50 kPa
• Allowable shaft adhesion in extremely low to very low strength rock (tension)	25 kPa
• Base bearing pressure on low to medium strength rock	1,500 kPa
• Allowable shaft adhesion in low to medium strength rock (compression)	150 kPa
• Allowable shaft adhesion in low to medium strength rock (tension)	75 kPa

Based on the above parameters, a 1.2 m diameter pier founded on low to medium strength rock would require socket lengths within low to medium strength rock of 0.6 m and 2.4 m to achieve working loads of 2000 kN and 3000 kN respectively. It is noted that sockets in excess of, say two pile diameters are likely to require high-torque drilling rigs and even then, slow penetration rates are likely. As such, consideration should be given to pile groups (with nominal pile spacing of no closer than three pile diameters), thus eliminating the need for excessive sockets. For example, a four pile group of 600 mm diameter piers socketed 0.5 m into low to medium strength rock could support a working load of around 2,200 kN. Alternatively, two 900 mm diameter piers would require socket lengths of 0.1 m (ie nominal socket) and 1.2 m respectively for working loads of 2000 kN and 3000 kN.

Suggested parameters for use in ‘limit state’ pile design calculations are included in Table 4 (following page).

Where a “limit state” design approach using ultimate stresses is adopted for foundation design in accordance with the guidelines contained within AS 2159 – 2009 (Ref 2), the design geotechnical strength (R_g) should be calculated as the ultimate geotechnical strength (R_{ug}) multiplied by a geotechnical strength reduction factor (ϕ_g) value of 0.65. For serviceability limit state, a modulus reduction factor (ϕ_m) value of 0.75 is considered appropriate. The nominated geotechnical strength factors are based on geotechnical inspections being undertaken during construction to confirm the appropriateness of the founding stratum for the nominated pressures and on the assumption that no pile testing is undertaken.

Table 4: Suggested Pile Design Parameters

Strata Description	Ultimate Shaft Adhesion (kPa)		Ultimate End Bearing Pressure (MPa)	Youngs Modulus, E (MPa)
	Compression	Tension		
ELS - VLS rock	100	50	2	100
VLS - LS rock	150	75	3	300
LS - MS rock	400	200	6	1000

Where:
ELS - VLS = Extremely low to very low strength
VLS - LS = Very low strength to low strength
LS - MS = Low to medium strength

It is expected that heavy duty (high torque) truck or crane mounted drilling equipment would penetrate the rock by auger methods. The drilling contractors however, must inspect the core samples to make their own assessment of drilling difficulty, particularly if sockets deeper than a nominal single pile diameter into the medium strength sandstone are proposed.

6.7 Ground Slabs

Following site preparation in accordance with Section 6.2, floor slabs can be designed as slab-on-ground supported by stiff clay or compacted filling.

Under these circumstances, floor slab design could be based on an estimated subgrade CBR not exceeding 4% for clay. The corresponding (short term) modulus (E) values would be 40 MPa. Corresponding moduli of subgrade reaction would be 15 – 20 kPa/mm for wheel loads, reducing to 1 – 2 kPa/mm for uniformly distributed loads up to 15 kPa but dependant on the area of the floor subject to loading.

The above criteria depend on the provision of surface and subsurface drainage to maintain the subgrade close to the optimum moisture content. The slabs should incorporate articulation and joint details which take account of the reactive subgrade. The slabs should also be cast independently of the walls which will be supported on a footings-to-rock foundation system.

Particular note is made for the likely intersection of shallow groundwater within the lift pit excavations. Based on information to date, is suggested that a tanked design could be based on a groundwater level at 1 m below existing surface levels. Alternatively, allowance will need to be made for subfloor drainage with discharge via a permanent pump.

6.8 Earthquake Design Parameters

Earthquake Hazard Maps published by the Australian Geological Survey Organisation are reproduced in AS 1170.4 – 2007 (Ref 5). The anticipated peak ground acceleration or acceleration coefficient for the Bowral area is quoted as 0.9 m/sec^2 or 0.09 g. Furthermore, based on a comparison of the soil profile encountered during the field testing with those included in Reference 5, it is suggested that a Class C_e classification be adopted for design purposes.

6.9 Preliminary Pavement Thickness Design

Based on the results of the investigation and previous experience in the Bowral area, a design CBR of 4% is considered appropriate for the residual clay, allowing for some variability in subgrade conditions. Pavement thicknesses (Ref 6) for a range of traffic loadings using conventional unbound materials (flexible) and concrete (rigid) are given in Table 5.

Table 5 – Preliminary Pavement Thickness Design

Design Traffic (ESA or CVAG)	Design CBR (%)	Total Flexible Thickness (mm)	Total Rigid Thickness (mm)
Car Park up to 3 T gross weight	4	200	165(265)$^{(1)}$
1 x 10^4	4	280	180(280)$^{(1)}$
5 x 10^4	4	315	190(290)$^{(1)}$
1 x 10^5	4	330	195(295)$^{(1)}$

Where ESA = Equivalent Standard Axles CVAG = Commercial Vehicle Axle Groups

Note(1) Bracketed figure indicates total boxing depth including 100 mm granular sub-base layer

The traffic loadings adopted must be confirmed by the design engineer prior to construction.

Pavement materials should be compacted in layers no thicker than 150 mm. Compaction to a minimum density ratio of 98% (modified compaction) will be required for basecourse, 95% (modified) for sub-base and 100% (standard) for subgrade material. Following excavation to design subgrade levels, proof rolling of all subgrades must be undertaken, with areas exhibiting deflection being over-excavated and replaced under engineering control with approved granular materials having a CBR value of not less than 20%.

The pavement material quality and compaction requirements are given in Table 6. Whilst the use of lesser quality pavement materials than that detailed in Table 6 may be feasible, some compromise in either performance and/or pavement life must be anticipated and accepted.

Table 6 – Pavement Material Quality and Compaction

Layer	Material Quality	Minimum Compaction
Wearing Course	To conform to Austroads	To conform to Austroads
Base Course	To conform to Austroads Soaked CBR ≥ 80%, PI ≤ 6%	Minimum dry density ratio of 98% Modified (AS 1289 Test 5.2.1)
Sub-base Course	To conform to Austroads 21 Soaked CBR ≥ 50%, PI ≤ 12%	Minimum dry density ratio of 95% Modified (AS 1289 Test 5.2.1)
Subgrade Replacement	Soaked CBR ≥ 20%	Minimum dry density ratio of 100% Standard (AS 1289 Test 5.1.1)
Subgrade		Minimum dry density ratio of 100% Standard (AS 1289 Test 5.1.1)

Where PI = Plasticity Index

The pavement gravels should be placed and compacted in layers no thicker than 150 mm with control exercised over placement moisture contents. If layer thicknesses greater than 150 mm are proposed, it may be necessary to test the top and bottom on the layer to ensure that the minimum level of compaction has been achieved through the layer.

Surface and subsurface drainage should be installed and maintained to protect the pavements and subgrade. Subsurface drains associated with pavements should be located at a minimum of 0.5 m depth below the excavation level. Guidelines on the arrangement of subsurface drainage are given on Page 20 of ARRB – SR41 (Ref 7). It should be noted that if the sub-base is of low permeability relative to the base layer, then the subsurface drain must intersect all pavement layers as shown in ARRB – SR41.

Particular note is made of the need for extensive subsurface drainage in pavement areas adjacent to any lawns or garden beds, where the ingress of water into the neighbouring pavement subgrade is likely. Preparation of the subgrade surface should be such that adequate crossfalls for the surface drainage purposes are achievable across the final pavement. Regular and on-going maintenance of the pavements, such as sealing of joints and surface cracks, will be required to minimise the potential of water ingress that could cause subgrade saturation and premature pavement failure.

7. References

1. Moffitt, R.S. 1999 Southern Coalfield Regional Geology 1:100 000 First Edition Geological Survey of New South Wales, Sydney
2. Australian Standard AS 2159 – 2009 *Piling - Design and Installation*.
3. Australian Standard AS 2870 – 2011 *Residential Slabs and Footings.*
4. Australian Standard AS 3798 – 2007 *Guidelines on Earthworks for Commercial and Residential Developments.*
5. AS 1170.4 Minimum design loads on structures – Part 4 Earthquake loads (known as SAA loading code) Australian Standards – 2007.
6. *Guide to Pavement Technology- Part 2: Pavement Structural Design,* Austroads 2012
7. ARRB – SR41 – A Structural Design Guide for Flexible Residential Street Pavements, Australian Road Research Board, Special Report No. 41, 1989

8. Limitations

Douglas Partners (DP) has prepared this report for this project at Bowral District Hospital in accordance with DP's proposal dated 30 June 2016 and acceptance dated 26 July 2016 The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Health Infrastructure for this project only and for the purposes 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. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations 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.

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This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report 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 or excavation. 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 and test pits 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 or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

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

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole 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; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements 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.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

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

If these occur, DP will be pleased to assist with investigations 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, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report 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. DP 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 and environmental 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.

Rock Descriptions

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq \text{100 mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

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

Sampling

Sampling is carried out during drilling or test pitting 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 it to obtain 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.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally 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 samples.

Continuous Spiral Flight Augers

The borehole 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 sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud 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 the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils 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 before the full penetration depth, 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 SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. 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 types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Douglas Partners

Description and Classification Methods

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

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
$\underline{\triangledown}$	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

July 2010

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General

■	Asphalt
▨	Road base
▨	Concrete
▦	Filling

Soils

▨	Topsoil
▨	Peat
▨	Clay
▨	Silty clay
▨	Sandy clay
▨	Gravelly clay
▨	Shaly clay
▥	Silt
▥	Clayey silt
▥	Sandy silt
▨	Sand
▨	Clayey sand
▨	Silty sand
▨	Gravel
▨	Sandy gravel
▨	Cobbles, boulders
▨	Talus

Sedimentary Rocks

▨	Boulder conglomerate
▨	Conglomerate
▨	Conglomeratic sandstone
▨	Sandstone
▤	Siltstone
▤	Laminite
▤	Mudstone, claystone, shale
■	Coal
▦	Limestone

Metamorphic Rocks

▨	Slate, phyllite, schist
▨	Gneiss
▨	Quartzite

Igneous Rocks

▨	Granite
▨	Dolerite, basalt, andesite
▨	Dacite, epidote
▨	Tuff, breccia
▨	Porphyry

Appendix B

Borehole Logs (Bores 1 - 4 and 101 – 104)
Dynamic Cone Penetrometer Report Sheet (1 sheet)
Color Photoplates
Drawings

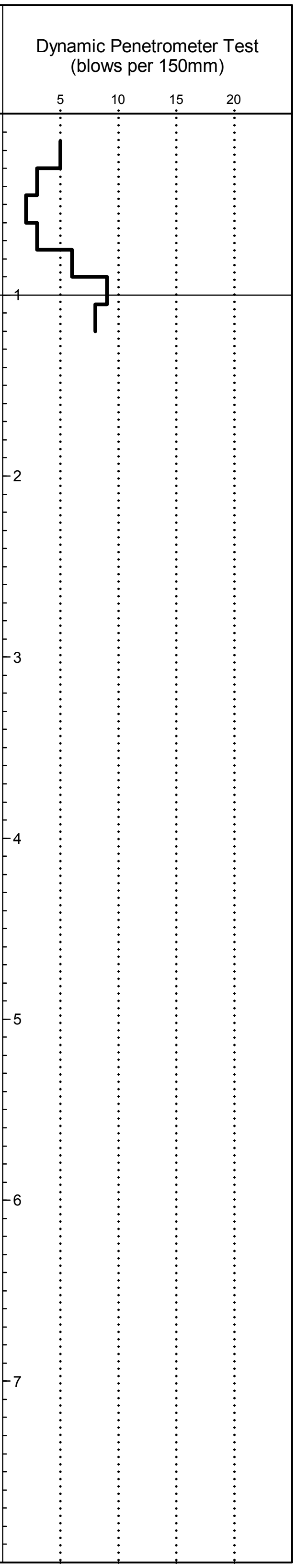
BOREHOLE LOG

CLIENT: Health Infrastructure
PROJECT: Proposed Hospital Upgrade
LOCATION: Bowral District Hospital, Mona Road, Bowral

SURFACE LEVEL: 680.0 AHD
EASTING: 263391
NORTHING: 6181164
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 89199
DATE: 12/8/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		ASPHALTIC CONCRETE - grey, asphaltic concrete		D	0.1			
		FILLING - grey, slightly silty, fine to medium gravelly sand, damp						
		FILLING - orange brown grey, slightly gravelly, silty clay, moist		D B	0.5 0.7			
	1	Bore discontinued at 1.0m Limit of investigation		D	1.0			



RIG: Kubota KX018-4 **DRILLER:** J.Boers **LOGGED:** CMcD **CASING:** Uncased
TYPE OF BORING: Power Auger (450mm diameter) to 1.0m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Surface levels inferred from nearmap.com

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Health Infrastructure
PROJECT: Proposed Hospital Upgrade
LOCATION: Bowral District Hospital, Mona Road, Bowral

SURFACE LEVEL: 680.5 AHD
EASTING: 263381
NORTHING: 6181140
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 89199
DATE: 12/8/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	VWP Construction Details
				Type	Depth	Sample	Results & Comments		
		ASPHALTIC CONCRETE - grey, asphaltic concrete		D	0.1				
		FILLING - orange grey, slightly silty, gravelly sand, damp		B	0.2				
		SANDSTONE - low to medium strength, moderately weathered, orange white, sandstone		D					
		Bore discontinued at 0.2m Refusal on possible medium strength sandstone							
									1
									2
									3
									4
									5
									6
									7

RIG: Kubota KX018-4 **DRILLER:** J.Boers **LOGGED:** CMcD **CASING:** Uncased
TYPE OF BORING: Power Auger (450mm diameter) to 0.2m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Surface levels inferred from nearmap.com

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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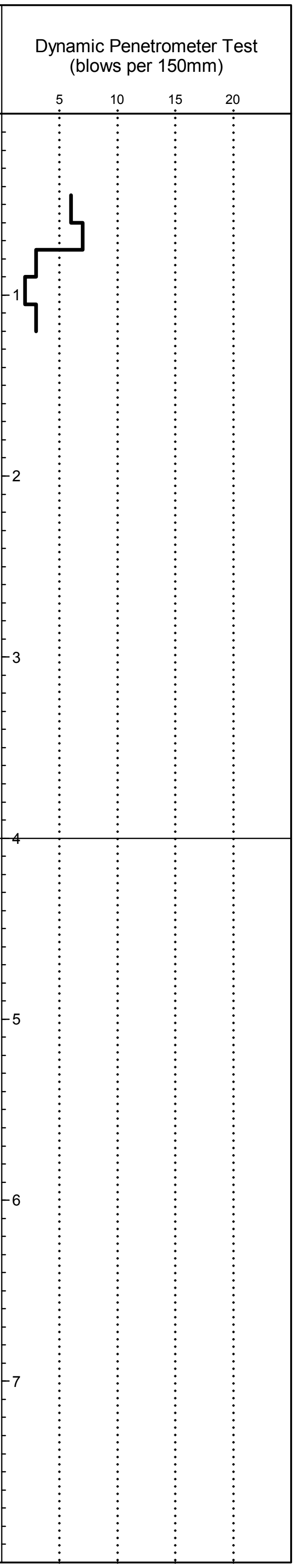
BOREHOLE LOG

CLIENT: Health Infrastructure
PROJECT: Proposed Hospital Upgrade
LOCATION: Bowral District Hospital, Mona Road, Bowral

SURFACE LEVEL: 680.1 AHD
EASTING: 263413
NORTHING: 6181144
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 89199
DATE: 12/8/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water
				Type	Depth	Sample	Results & Comments	
		ASPHALTIC CONCRETE - grey, asphaltic concrete		D B	0.1 0.3			
		FILLING - grey, slightly silty, slightly clayey, fine to medium grained gravelly sand, moist						
		SILTY CLAY - stiff, orange brown, silty clay with some gravel (ironstone, sandstone), moist		D B	0.5 0.7			
	1			D	1.0			▼ 12-08-16
		- becoming orange light grey below 1.5m						
	2							
	3	SANDSTONE - very low to low strength, highly weathered, orange light grey, sandstone						
	4	Bore discontinued at 4.0m Refusal on medium strength sandstone						
	5							
	6							
	7							



RIG: Kubota KX018-4 **DRILLER:** J.Boers **LOGGED:** CMcD **CASING:** Uncased

TYPE OF BORING: Power Auger (450mm diameter) to 4.0m

WATER OBSERVATIONS: Free groundwater observed at 1.1m

REMARKS: Surface levels inferred from nearmap.com

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

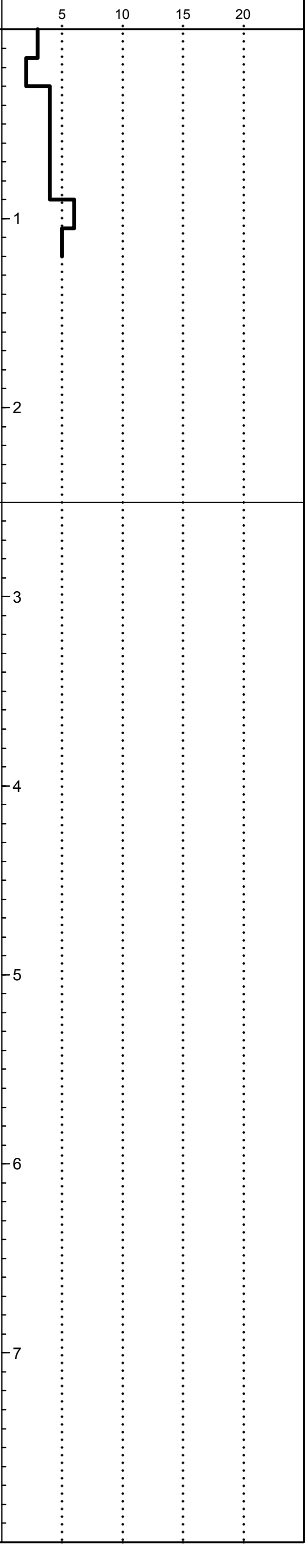
CLIENT: Health Infrastructure
PROJECT: Proposed Hospital Upgrade
LOCATION: Bowral District Hospital, Mona Road, Bowral

SURFACE LEVEL: 679.6 AHD
EASTING: 263451
NORTHING: 6181133
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 89199
DATE: 12/8/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Sampling & In Situ Testing Depth	Sampling & In Situ Testing Sample	Results & Comments	Water
		TOPSOIL - dark grey, silty clay, moist		D	0.1			
		SILTY CLAY - stiff, grey, silty clay, moist						
		SILTY CLAY - stiff, orange brown, silty clay, moist		D B D	0.5 0.7 1.0			
		- saturated and very soft at 1.2m						▼ 12-08-16
		SANDSTONE - extremely low to low strength, highly weathered, orange brown, sandstone						
		Bore discontinued at 2.5m Refusal on medium strength sandstone						

Dynamic Penetrometer Test
(blows per 150mm)



RIG: Kubota KX018-4
DRILLER: J.Boers
LOGGED: CMcD
CASING: Uncased
TYPE OF BORING: Power Auger (150mm diameter) to 2.5m
WATER OBSERVATIONS: Free groundwater observed at 1.2m
REMARKS: Surface levels inferred from nearmap.com

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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DOUGLAS PARTNERS PTY LTD

PROPOSED HOSPITAL UPGRAD – BOWRAL DISTRICT HOSPITAL

BORE 101 PROJECT 89199.00 SEPT 2016

1.80 – 4.74 m

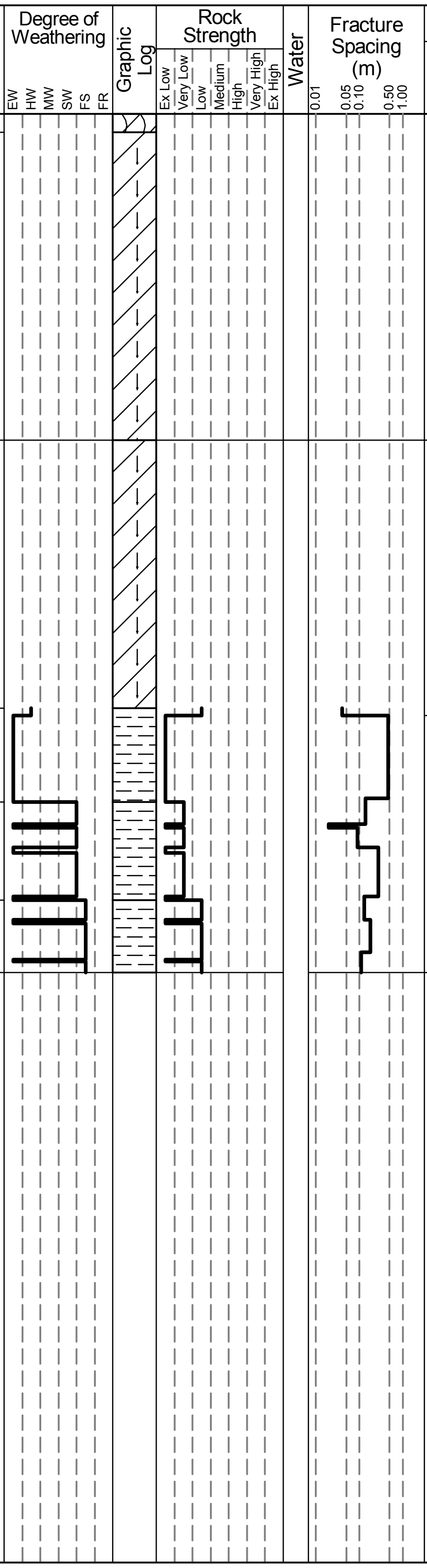
BOREHOLE LOG

CLIENT: Health Infrastructure
PROJECT: Proposed Hospital Upgrade
LOCATION: Bowral District Hospital, Mona Road, Bowral

SURFACE LEVEL: 679.0 AHD
EASTING: 263450
NORTHING: 6181155
DIP/AZIMUTH: 90°/--

BORE No: 101
PROJECT No: 89199
DATE: 18/8/2016
SHEET 1 OF 1

Depth	RL (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
0		TOPSOIL - dark grey, silty clay with some rootlets, damp		A			
	678.90	SILTY CLAY - very stiff, light brown grey, silty clay, damp - becoming orange brown light grey and slightly gravelly below 0.5m	Unless otherwise stated, rock is fractured along planar, smooth to rough, iron-stained, near horizontal bedding partings	A U A S R			 4,8,12 N = 20
	677.20	SILTY CLAY - very stiff, light grey mottled orange brown, medium plasticity, silty clay with some extremely low strength, extremely weathered, sandstone bands, moist		C	100		
	675.72	SHALE - extremely low strength, extremely weathered, fractured to slightly fractured, grey orange brown, shale	3.28m: B 5° 3.32m: clay seam 5° 480mm	C	100	0	
	675.20	SHALE - very low strength, slightly weathered to fresh stained, fractured to slightly fractured, mid to dark grey, shale	3.92m: B 5° clay 20mm 4.05m: B 5° clay 30mm	C	100	78	PL(A) = 0.1
	674.66	SHALE - low strength, fresh stained, fractured to slightly fractured, mid to dark grey, shale	4.32m: B 5° clay 20mm 4.45m: B 5° clay 20mm 4.63m: B 5° clay 10mm				PL(A) = 0.3
	674.26	Bore discontinued at 4.74m (Limit of investigation)					



RIG: DT100 **DRILLER:** Ground Test (G.M) **LOGGED:** CMcD **CASING:** HW to 1.0m

TYPE OF BORING: SFA (TC bit) to 1.0m, Rotary (Water) to 1.8m, Coring (NMLC) to 4.74m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface levels inferred from nearmap.com

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
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BOREHOLE LOG

CLIENT: Health Infrastructure
PROJECT: Proposed Hospital Upgrade
LOCATION: Bowral District Hospital, Mona Road, Bowral

SURFACE LEVEL: 680.0 AHD
EASTING: 263442
NORTHING: 6181106
DIP/AZIMUTH: 90°/--

BORE No: 102
PROJECT No: 89199
DATE: 18/8/2016
SHEET 1 OF 1

Depth	RL (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 F - Fault	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
0	679.90	TOPSOIL - dark grey, silty clay with some rootlets, damp							A			
		SILTY CLAY - stiff, light brown grey, silty clay, damp							A			
		- becoming orange brown grey below 0.4m							U			Cu = 60 - 90 kPa
1	679	- extremely low strength, extremely weathered, orange red brown, shale bands below 1.0m							A			
									S			5,8,14 N = 22
	678.55	Bore discontinued at 1.45m (Refusal on low to medium strength shale)										
2	678											
3	677											
4	676											
5	675											
6	674											
7	673											

RIG: DT100 **DRILLER:** Ground Test (G.M) **LOGGED:** CMcD **CASING:** HW to 1.0m
TYPE OF BORING: SFA (TC bit) to 1.0m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Surface levels inferred from nearmap.com

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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PROPOSED HOSPITAL UPGRAD – BOWRAL DISTRICT HOSPITAL

BORE 103 PROJECT 89199.00 SEPT 2016

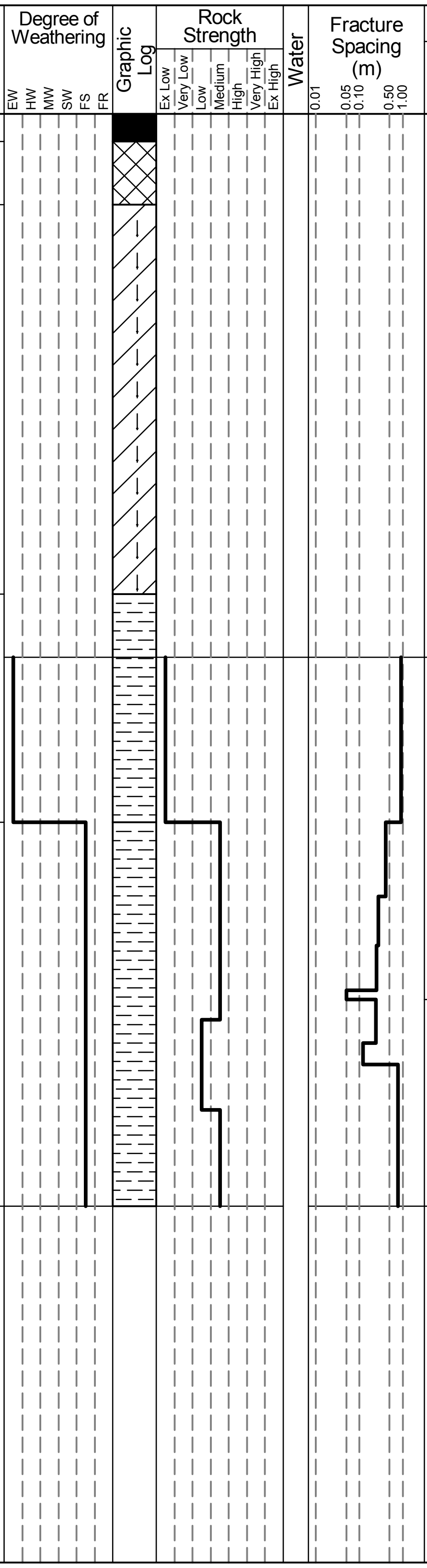
3.0– 6.03 m

BOREHOLE LOG

CLIENT: Health Infrastructure
PROJECT: Proposed Hospital Upgrade
LOCATION: Bowral District Hospital, Mona Road, Bowral

SURFACE LEVEL: 680.2 AHD
EASTING: 263383
NORTHING: 6181167
DIP/AZIMUTH: 90°/--

BORE No: 103
PROJECT No: 89199
DATE: 19/8/2016
SHEET 1 OF 1



RL (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
680	ASPHALTIC CONCRETE - dark grey, asphaltic concrete, damp		A			
680.05	FILLING - brown orange, silty clay with some gravel, moist		A			
679.70	SILTY CLAY - stiff to very stiff, grey orange, silty clay, damp to moist		U			pp = 150-260 Cu = 51 - 65 kPa
			A			
679	- becoming firm and grey brown below 1.0m		S			3,3,3 N = 6
678		Unless otherwise stated, rock is fractured along planar, smooth to rough, near horizontial bedding partings				
677.55	SHALE - extremely low strength, extremely weathered, orange grey, shale		S			8,18,25/120 refusal
677			C	100	0	
676.29	SHALE - low to medium strength, fresh stained, slightly fractured, grey, shale	3.91m: B 5° 4.32m: B 5°	C	100	100	PL(A) = 0.4
676 / 675		4.59m: B 5° clay 2mm 4.84m: B 5° clay 2mm 4.89m: B 5° 5.13m: B 5° 5.25m: B 5°	C	100	96	PL(A) = 0.2 PL(A) = 0.9
674.17	Bore discontinued at 6.03m (Limit of investigation)					
674						
673						

RIG: DT100 **DRILLER:** Ground Test (G.M) **LOGGED:** CMcD **CASING:** HW to 2.5m
TYPE OF BORING: SFA (TC bit) to 2.5m, Rotary (Water) to 3.0m, Coring (NMLC) to 6.03m
WATER OBSERVATIONS: No free groundwater observed
REMARKS: Surface levels inferred from nearmap.com

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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PROPOSED HOSPITAL UPGRAD – BOWRAL DISTRICT HOSPITAL

BORE 104 **PROJECT 89199.00** **SEPT 2016**

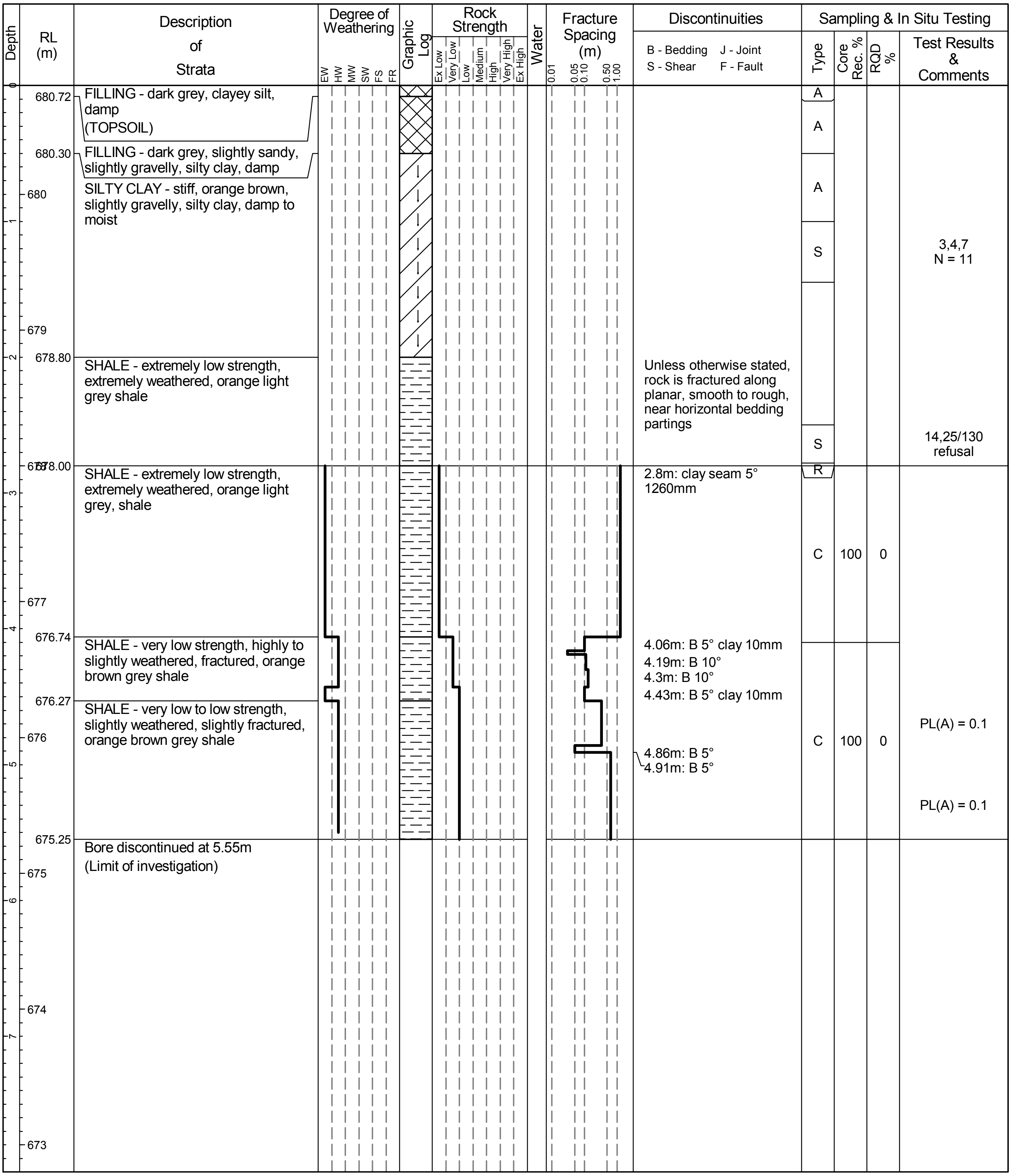
2.8 – 5.55 m

BOREHOLE LOG

CLIENT: Health Infrastructure
PROJECT: Proposed Hospital Upgrade
LOCATION: Bowral District Hospital, Mona Road, Bowral

SURFACE LEVEL: 680.8 AHD
EASTING: 263414
NORTHING: 6181083
DIP/AZIMUTH: 90°/--

BORE No: 104
PROJECT No: 89199
DATE: 31/8/2016
SHEET 1 OF 1



RL (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
680.72	FILLING - dark grey, clayey silt, damp (TOPSOIL)		A A			
680.30	FILLING - dark grey, slightly sandy, slightly gravelly, silty clay, damp		A			
680	SILTY CLAY - stiff, orange brown, slightly gravelly, silty clay, damp to moist		S			3,4,7 N = 11
679						
678.80	SHALE - extremely low strength, extremely weathered, orange light grey shale	Unless otherwise stated, rock is fractured along planar, smooth to rough, near horizontal bedding partings	S			14,25/130 refusal
678.00	SHALE - extremely low strength, extremely weathered, orange light grey, shale	2.8m: clay seam 5° 1260mm	R C	100	0	
677						
676.74	SHALE - very low strength, highly to slightly weathered, fractured, orange brown grey shale	4.06m: B 5° clay 10mm 4.19m: B 10° 4.3m: B 10° 4.43m: B 5° clay 10mm	C	100	0	
676.27	SHALE - very low to low strength, slightly weathered, slightly fractured, orange brown grey shale	4.86m: B 5° 4.91m: B 5°				PL(A) = 0.1 PL(A) = 0.1
676						
675.25	Bore discontinued at 5.55m (Limit of investigation)					
675						
674						
673						

RIG: Bobkat **DRILLER:** Ground Test (G.M) **LOGGED:** CMcD **CASING:** HW to 2.5m

TYPE OF BORING: SFA (TC bit) to 2.5m, Rotary (Water) to 2.8m, Coring (NMLC) to 5.55m

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Surface levels inferred from nearmap.com

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
Unit 1, 1 Luso Drive
PO Box 486
Unanderra NSW 2526
Phone (02) 4271 1836
Fax (02) 4271 1897

Results of Dynamic Penetrometer Tests

Client Health Infrastructure
Project Proposed Hospital Upgrade
Location Bowral & District Hospital, Mona Road

Project No. 89199.00
Date 01/09/2016
Page No. 1 of 1

Test Locations	105									
RL of Test (AHD)	681.6									
Depth (m)	**Penetration Resistance** Blows/150 mm									
0.00 – 0.15	6									
0.15 – 0.30	7									
0.30 – 0.45	8									
0.45 – 0.60	8									
0.60 – 0.75	4									
0.75 – 0.90	7									
0.90 – 1.05	4									
1.05 – 1.20	6									
1.20 – 1.35	7									
1.35 – 1.50	5									
1.50 – 1.65	5									
1.65 – 1.80	6									
1.80 – 1.95	8									
1.95 – 2.10	14									
2.10 – 2.25	29									
2.25 – 2.40	25 ref									
2.40 – 2.55										
2.55 – 2.70										
2.70 – 2.85										
2.85 – 3.00										
3.00 – 3.15										
3.15 – 3.30										
3.30 – 3.45										
3.45 – 3.60										

Test Method AS 1289.6.3.2, Cone Penetrometer ☑
AS 1289.6.3.3, Sand Penetrometer ☐

Tested By CM
Checked By CM

Remarks Ref = Refusal, 25/110 indicates 25 blows for 110 mm penetration

Photo 1 – View from Bowral Street across proposed development area.

Photo 2 – View south-west across proposed development area.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Hospital Upgrade** **Bowral & District Hospital, Bowral**	PROJECT: 89199.00 PLATE No: 1 REV:
	CLIENT: Health Infrastructure	DATE: Sept 2016

Photo 3 – View to north-east towards Bowral Street.

Photo 4 – Existing car park. Bore 3 marked on pavement.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Hospital Upgrade** **Bowral & District Hospital, Bowral**	PROJECT:	89199.00
		PLATE No:	2
		REV:	
	CLIENT: Health Infrastructure	DATE:	Sept 2016

Photo 5 – Drilling at Bore 4

Photo 6 – Reinstated Bore 2.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs**	PROJECT:	89199.00
	Proposed Hospital Upgrade	PLATE No:	3
	Bowral & District Hospital, Bowral	REV:	
	CLIENT: Health Infrastructure	DATE:	Sept 2016

Photo 7 – Existing structure (possibly to be demolished)

Photo 8 – Existing structure (possibly to be demolished).

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Hospital Upgrade** **Bowral & District Hospital, Bowral**	PROJECT: 89199.00 PLATE No: 4 REV:
	CLIENT: Health Infrastructure	DATE: Sept 2016

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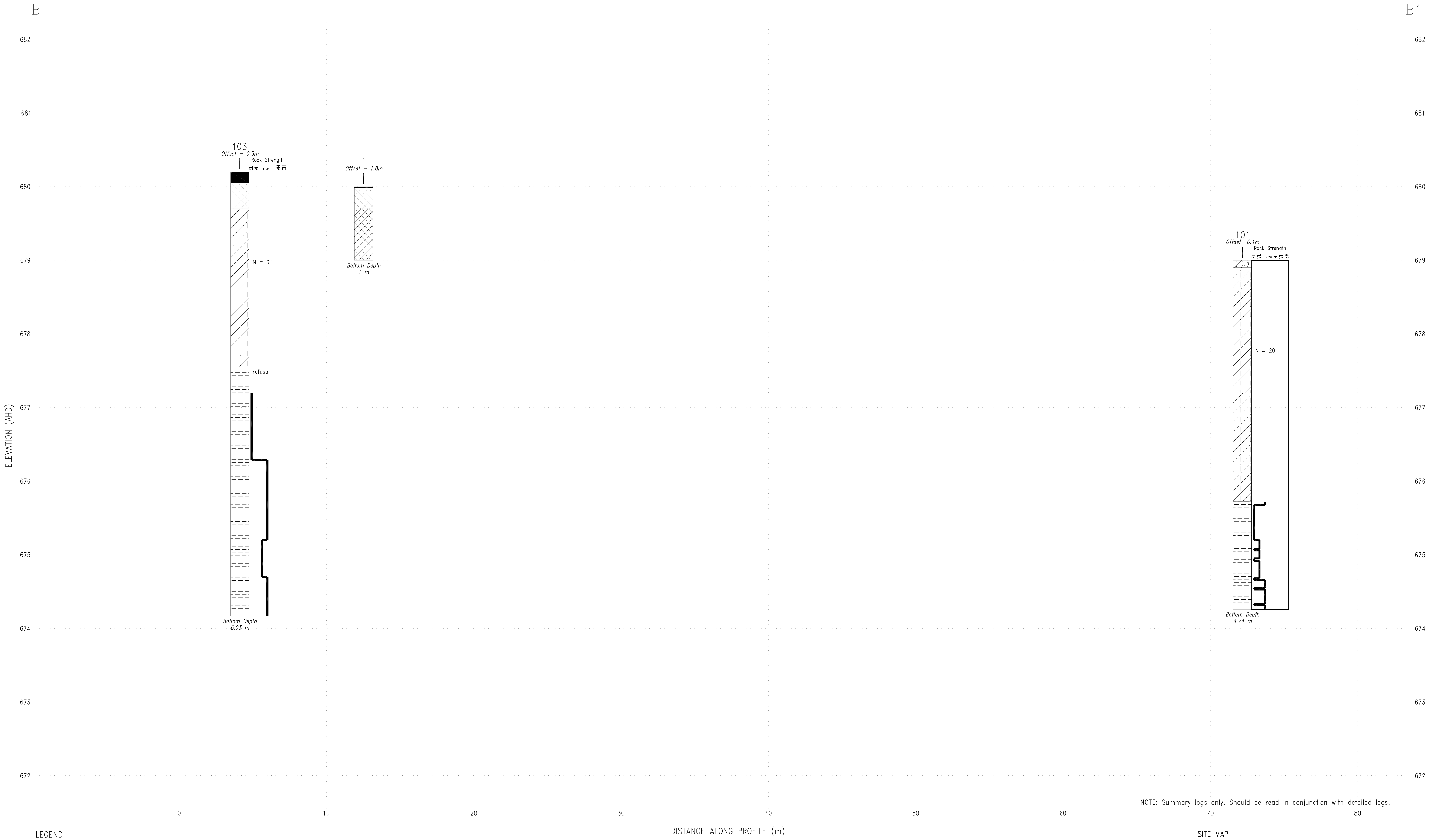
CLIENT: Health Infrastructure
OFFICE: Wollongong
DRAWN BY: CMcD
SCALE: As shown
DATE: 6/09/2016

TITLE: **Test Locations**
Proposed Hospital Upgrade
Bowral District Hospital, Mona Road, Bowral

PROJECT No: 89199.00
DRAWING No: 1
REVISION: A



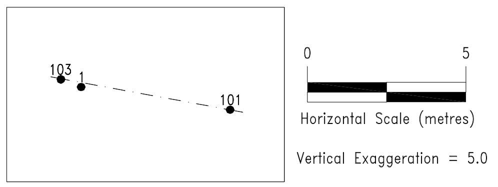
NOTE: Summary logs only. Should be read in conjunction with detailed logs.

LEGEND

- ■ Asphaltic Concrete
- ▨ Filling
- ▨ Topsoil
- ▨ Silty Clay
- ▤ Shale

TESTS / OTHER
N – Standard penetration test value
▽ – Water level

SITE MAP



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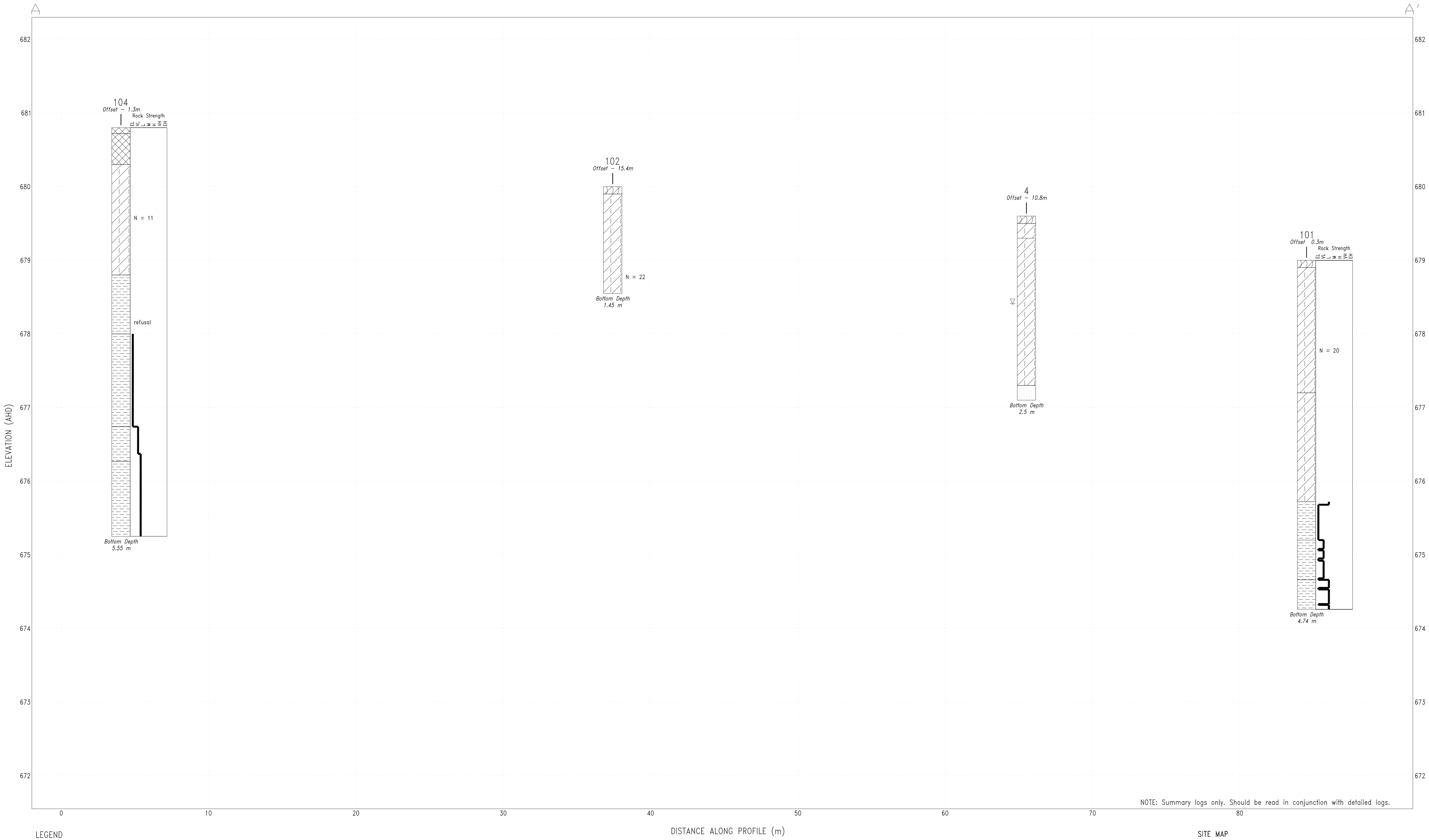
CLIENT:	Health Infrastructure		
OFFICE:	Wollongong	DRAWN BY:	DJM
SCALE:	1:250 (H) 1:50 (V) @ A3	DATE:	05.10.2016

TITLE: Cross–section B–B'
Proposed Hospital Upgrade
Bowral District Hospital, Mona Road, Bowral

PROJECT No:	89199
DRAWING No:	2
REVISION:	0



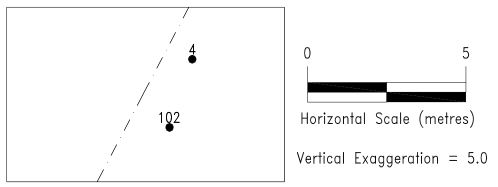
NOTE: Summary logs only. Should be read in conjunction with detailed logs.

LEGEND

▨ Topsoil
▨ Silty Clay
░ Sandstone
☰ Shale
▩ Filling

TESTS / OTHER
N – Standard penetration test value
⊻ – Water level

SITE MAP



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CLIENT: Health Infrastructure
OFFICE: Wollongong
DRAWN BY: DJM
SCALE: 1:250 (H) 1:50 (V) @ A3
DATE: 05.10.2016

TITLE: Cross–section A–A'
Proposed Hospital Upgrade
Bowral District Hospital, Mona Road, Bowral

PROJECT No: 89199
DRAWING No: 3
REVISION: 0

Appendix C

Laboratory Test Report Sheets

Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Unanderra Laboratory
Unit 1/1 Luso Drive UNANDERRA NSW 2526
Phone: (02) 4271 1836
Fax: (02) 4271 1897
Email: david.evans@douglaspartners.com.au

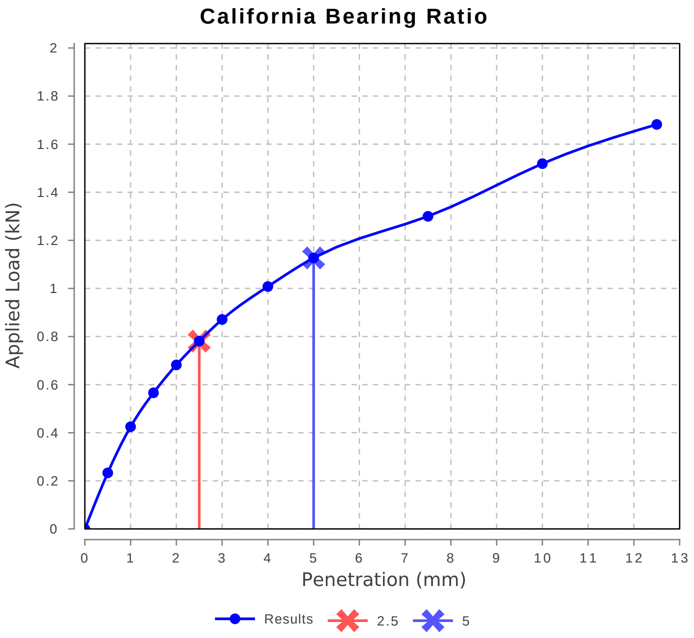
Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: David Evans
Nata Accredited Laboratory Number: 828

Report Number:	**89199.00-1**
Issue Number:	1
Date Issued:	31/08/2016
Client:	Health Infrastructure (ABN 89600377397) PO Box 1060, North Sydney NSW 2059
Project Number:	89199.00
Project Name:	Proposed Hospital Upgrade
Project Location:	Bowral & District Hosapital, Mona Road, BOWRAL
Client Reference:	
Work Request:	61
Sample Number:	16-61A
Date Sampled:	31/08/2016
Sampling Method:	Sampled by Engineering Department
Sample Location:	**Pit 3 (0.5 - 0.7m)**
Lot No:	
Material:	Silty clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**6**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Maximum Dry Density (t/m^3)	1.82		
Optimum Moisture Content (%)	18.8		
Laboratory Moisture Ratio (%)	100.5		
Laboratory Density Ratio (%)	99.5		
Moisture Content at Placement (%)	18.9		
Moisture Content Top 30mm (%)	20.5		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	4		

Moisture Content (AS 1289 2.1.1)	
Moisture Content (%)	19.3



Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Unanderra Laboratory
Unit 1/1 Luso Drive UNANDERRA NSW 2526
Phone: (02) 4271 1836
Fax: (02) 4271 1897
Email: david.evans@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

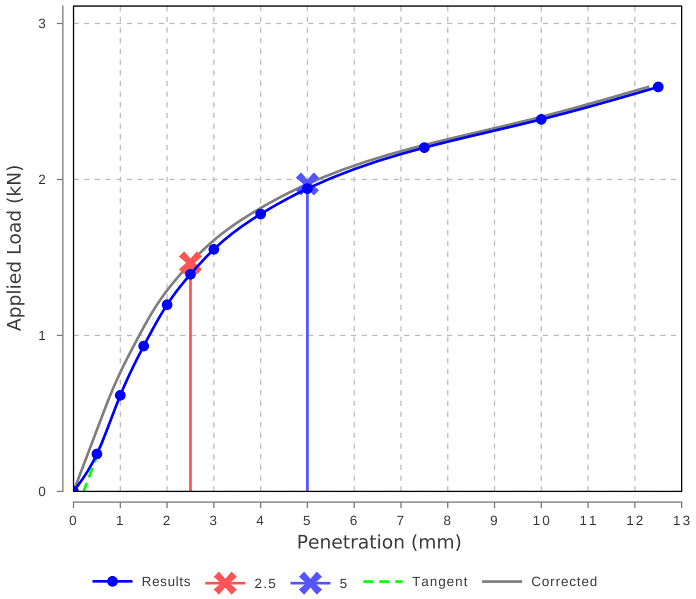
Approved Signatory: David Evans
Nata Accredited Laboratory Number: 828

Report Number: **89199.00-1**
Issue Number: 1
Date Issued: 31/08/2016
Client: Health Infrastructure (ABN 89600377397)
PO Box 1060, North Sydney NSW 2059
Project Number: 89199.00
Project Name: Proposed Hospital Upgrade
Project Location: Bowral & District Hosapital, Mona Road, BOWRAL
Client Reference:
Work Request: 61
Sample Number: 16-61B
Date Sampled: 31/08/2016
Sampling Method: Sampled by Engineering Department
Sample Location: **Pit 4 (0.5 - 0.7m)**
Lot No:
Material: Silty Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**11**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Maximum Dry Density (t/m^3)	1.73		
Optimum Moisture Content (%)	19.3		
Laboratory Moisture Ratio (%)	96.0		
Laboratory Density Ratio (%)	100.5		
Moisture Content at Placement (%)	18.5		
Moisture Content Top 30mm (%)	22.7		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			

Moisture Content (AS 1289 2.1.1)	
Moisture Content (%)	27.6

California Bearing Ratio



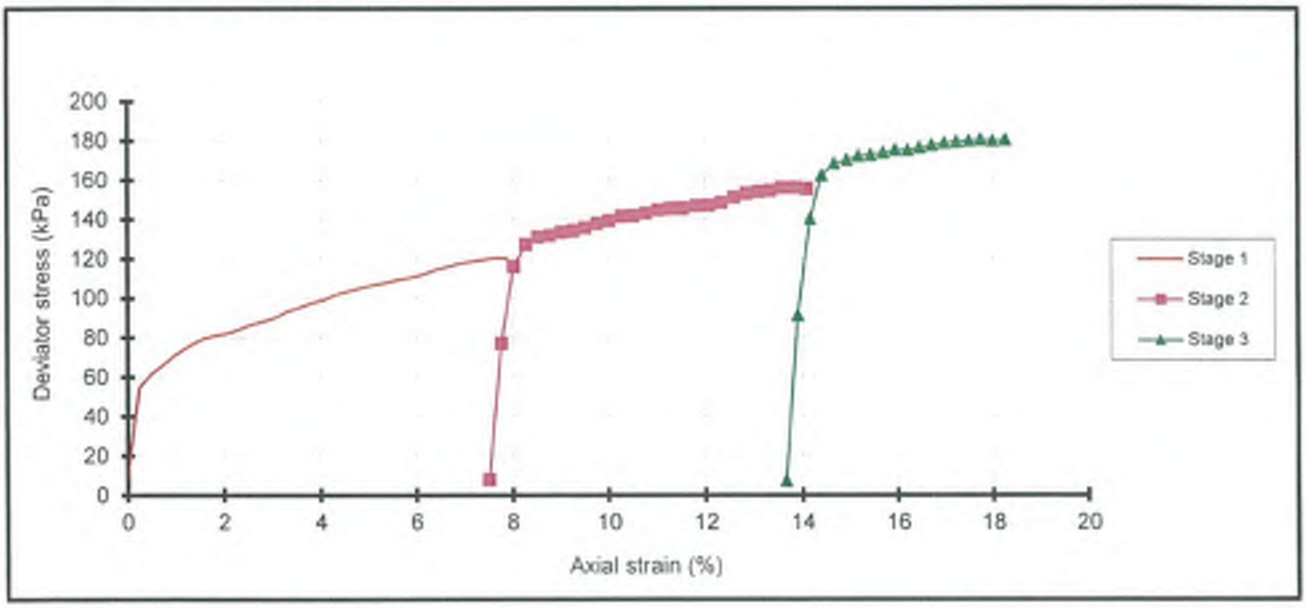
Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
231 Normanby Road
PO Box 5051
South Melbourne VIC 3205
Phone (03) 9673 3500
Fax (03) 9673 3599

Triaxial Compression Test Results

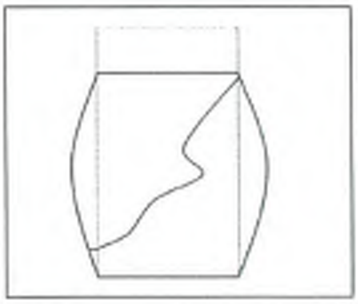
(UNDRAINED WITHOUT PORE PRESSURE MEASUREMENT)

Client :	Health Infrastructure (ABN 89600377397)	**Project No. :**	89199.00
		Report No. :	M16146002
Project :	BOWRAL, Proposed Hospital Upgrade	**Report Date :**	08 Sep 2016
		Date Sampled :	-
Location :	Bowral & District Hospital, Mona Rd, Bowral	**Date of Test:**	02 Sep 2016
Test Location :	Bore 102	**Sample Type:**	Undisturbed
Depth / Layer :	0.5-0.9(m)	**Page:**	1 of 1
Sample Description:	Silty CLAY		



UNDRAINED SHEAR STRENGTH	**Stage 1**	**Stage 2**	**Stage 3**
C_u (kPa)	**60**	**78**	**90**
STAGE DETAILS			
Cell pressure (kPa):	50	100	200
Strain rate (mm/min):	1.50	1.50	1.50
Strain at failure (%):	7.64	6.87	4.73
Maximum deviator stress (kPa):	121	156	181
SPECIMEN DETAILS			
Initial Moisture content (%):	21.9		
Dry density (t/m^3):	1.71		
Sample Length(mm):	101		
Sample Diameter(mm):	48		

MODE OF FAILURE DIAGRAM



1. Failure criteria : maximum deviator stress for each stage
2. Membrane corrections were applied to the deviator stress

Test Method(s): AS1289.6.4.1, AS1289.2.1.1

NATA Accredited Laboratory Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested	AD
Checked	AG

Peter Chan
Associate

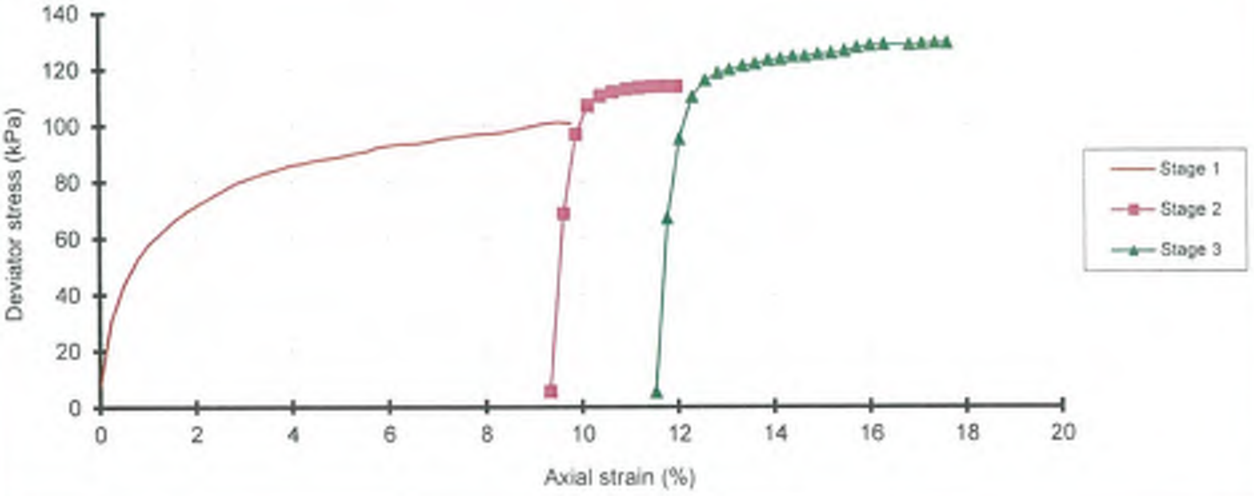
Douglas Partners
Geotechnics | Environment | Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
231 Normanby Road
PO Box 5051
South Melbourne VIC 3205
Phone (03) 9673 3500
Fax (03) 9673 3599

Triaxial Compression Test Results

(UNDRAINED WITHOUT PORE PRESSURE MEASUREMENT)

Client :	Health Infrastructure (ABN 89600377397)	**Project No. :**	89199.00
		Report No. :	M16146003
Project :	BOWRAL, Proposed Hospital Upgrade	**Report Date :**	08 Sep 2016
		Date Sampled :	-
Location :	Bowral & District Hospital, Mona Rd, Bowral	**Date of Test:**	02 Sep 2016
Test Location :	Bore 103	**Sample Type:**	Undisturbed
Depth / Layer :	0.5-0.9(m)	**Page:**	1 of 1
Sample Description:	Silty CLAY		

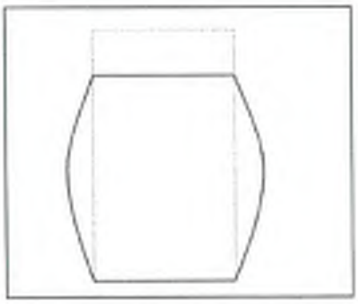


UNDRAINED SHEAR STRENGTH	**Stage 1**	**Stage 2**	**Stage 3**
C_u (kPa)	**51**	**57**	**65**

STAGE DETAILS			
Cell pressure (kPa):	50	100	200
Strain rate (mm/min):	1.50	1.50	1.50
Strain at failure (%):	9.50	2.95	6.60
Maximum deviator stress (kPa):	101	114	129

SPECIMEN DETAILS	
Initial Moisture content (%):	21.4
Dry density (t/m³):	1.13
Sample Length(mm):	98
Sample Diameter(mm):	58

MODE OF FAILURE DIAGRAM



1. Failure criteria : maximum deviator stress for each stage
2. Membrane corrections were applied to the deviator stress.

Test Method(s): AS1289.6.4.1, AS1289.2.1.1

NATA Accredited Laboratory Number: 828

Tested	AD
Checked	AG

P. Chan

Peter Chan
Associate

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
231 Normanby Road
PO Box 5061
South Melbourne VIC 3205
Phone (03) 9673 3500
Fax (03) 9673 3599

Result of Shrink-Swell Index Determination

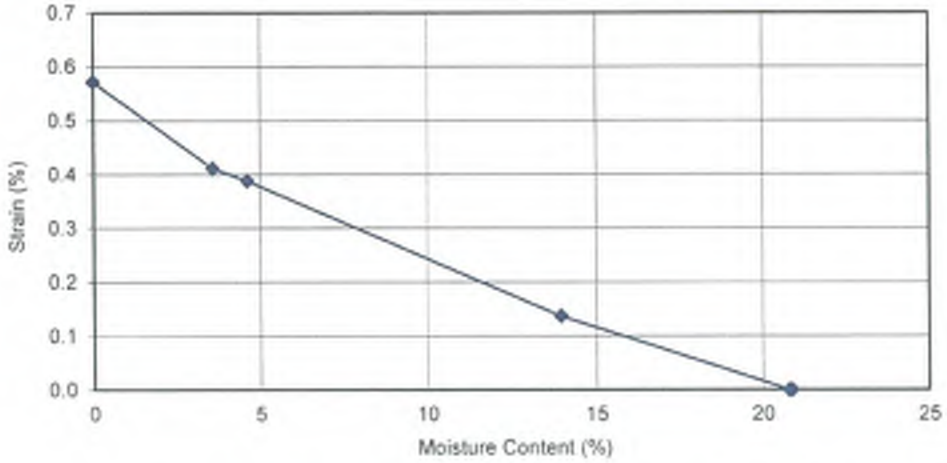
Client :	Health Infrastructure (ABN 89600377397)	**Project No. :**	89199.00
		Report No. :	M16146004
Project :	BOWRAL, Proposed Hospital Upgrade	**Report Date :**	08/09/2016
		Date Sampled :	-
Location :	Bowral & District Hospital, Mona Rd, Bowral	**Date of Test:**	01/09/2016
Test Location :	Bore 103		
Depth / Layer :	0.5-0.9(m)	**Page:**	1 of 1

CORE SHRINKAGE TEST

Shrinkage - air dried	0.4 %
Shrinkage - oven dried	0.6 %
Significant inert inclusions	0 %
Extent of cracking	SC
Extent of soil crumbling	5 %
Moisture content of core	20.8 %

SWELL TEST

Pocket penetrometer reading at initial moisture content	- kPa
Pocket penetrometer reading at final moisture content	400 kPa
Initial Moisture Content	20.5 %
Final Moisture Content	20.9 %
Swell under 25kPa	0.0 %



SHRINK-SWELL INDEX Iss 0.3% per Δ pF

Description:	Silty CLAY
Test Method(s):	AS 1289.7.1.1, AS 1289.2.1.1
Sampling Method(s):	Sampled by Melbourne Engineering Department

Extent of Cracking:

UC - Uncracked
SC - Slightly cracked
MC - Moderately cracked
HC - Highly cracked
FR - Fractured

Remarks:

Note that NATA accreditation does not cover
the performance of pocket penetrometer readings

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

NATA Accredited Laboratory Number: 828

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards. Accredited for compliance with ISO/IEC 17025

Tested	AD
Checked	AG

P. Chan
Peter Chan
Associate

12 Ashley Street, Chatswood, NSW 2067
tel: +61 2 9910 6200
email: sydney@envirolab.com.au
envirolab.com.au
Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 152653

Client:

Douglas Partners Unanderra
Unit 1, 1 Luso Drive
Unanderra
NSW 2526

Attention: Arthur Castrissios

Sample log in details:

Your Reference: **89199 - Proposed Hospital Upgrade**
No. of samples: 2 soils
Date samples received / completed instructions received: 31/08/16 / 31/08/16

Analysis Details:

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

Report Details:

Date results requested by: / Issue Date: 7/09/16 / 5/09/16
Date of Preliminary Report: Not Issued
NATA accreditation number 2901. This document shall not be reproduced except in full.
Accredited for compliance with ISO/IEC 17025 - Testing **Tests not covered by NATA are denoted with *.**

Results Approved By:

David Springer
General Manager

Misc Inorg - Soil			
Our Reference:	UNITS	152653-1	152653-2
Your Reference	-------------	102	103
Depth	------------	1.0	2.5
Date Sampled		18/08/2016	19/08/2016
Type of sample		Soil	Soil
Date prepared	-	01/09/2016	01/09/2016
Date analysed	-	01/09/2016	01/09/2016
pH 1:5 soil:water	pH Units	6.2	5.9
Electrical Conductivity 1:5 soil:water	µS/cm	12	49
Chloride, Cl 1:5 soil:water	mg/kg	10	67
Sulphate, SO4 1:5 soil:water	mg/kg	<10	<10

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			01/09/2016	[NT]	[NT]	LCS-1	01/09/2016
Date analysed	-			01/09/2016	[NT]	[NT]	LCS-1	01/09/2016
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-1	100%
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	LCS-1	104%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-1	105%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-1	116%

Report Comments:

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

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

Quality Control Definitions

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

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

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

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

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

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.