Douglas Partners
Geotechnics / Environment / Groundwater

# Report on
# Preliminary Geotechnical Investigation

Proposed Northside Private Hospital
Part Lot 2 in DP 1226923, Faunce Street West, West Gosford

Prepared for
AA Crown Holdings Pty Ltd

Project 83574.00
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Integrated Practical Solutions

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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# Report on Preliminary Geotechnical Investigation
# Proposed Northside Private Hospital
# Part Lot 2 in DP 1226923, Faunce Street West, West Gosford

## 1. Introduction

This report presents the results of a preliminary geotechnical investigation undertaken for the proposed Northside Private Hospital at Part Lot 2 in DP 1226923, Faunce Street West, West Gosford. The investigation was commissioned in an email dated 18 February 2019 by Mr John Kilzi of Donald Cant Watts Corke Pty Ltd, on behalf of the client AA Crown Holdings Pty Ltd, and was undertaken in accordance with Douglas Partners' proposal CCT190039 dated 5 February 2019.

It is understood that the proposed development will include the construction of a ten storey hospital building, with three additional lower ground and basement car parking levels. The lower basement level ranges from RL 4.7 m to 5.7 m AHD.

The preliminary geotechnical investigation was carried out to provide indicative information on the following:

- Subsurface conditions at test locations;
- Presence of groundwater within the depth of proposed excavation;
- Depth to top of bedrock;
- Excavation conditions and support requirements; and
- Preliminary advice on footing design and types.

The investigation included the drilling of three boreholes. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

For the purposed of the investigation, a set of architectural drawings (GPH-A-E-1 to E-4, P-1 to P-B2, PER-1 to PER-3 and SE-1 to SE-2, prepared by Health Project International) have been provided to Douglas Partners Pty Ltd.

The geotechnical investigation has been carried out concurrently with a preliminary site investigation (PSI) for contamination which has been reported separately.

## 2. Site Description and Regional Geology

The site is located within the south-western area of Lot 2 in DP 1226923, on the corner of Faunce Street West and Racecourse Road, West Gosford. The proposed Northside Private Hospital development (the 'site') covers an irregular shaped area of approximately 1 ha.

The site is bounded by Faunce Street West to the south, Racecourse Road to the west, an existing Ausgrid substation to the east and structures associated with a former Ausgrid depot to the north and north-east.

Figure 1 below, shows an aerial view of the site.

**Figure 1 – Aerial view of site (sourced from Google Earth with Nearmap Overlay dated 27 December 2018)**

At the time of the investigation, the site was occupied by buildings associated with a former Ausgrid depot, and was being used to repair vehicles. Areas surrounding the existing buildings were generally covered with asphalt or concrete pavements.

Along the southern boundary, in the eastern area of the site, a cut batter was also observed and sandstone bedrock was exposed.

Figure 2 to Figure 5 below show photographs of the site, taken at the time of the investigation.

Figure 2 – Panoramic view of the site, looking northeast

Figure 3 – Panoramic view of the site, looking southwest

Figure 4 – Panoramic view of the site, looking northwest

**Figure 5 – View of the cut batter along the southern boundary, looking west**

Review of the local topographical mapping indicates that surface levels at the site generally fall to the north, from about RL 14 m (toe of cut batter) to about RL 10 m AHD. The crest of the cut batter in the south-western area of the site is at approximately RL 18 m AHD.

Review of the interim 1:25 000 scale geology map for Gosford indicates that the site is underlain by the Terrigal Formation of the Narrabeen Group which typically comprises sandstone, siltstone, claystone and conglomerate.

The conditions encountered during the investigation are consistent with the geological mapping.

## 3. Field Work Methods

The field work was undertaken on 1 March 2019 and included the drilling of three boreholes (designated Bores 1 to 3). The boreholes were drilled to depths ranging from 4.0 m to 5.8 m depth using a track mounted drilling rig. Bores 1 and 3 were drilled to auger refusal, using a tungsten carbide (TC) tip, whilst Bore 2 included NLMC coring of the underlying bedrock.

Standard penetrometer tests (SPTs) were carried out to provide information on the relative strengths and densities of the subsurface soils.

Engineering logs of the subsurface profiles encountered within the bores were prepared by an engineering geologist who also collected representative samples for strata identification and subsequent laboratory testing purposes (i.e. point load testing on the recovered rock core).

At the completion of drilling, the boreholes were left open for a period of five days, to allow monitoring of the stabilised groundwater levels. The boreholes were then backfilled using soil cuttings with coldmix asphalt at the surface.

Groundwater levels were also recorded for three existing monitoring wells (identified as MW2 to MW4) that have been installed at the site by others.

The approximate locations of the boreholes and existing monitoring wells are shown on Drawing 1, in Appendix B.

Surface levels and GPS coordinates were recorded for each borehole and monitoring well location using a differential GPS unit, which at the time had an accuracy of ± 100 mm.

## 4. Field Work Results

### 4.1 Boreholes

The results of the field work are given in the borehole log sheets in Appendix C. The logs should be read in conjunction with the explanatory notes, which define the descriptive terms and classification methods.

A summary of the subsurface conditions encountered is as follows:

| | |
|---|---|
| PAVEMENT MATERIAL | Generally comprising a thin (20 mm) spray seal wearing course, underlain by sandy gravel roadbase to depths ranging from 0.1 m to 0.2 m depth; underlain by |
| RESIDUAL SANDY CLAY or CLAY | In Bores 1 and 3, typically stiff, becoming very stiff to hard from 2.0 m to 2.2 m depth; underlain by |
| SANDSTONE / SILTSTONE | Initially extremely low strength, extremely to highly weathered sandstone and siltstone. In Bore 2, where rock coring was undertaken to confirm the presence of bedrock, the bedrock was typically low and medium strength below 1.3 m depth with some extremely low strength bands. Auger refusal (using TC bit) was also encountered in Bores 1 and 3 at 4.0 m and 5.8 m depth, respectively, indicating the possible presence of at least low strength bedrock at these depths. |

Rock core photos for Bore 2 are provided in the photo plates in Appendix C.

### 4.2 Groundwater

A summary of the groundwater observations is provided in Table 1, on the following page. It should be noted that the groundwater levels are variable and can be affected by factors such as climatic conditions, soil permeability and bedrock defects.

**Table 1 – Summary of Groundwater Observations**

| Bore / Monitoring Well | Surface RL (m AHD) | Depth (m) to Groundwater During Drilling | Depth (m) to Standing Groundwater | RL (m AHD) of Standing Groundwater |
|---|---|---|---|---|
| Bore 1 | 12.70 | NE | 1.71 | 10.99 |
| Bore 2 | 13.80 | NE[1] | 2.04 | 11.76 |
| Bore 3 | 12.78 | 4.1 | 3.89 | 8.89 |
| MW2 | 12.20 | NA | 4.32 | 7.88 |
| MW3 | 12.81 | NA | 1.39 | 11.42 |
| MW4 | 13.12 | NA | 1.92 | 11.20 |

Notes to Table 1:

| | |
|---|---|
| 1 | Groundwater observations within rock profile precluded during drilling given the introduction of drilling fluids. |
| NE | Not encountered during drilling. |
| NA | Not applicable. |

## 5. Proposed Development

It is understood that the proposed Northside Private Hospital development will comprise the construction of a ten storey hospital building, with three additional lower ground and basement car parking levels.

Existing buildings and possibly in-ground tank structures (associated with the former Ausgrid depot) will be demolished to make way for the proposed development.

It is understood that the lower basement (B2) level ranges from RL 4.7 m to 5.7 m AHD. As such, it is anticipated that excavation up to approximately 9 m to 10 m depth will be required.

Figure 6, on the following page, shows a section through the proposed development.

At the time of reporting, the design of the building was only in preliminary stages, and design column loads were not available.

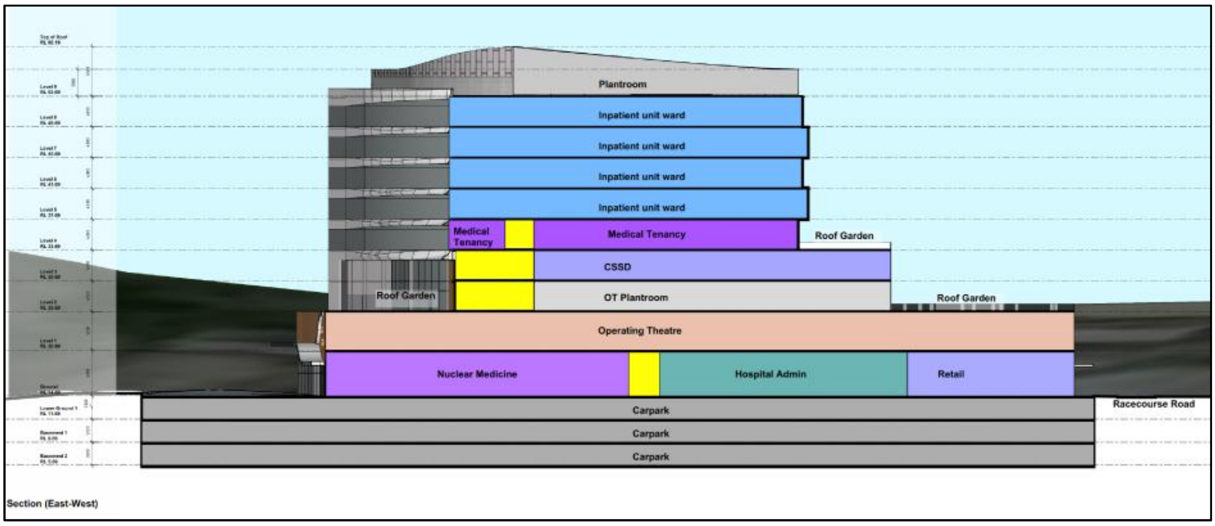

**Figure 6 – East-West section through proposed development**

## 6. Comments

### 6.1 Excavation Conditions

It is understood that excavation up to about 9 m to 10 m depth will be required for the proposed development. Based on the conditions encountered in the bores, excavation conditions are likely to include stiff and very stiff to hard residual clay soils to depths up to approximately 3 m, below which sandstone and siltstone bedrock is present. It is noted that bedrock is present directly beneath the pavement material at Bore 2.

The sandstone and siltstone bedrock is initially extremely low to very low strength. This weaker material is underlain by low and medium strength bedrock, as suggested by auger refusal in Bores 1 and 3 at 4.0 m and 5.8 m depth, respectively, and as identified in Bore 2 below 1.3 m depth.

Given the preliminary nature of the investigation, rock coring has not been carried over the full depth of the proposed basement excavation.

It is anticipated that removal of the soil and extremely low to very low strength bedrock will be readily carried out by conventional earthmoving equipment, possibly with light ripping assistance. Excavation of low and medium strength bedrock will require the assistance of heavy ripping equipment and rock hammers. Rock saws may also be required for detailed excavations such as footings, services trenches and batter trimming.

### 6.2 Retaining Walls

Given the deep excavations required, the proximity to site boundaries and adjacent structures and the expected presence of groundwater, retaining structures should be installed ahead of the proposed excavation.

Contiguous or soldier pile walls may be used to support the deep bulk excavation proposed at the site. Contiguous pile walls are typically constructed by installing piles just touching, whilst soldier pile walls are typically constructed with piles installed at about 2 m spacing with reinforced spray concrete infill panels. Contiguous pile walls have a highly irregular surface finish and may also require shotcreting to provide a suitable finish and prevent loss of material through the face of the wall. Given the presence of groundwater, any seepage should be controlled by the installation of vertical and inclined strip drains.

Alternatively, if required, a secant pile wall (intersecting concrete piles) could be constructed to facilitate a tanked basement.

Given the predominantly clay and rock profile, uncased bored piles are expected to remain stable sufficient for the placement of a reinforcing cage and concrete. Consideration would, however, need to be given to the inflow of groundwater within the pile holes.

Given the depth of the proposed excavations, at least two rows of anchoring are expected to be required during construction, and hence the walls should be designed as ‘braced’ retaining walls. Similarly, the upper floor levels of the basement would provide propping to the walls.

As a result of bracing (i.e. anchoring and propping), the retaining structures should be based on a trapezium earth pressure distribution. The maximum earth pressure in the trapezium distribution is determined using the earth pressure coefficient multiplied both by the retained height (H) and the unit weight of the retained material. This pressure is applied to the central half of the wall. The pressure increases linearly from zero to full pressure over the upper 0.25H, then decreases linearly to zero pressure over the lowest 0.25H.

Braced retaining walls should be designed for ‘at rest’ conditions ($K_0$).

Any smaller walls that are unbraced (i.e. external to the building) could be designed as gravity or cantilever type walls, using a triangular earth pressure distribution and active earth pressure coefficients ($K_a$).

The geotechnical parameters provided in Table 2, on the following page, are recommended for preliminary design purposes.

The retaining walls should be designed so that they meet or exceed the following factors of safety for each of the four possible failure modes:

| | |
|---|---|
| Sliding - | 1.5 |
| Overturning - | 1.5 |
| Bearing Capacity - | 2.0 |
| Overall Stability - | 1.5 |

**Table 2 – Preliminary Retaining Wall Design Parameters**

| Founding Strata | Unit Weight ($kN/m^3$) | At Rest Earth Pressure[1] ($K_a$) | At Rest Earth Pressure[1] ($K_0$) | Ultimate Passive Earth Pressure[2] (kPa) |
|---|---|---|---|---|
| Stiff or stronger Sandy Clay or Clay | 20 | 0.3 | 0.45 | 150 kPa (drained) or $K_p$ = 2 (undrained) |
| Extremely low strength Bedrock | 22 | 0.3 | 0.45 | 300 |
| Low Strength Bedrock | 22 | 0.25 | 0.38 | 2000[3] |
| Medium strength Bedrock | 22 | 0.15 | 0.23 | 4000[3] |

Notes:

1 The earth pressure design parameters given above are based on the assumption that full drainage will be provided behind the retaining wall so hydrostatic water pressures are not applied. It also assumes flat surface behind and in front of the walls.

2 A factor of safety of 2.5 is considered appropriate to convert the passive pressures from ultimate to allowable.

3 Confirmation of the presence of such material below the depth of proposed excavation required.

## 7. Footings

Given the depth of excavation proposed at the site, sandstone or siltstone bedrock will be exposed at the base of the excavation. As such, it is likely that high level footings would be considered appropriate.

For preliminary design purposes, assuming at least very low strength bedrock is present at the base of the excavation, high level footings could be design based on an allowable bearing capacity of 800 kPa.

Higher bearing capacities could be achieved for higher strength bedrock, however, additional investigation is required to confirm the strength of the bedrock below the basement level.

The base of the footing excavations should be protected by a blinding layer of weak concrete immediately after excavation and verification of suitable founding strata.

Alternatively to high level footings, concrete bored piles could also be adopted. Similarly to above, additional investigation would be required to confirm the design parameters for piles.

All footing excavations should be inspected by a geotechnical engineer to confirm that the design bearing stratum has been achieved.

## 8. Further investigation

The investigation carried out at the site to date is considered to be sufficient for preliminary design and planning purposes only. Further geotechnical investigation will be required in order to obtain information for detailed design. Further investigation should be carried out to assess and confirm the following:

- Retaining wall design parameters including:
  - Rock anchor design parameters;
  - Passive pressures for toe embedment;
- Founding conditions at and below the basement level;
- Groundwater inflow rates (during construction and long term) for design of drainage, if installed rather than designing for tanked basement, and effect of long term dewatering on surrounding areas;
- Subgrade conditions (including design California bearing ratio) in areas of proposed external pavements;
- Pavement thickness design for half road reconstruction of Faunce Street West and Racecourse Road, if required by Council; and
- Waste classification of excavated soils and rock to be removed from site (could be included in detailed site investigation for contamination (if required).

If other geotechnical matters, not listed above, are required to be investigated, then DP would be pleased to assist.

## 9. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at West Gosford in accordance with DP's proposal CCT190039 dated 5 February 2019 and acceptance received from Mr John Kilzi of Donald Cant Watts Corke (DCWC) Pty Ltd, on behalf of the client AA Crown Holdings Pty Ltd dated 18 February 2019. The work was carried out in accordance with the Northside Private Hospital Gosford Consultancy Agreement, signed 27 March 2019. This report is provided for the exclusive use of DCWC Pty Ltd and AA Crown Holdings Pty Ltd 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. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. 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 unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

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 scope for work for this investigation/report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

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.

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# Appendix A

## Report Notes

## 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.

## Copyright

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.

# Sampling Methods

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## 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*

## Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726-1993, 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 Descriptions*

## 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.

# 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 - 2007. The terms used to describe rock strength are as follows:

| Term | Abbreviation | Point Load Index $Is_{(50)}$ MPa | Approximate 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 $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

## 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 longer 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:

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

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 |

# Symbols & Abbreviations

Douglas Partners

## 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 |
| ▽ | 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 |

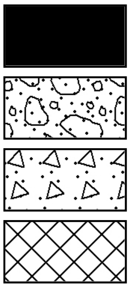
### Other

| | |
|---|---|
| fg | fragmented |
| bnd | band |
| qtz | quartz |

# *Symbols & Abbreviations*

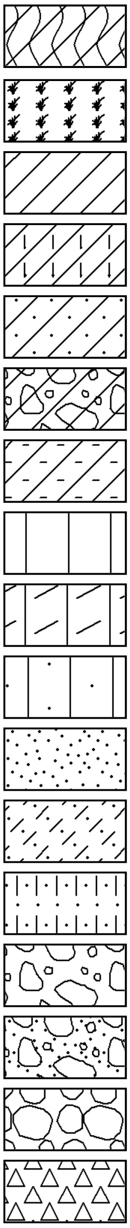
## Graphic Symbols for Soil and Rock

### General



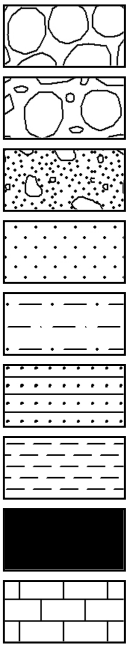
- Asphalt
- Road base
- Concrete
- Filling

### Soils



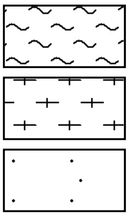
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

### Sedimentary Rocks



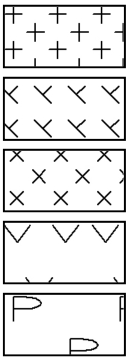
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

### Metamorphic Rocks



- Slate, phyllite, schist
- Gneiss
- Quartzite

### Igneous Rocks



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

# Appendix B

Results of Field Work

# BOREHOLE LOG

**CLIENT:** AA Crown Holdings Pty Ltd
**PROJECT:** Proposed Northside Private Hospital
**LOCATION:** Part Lot 2 in DP1226923 Faunce Street West, West Gosford

**SURFACE LEVEL:** 12.7 AHD
**EASTING:** 344700.7
**NORTHING:** 6300836.7
**DIP/AZIMUTH:** 90°/--

**BORE No:** 1
**PROJECT No:** 83574.00
**DATE:** 1/3/2019
**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 | Sampling & In Situ Testing: Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|---|
| | 0.02 | SPRAY SEAL WEARING COURSE | | | | | | | |
| | 0.2 | FILLING: Generally comprising dark brown-grey slightly sandy gravel (roadbase), humid | | | | | | | |
| | 0.5 | SANDY CLAY: Firm to stiff brown sandy clay with trace organics, M=Wp (possible filling) | | | | | | | |
| | | CLAY: Stiff organic orange-red brown slighty sandy clay, M<Wp<br>- From 1.0m mottled grey | | S | 1.0<br>1.45 | | pp = 300-400<br>4,5,8<br>N = 13 | ▼ 06-03-19 | |
| | | - From 2.0m very stiff to hard, light grey mottled red-brown sandy clay with ironstone gravel | | S | 2.5<br>2.74 | | pp >500<br>20,20/90,-<br>refusal | | |
| | 2.9 | SANDSTONE: Extremely low strength, extremely weathered red-brown sandstone with ironstone and clay bands<br>- From 3.8m depth harder drilling, possibly low strength | | | | | | | |
| | 4.0 | Bore discontinued at 4.0m - TC bit refusal | | | | | | | |

**RIG:** Traccess **DRILLER:** S. Kennedy **LOGGED:** T. Warriner **CASING:**

**TYPE OF BORING:** 100mm diameter Spiral Flight Auger

**WATER OBSERVATIONS:** No free groundwater observed during drilling. Free groundwater observed at 1.71m depth after five days

**REMARKS:**

**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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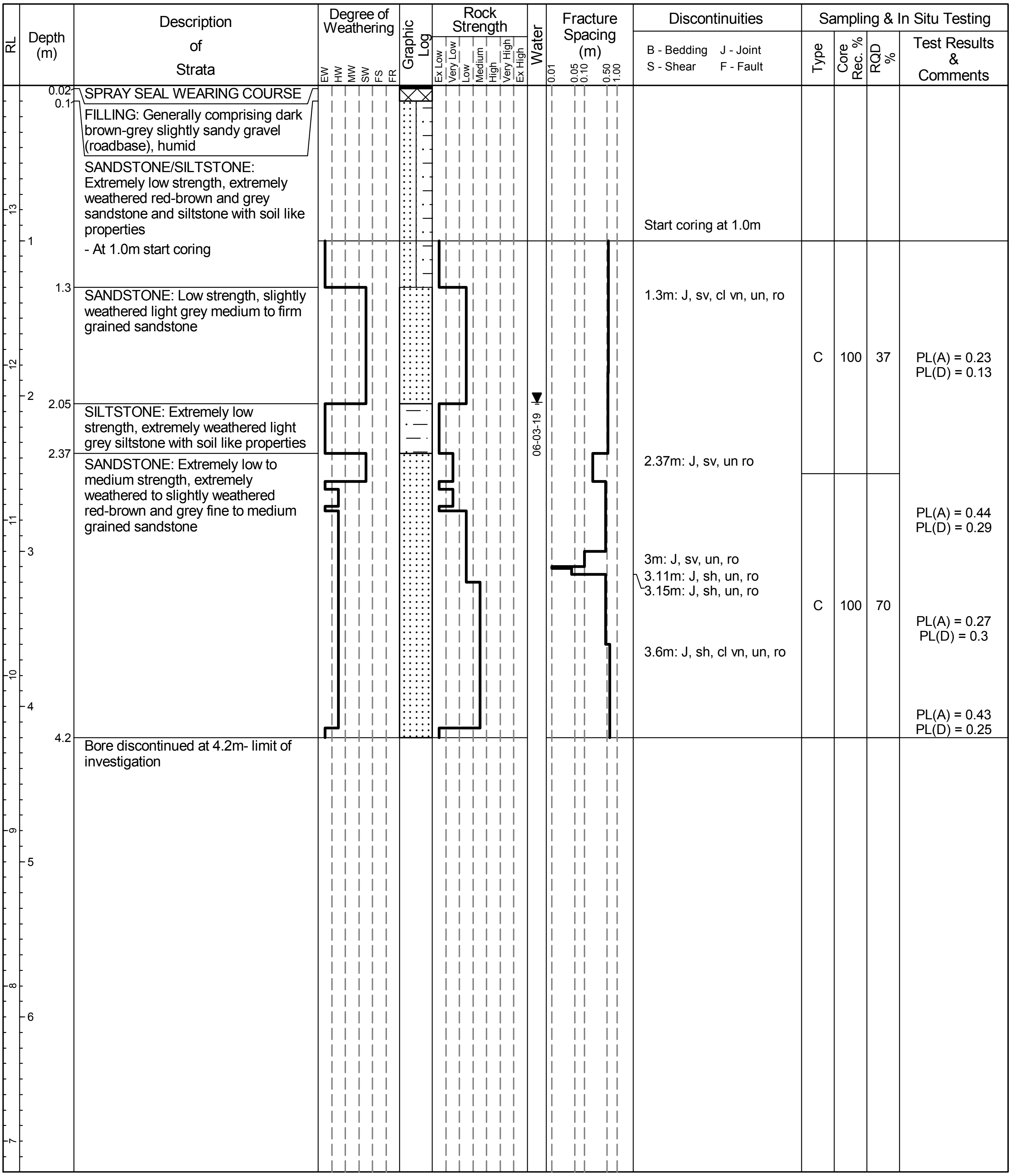
# BOREHOLE LOG

**CLIENT:** AA Crown Holdings Pty Ltd
**PROJECT:** Proposed Northside Private Hospital
**LOCATION:** Part Lot 2 in DP1226923 Faunce Street West, West Gosford

**SURFACE LEVEL:** 13.8 AHD
**EASTING:** 344741.1
**NORTHING:** 6300798.2
**DIP/AZIMUTH:** 90°/--

**BORE No:** 2
**PROJECT No:** 83574.00
**DATE:** 1/3/2019
**SHEET** 1 OF 1



| Depth (m) | Description of Strata | Discontinuities<br>B - Bedding J - Joint<br>S - Shear F - Fault | Type | Core Rec. % | RQD % | Test Results & Comments |
|---|---|---|---|---|---|---|
| 0.02 | SPRAY SEAL WEARING COURSE | | | | | |
| 0.1 | FILLING: Generally comprising dark brown-grey slightly sandy gravel (roadbase), humid | | | | | |
| | SANDSTONE/SILTSTONE: Extremely low strength, extremely weathered red-brown and grey sandstone and siltstone with soil like properties<br>- At 1.0m start coring | Start coring at 1.0m | | | | |
| 1.3 | SANDSTONE: Low strength, slightly weathered light grey medium to firm grained sandstone | 1.3m: J, sv, cl vn, un, ro | C | 100 | 37 | PL(A) = 0.23<br>PL(D) = 0.13 |
| 2.05 | SILTSTONE: Extremely low strength, extremely weathered light grey siltstone with soil like properties | | | | | |
| 2.37 | SANDSTONE: Extremely low to medium strength, extremely weathered to slightly weathered red-brown and grey fine to medium grained sandstone | 2.37m: J, sv, un ro<br>3m: J, sv, un, ro<br>3.11m: J, sh, un, ro<br>3.15m: J, sh, un, ro<br>3.6m: J, sh, cl vn, un, ro | C | 100 | 70 | PL(A) = 0.44<br>PL(D) = 0.29<br>PL(A) = 0.27<br>PL(D) = 0.3<br>PL(A) = 0.43<br>PL(D) = 0.25 |
| 4.2 | Bore discontinued at 4.2m- limit of investigation | | | | | |

**RIG:** Traccess **DRILLER:** S. Kennedy **LOGGED:** T. Warriner **CASING:** HW to 1.0m depth

**TYPE OF BORING:** 100mm diameter Spiral Flight Auger to 1.0m, then NMLC coring to 4.2m

**WATER OBSERVATIONS:** No free groundwater observed during drilling. Free groundwater observed at 2.04m depth after five days

**REMARKS:**

**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 Northside Private Hospital**

**BORE 2** | **PROJECT 83574.00** | **1 March 2019**

**1.0 m – 4.2 m**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CLIENT: | AA Crown Holdings Pty Ltd | TITLE: | **Core Photograph**<br>**Proposed Northside Private Hospital**<br>**Part Lot 2 in DP 1226923, Faunce Street West, West Gosford** | | | | |
| PROJECT No: | 83574.00 | | | | | | |
| OFFICE: | Central Coast | | | | | | |
| **Douglas Partners**<br>Geotechnics / Environment / Groundwater | | DATE: | 28.03.2019 | DRAWN BY: | TDM | BORE No: | 2 |
| | | SCALE: | As shown | PLATE No: | 1 | REVISION: | 0 |

# BOREHOLE LOG

**CLIENT:** AA Crown Holdings Pty Ltd
**PROJECT:** Proposed Northside Private Hospital
**LOCATION:** Part Lot 2 in DP1226923 Faunce Street West, West Gosford

**SURFACE LEVEL:** 12.8 AHD
**EASTING:** 344776.4
**NORTHING:** 6300838.3
**DIP/AZIMUTH:** 90°/--

**BORE No:** 3
**PROJECT No:** 83574.00
**DATE:** 1/3/2019
**SHEET** 1 OF 1

| Depth (m) | Description of Strata | Graphic Log | Sampling & In Situ Testing: Type | Sampling & In Situ Testing: Depth | Sampling & In Situ Testing: Sample | Sampling & In Situ Testing: Results & Comments | Water | Well Construction Details |
|---|---|---|---|---|---|---|---|---|
| 0.02 | SPRAY SEAL WEARING COURSE | | | | | | | |
| 0.1 | FILLING: Generally comprising dark brown-grey slightly sandy gravel (roadbase), humid | | | | | | | |
| | SANDY CLAY: Stiff light brown sandy clay | | | | | | | |
| | - From 1.0m becomes mottled orange-brown slightly sandy slightly gravelly clay | | S | 1.0<br>1.45 | | pp = 350-450<br>4,5,8<br>N = 13 | | |
| | - From 1.8m red-brown mottled grey | | | | | | | |
| | - From 2.2m very stiff to hard, light grey mottled red-brown | | S | 2.5<br>2.95 | | pp >500<br>8,12,22<br>N = 34 | | |
| 2.8 | SANDSTONE/SILTSTONE: Extremely low strength, extremely weathered light grey sandstone and siltstone with some clay bands | | | | | | ▼ 06-03-19<br>▷ | |
| | | | S | 4.0<br>4.45 | | pp >500<br>11,16,23<br>N = 39 | | |
| | - From 5.5m depth harder drilling, possibly low strength | | S | 5.5<br>5.64 | | pp >500<br>20/140,-,-<br>refusal | | |
| 5.8 | Bore discontinued at 5.8m- TC bit refusal | | | | | | | |

**RIG:** Traccess **DRILLER:** S. Kennedy **LOGGED:** T. Warriner **CASING:**
**TYPE OF BORING:** 100mm diameter Spiral Flight Auger
**WATER OBSERVATIONS:** Free groundwater observed at 4.1m depth during drilling. Stabilised to 3.89m depth after five days
**REMARKS:**

**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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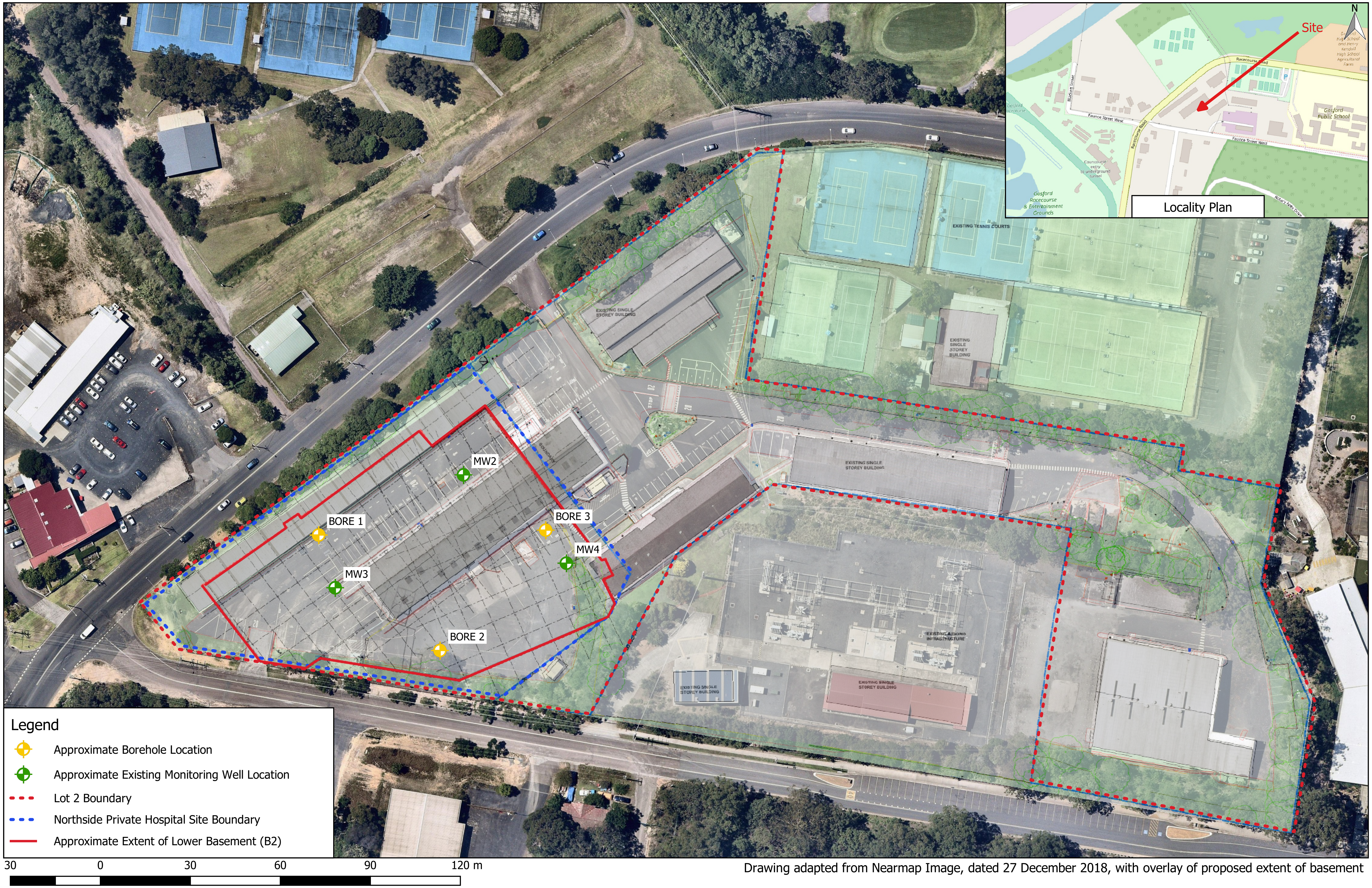
# Appendix C

Drawing 1 – Test Location Plan



Drawing adapted from Nearmap Image, dated 27 December 2018, with overlay of proposed extent of basement

**Douglas Partners**
Geotechnics / Environment / Groundwater

CLIENT: AA Crown Holdings Pty Limited
OFFICE: Central Coast
DRAWN BY: TDM
SCALE: 1:1200 @ A3
DATE: 28.03.2019

TITLE: **Test Location Plan**
**Proposed Northside Private Hospital**
**Part Lot 2 in DP 1226923, Faunce Street West, West Gosford**

PROJECT No: 83574.00
DRAWING No: 1
REVISION: 0