Health Infrastructure c/- Johnstaff

Concord Hospital Redevelopment Project

Geotechnical Site Investigation for Lift Well in Phase 1 Development

18 May 2018
Concord Hospital Redevelopment Project

Geotechnical Site Investigation for Lift Well in Phase 1 Development

Prepared for
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18 May 2018

Document authorisation

Our ref: SYDGE221253-AC
For and on behalf of Coffey

Robert Turner
Principal Geotechnical Engineer

Quality information

Revision history

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<th>Author</th>
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<td>Original issue</td>
<td>23 Jan 2018</td>
<td>R Turner</td>
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Distribution

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1. Introduction

Concord Hospital is located at 1H Hospital Road, Concord West NSW, situated on the southern shores of Parramatta River on a peninsula ridge (up to RL 12 m) oriented south-west to north-east that separates Bray's Bay and Yaralla Bay.

The redevelopment works are located in three different areas of the Hospital precinct (designated as Phases 1, 2 and 3):

- Phase 1 involves demolition of the existing structures and construction of a new multi storey building with one basement level, located in the red zone in Plate 1.
- Phase 2 covers two areas located in the blue zones in Plate 1. Details of these proposed developments are not yet confirmed. In this report Coffey refers to the site adjacent to Hospital Road as Site 2A and the site adjacent to Yaralla Bay as Site 2B.
- Phase 3 is a proposed multi storey carpark located between Hospital Road and Bray's Bay (purple zone in Plate 1). This area is currently an at-grade carpark.

Plate 1- Concord Hospital Phasing Plan (refer Figure 1 for full drawing)
On behalf of Health Infrastructure, Johnstaff engaged Coffey Services Australia Pty Ltd (Coffey) to conduct geotechnical and contamination investigations for redevelopment projects at Concord Hospital. Coffey conducted geotechnical drilling investigations in each of the sites referenced above to either supplement previous investigations conducted by Douglas Partners (Phases 1 and 3) or to provide information on sites not previously investigated (Phase 2 – Sites 2A and 2B).

This report presents the results of geotechnical investigation to supplement previous investigation by Douglas Partners for Phase 1 site, specifically focusing on the proposed lift well. In Plate 1, the lift well is located in the projection on the north western side of the rectangular building footprint.

The geotechnical investigation was carried out generally as planned in our fee proposal reference SYDGE211253AA dated 6 October 2017.

2. Site Information

2.1. Terrain

The hospital precinct is situated on the southern shoreline of Parramatta River on a peninsula ridge (up to RL 12 m) oriented south-west to north-east that separates Bray’s Bay (on the north-west shore) and Yaralla Bay (on the south-east shore).

Phase 1 occupies about 1.6 hectares located to the south east of Hospital Road, south of existing Building 5 and west of Yaralla Bay. Ground levels are typically RL 9 m upslope near Building 5 and to RL 3.5 m near Yaralla Bay.

The site is presently occupied by low rise buildings, pavements, landscaping and a tennis court on a low fill platform.

2.2. Local Geology

Published geological maps (Sydney 1:100 000 Geological Sheet 9130, 1st edition. Geological Survey of NSW) indicate the site locality is underlain by several geological units as summarised below:

- Ashfield Shale (dark grey to black shale with laminite) capping the main peninsula ridgeline and forming the foreshores of Bray’s Bay.
- Hawkesbury Sandstone (medium to coarse-grained quartz sandstone with minor shale and laminite lenses) underlying the Ashfield Shale, outcropping at the eastern end of the peninsula;
- Quaternary Alluvium (silty to peaty quartz sand, silt and clay) overlying the Ashfield Shale and Hawkesbury Sandstone at the south of the hospital precinct on the northern shores of Yaralla Bay.

Although not noted on the geology map, Ashfield Shale and Hawkesbury Sandstone are separated by the Mittagong Formation comprising interbedded sandstones, shale and laminite, which varies in thickness but is usually only a few metres thick. Whilst the formation often appears to be predominantly sandstone, its bedding and defect characteristics are more similar to the Ashfield Shale and it is mapped within that Unit unless specific outcrops are evident.

Phase 1 is located across the boundary of Ashfield Shale in the north and Quaternary Alluvium in the south. The proposed lift well is located within the area mapped as Ashfield Shale.
2.3. Previous investigations

Coffey was provided with Douglas Partners Report titled “Geotechnical Investigation, Concord Repatriation General Hospital Redevelopment”, reference 85356.00.R.001.Rev0, dated 11 April 2016, referred to herein as DP 2016. Two areas were investigated; the proposed “Tower Building” now referred to as Phase 1, and the proposed multi-storey carpark (now referred to as Phase 3).

Eight Douglas boreholes (BH10 to BH17) were located in or near the Phase 1 footprint as shown on Figure 2. The following is an extract from DP2016 describing the generalised interpreted ground conditions:

> At the proposed tower buildings (BH 10 to BH 17) the test results generally indicate the following profile:
> - **Filling** – including asphaltic concrete and concrete pavement surfaces at some locations, underlain by variable filling including gravelly sand, clayey silt and silty clay to typical depths of between 0.2 m and 0.5 m, but up to 1.4 m depth at BH 11; underlain by,
> - **Clay** – stiff and very stiff clay, with some shaly clay to depths of up to 2.6 m, but absent in some locations (BH 10, BH 15, BH 17); underlain by,
> - **Shale and Laminite** – extremely low and very low strength, fragmented to fractured, light grey and light grey brown shale and laminite, with some low to high strength iron-cemented bands, to depths of 0.3 m to 5.85 m, then generally low and medium strength to depths of 2.83 to 7.5 m; then generally medium strength and fractured to slightly fractured to depths of 5.6 m to 8.2 m; underlain by high strength shale and laminite at some locations; underlain by,
> - **Sandstone** – medium then coarse grained, slightly fractured and unbroken sandstone from depths of 7 m to 9.2 m (though not encountered at BH 10, BH 11 and BH 13, and from shallower depth, 4.1 m, at BH 17), generally high strength with some very high strength bands, except at BH 17, where an upper layer of low to medium strength sandstone was present, before improving to high strength sandstone with a very high strength band, from 5.6 m depth

It can be inferred from the above description and from examination of the geotechnical sections prepared by Douglas that despite the relatively consistent stratigraphy, the rock strength weathering and defect conditions are quite variable across the site.

Douglas borehole BH10 drilled to 6.1m depth was the closest borehole to the lift well. That borehole log and core photograph are attached in Appendix A. The locations of the Douglas boreholes are shown on Figure 2.
3. Coffey 2017 lift well investigation

Based on the project brief and the site information described in Section 2, we prepared an investigation plan that was described in our fee proposal reference SYDGE211253AA dated 6 October 2017. The planning and risk management preparation was conducted generally as outlined in our proposal.

We conducted the drilling investigation for all three development Phases in a continuous episode in November and December 2017.

For Phase 1, we drilled two boreholes BH101 and BH102 in the proposed lift well zone on the uphill northern side of the Phase 1 footprint at the locations shown in Figure 2. These boreholes were drilled to nominal 6 m and 8 m depths respectively. Coffey borehole locations were measured from existing site features, and ground elevations at the test locations were interpolated from survey plans provided.

The boreholes were drilled using a track mounted Hanjin DB8 drilling rig. Through soil, the boreholes were advanced using solid flight augers with Standard Penetration Tests at intervals within the soil profile. Once rock was encountered, the boreholes were cored using NMLC methods to target depth.

A Coffey geotechnical professional was on site to direct the fieldwork, to locate the boreholes, collect samples and rock core, and log the encountered ground conditions. The borehole logs are presented in Appendix A, with core photographs and explanatory notes.

After drilling, groundwater monitoring standpipes were installed in both boreholes to allow future groundwater level monitoring. Groundwater was not recorded in BH101. Standing water level in BH102 was RL 4.2 m one week after completion of drilling.

After completion of fieldwork, point load strength index testing of rock core was conducted at approximately 1 m interval along the cores. The results of the point load index strength testing are presented and plotted on the borehole logs in Appendix A. As is common with fissile rocks like shale and siltstone, the test results for diametral orientation (across the core) were generally lower than the axial orientation (along the core axis).
4. Interpreted geotechnical conditions at lift well

Details of the stratigraphy encountered in the Coffey boreholes are provided in the borehole logs in Appendix A, together with the Douglas log for BH10, which is their nearest borehole to the lift well.

**Table 1: Summary Conditions – BH101 (Coffey)**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>RL at top of Unit</th>
<th>Generalised Stratigraphy</th>
<th>Interpreted Rock Classification[^1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 to 1.0</td>
<td>8.6m</td>
<td>Fill - pavement and general filling</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1.0 to 3.5</td>
<td>7.6m</td>
<td>Shale – moderately weathered initially grading to fresh at RL 5.9m. Initially low to medium strength, becoming medium to high strength below RL 6.6m. Highly fractured - defects at 50mm to 200mm spacing.</td>
<td>Shale Class III</td>
</tr>
<tr>
<td>3.5 to 6.0</td>
<td>5.1m</td>
<td>Shale – fresh, medium to high strength, fractured (defects at average 300mm spacing)</td>
<td>Shale Class II</td>
</tr>
</tbody>
</table>

**Table 2: Summary Conditions – BH102 (Coffey)**

<table>
<thead>
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<th>Depth (m)</th>
<th>RL at top of Unit</th>
<th>Generalised Stratigraphy</th>
<th>Interpreted Rock Classification[^1]</th>
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<tbody>
<tr>
<td>0.0 to 1.3</td>
<td>8.3 m</td>
<td>Pavement and general filling over thin residual clay</td>
<td>Not applicable</td>
</tr>
<tr>
<td>1.3 to 3.3</td>
<td>7.0 m</td>
<td>Shale – moderately to slightly weathered, low and medium strength, becoming medium to high strength below RL 6.3m. Fractured to highly fractured - defects at 100mm to 200mm spacing.</td>
<td>Shale Class III</td>
</tr>
<tr>
<td>3.3 to 8.0</td>
<td>5.0 m</td>
<td>Shale – slightly weathered to fresh, mainly medium strength with some high strength, fractured (defects at average 300mm to 500mm spacing)</td>
<td>Shale Class II</td>
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**Table 3: Summary Conditions - BH10 (Douglas Partners)**

<table>
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<th>Depth (m)</th>
<th>RL at top of Unit</th>
<th>Generalised Stratigraphy</th>
<th>Interpreted Rock Classification[^1 &amp; 2]</th>
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<td>0.0 to 0.3</td>
<td>8.2 m</td>
<td>Fill associated with pavement construction</td>
<td>Not applicable</td>
</tr>
<tr>
<td>0.3 to 1.0</td>
<td>7.9 m</td>
<td>Shale – very low and low strength</td>
<td>Shale Class IV</td>
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<tr>
<td>1.0 to 4.4</td>
<td>7.2 m</td>
<td>Shale – distinctly weathered, medium strength, highly fractured or fractured, with some clay bands between 1m to 3m depth</td>
<td>Shale Class III</td>
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<tr>
<td>4.4 to 6.1</td>
<td>3.8 m</td>
<td>Shale – fresh, medium strength to 5.6m depth, then high strength, fractured</td>
<td>Shale Class III</td>
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</tbody>
</table>

**Notes to Tables 1, 2 and 3**

1. Rock classification using the system outlined in Pells et al (1998) “Foundations on Sandstone and Shale in the Sydney Region” (Australian Geomechanics Journal, Dec 1998). The classifications reported in Tables 1 and 2 are interpreted from the borehole core and may not necessarily represent the ground conditions remote from the borehole. The classifications are intended for foundation assessment, not excavatability.

2. The classification in Table 3 is Coffey’s interpretation of the Douglas BH10 based on the log and core photograph. In DP2016 Table 13, Douglas interpret Shale Class III from depth 1.0m to 1.6m, then Shale Class II below that. Coffey recognise that their interpretation is limited by not witnessing the actual core, but we are unable to agree with the Douglas interpretation on the documented information in DP2016.
5. Lift well design

Coffey has been advised that for the two new service lifts, the “lift pit depths will be approximately 1850mm deep measured from FFL of lowest level served to the surface of the pit.” For a Lower Ground Level of nominal RL 9.1m shown on drawing IA064700-MAIN-AR-DWG-0111, then the Pit floor level would be nominally RL 7.25m.

5.1. Excavation conditions

Based on the boreholes referenced in Section 4, the lift well excavation will penetrate Fill, Residual Soil, Shale Class V or IV, with some Shale Class III near the base of the excavation at some locations.

Soil strength material and very low strength rock should be able to be excavated using conventional earthmoving plant such as heavy excavators with toothed buckets.

Some low and medium strength rock within Shale Classes V to III would require high powered excavation plant fitted with rippers and rock breakers, or the use of rock grinders or rock saws. Such plant would also be required for footing excavation into Class III Shale or better for the lift well foundations.

Sections 8.2.2 and 8.2.3 of DP2016 provide recommendations for temporary unsupported batter slopes and for design of retaining walls that can be adopted for lift well design and construction. When referring to Table 8 of DP2016 regarding recommended batter slope, we caution that in our opinion all the vertical (V) and horizontal (H) symbols have been inadvertently transposed, e.g. the temporary batter slope for low and medium strength shale should read 0.5H : 1V and not 0.5V : 1H.

5.2. Foundations

The lift well base elevation of RL 7.25 m is expected to coincide approximately with the top of Shale Class III. For this material, we recommend an allowable bearing pressure of 3 MPa subject to acceptable settlement based on an elastic modulus of 800 MPa for Class III shale.

Alternatively, bored pile footings could be adopted using limit state design based on the ultimate parameters in Table 4.

Table 4: Recommended Pile Design Parameters

<table>
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<tr>
<th>Material</th>
<th>Ultimate Shaft Adhesion (kPa)</th>
<th>Ultimate End Bearing Value (MPa)</th>
<th>Ultimate Lateral Yield Pressure, ( p_y ) (MPa)</th>
<th>Young’s Modulus EV (MPa)</th>
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<tr>
<td>Class V/IV Shale</td>
<td>150</td>
<td>3</td>
<td>1.5</td>
<td>200</td>
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<tr>
<td>Class III Shale</td>
<td>500</td>
<td>20</td>
<td>5</td>
<td>800</td>
</tr>
<tr>
<td>Class II Shale</td>
<td>800</td>
<td>60</td>
<td>15</td>
<td>1,500</td>
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</table>

Notes to Table 4:
1. Potential shaft adhesion should be ignored where the pile embedment is less than 2 pile diameters.
2. For uplift loads, the ultimate shaft adhesion should be factored by 0.6.
3. Ultimate lateral yield pressure in clay soil depends on pile spacing/diameter ratio and depth of embedment. The quoted values should be used for preliminary design only, and should be halved if the depth of embedment is less than 3 pile diameters.

For limit state design a geotechnical reduction factor (\( \phi_g \)) is to be applied to the ultimate geotechnical pile capacity assessed using the ultimate shaft resistance and end bearing values shown in Table 4 to derive the design ultimate geotechnical pile capacity.
In accordance with AS2159-2009, $\phi_g$ is dependent on assignment of an Average Risk Rating (ARR) which takes into account various geotechnical uncertainties, redundancy of the foundation system, construction supervision, and the quantity and type of pile testing. The assessment of $\phi_g$ therefore depends on the structural design of the foundation system as well as the design and construction method, and testing (if any) to be employed by the designer and piling contractor. Where testing is undertaken, it may be possible to adopt a $\phi_g$ value that leads to a more economical design.

To assist with preliminary design, a $\phi_g$ value of 0.4 could be adopted, assuming no pile load testing. Once the pile designer has evaluated the ARR, this value could be revised.

The use of limit state design also requires that serviceability performance of the foundation system be assessed, including pile group interaction effects. Such assessment should be carried out by an experienced geotechnical professional using well-established and soundly based methods. The elastic modulus values given in Table 4 may be adopted for such assessment, but it should be recognised that the accuracy of settlement prediction is a function of construction methodology as well as the assessed values of material stiffness, both of which can involve considerable uncertainty. Therefore, the accuracy of settlement predictions may be no better than $\pm 50\%$. Where foundation settlement is critical to the performance of the structure, serviceability pile load testing should be carried out to confirm the design assumptions and/or assess prediction accuracy.

5.3. Earthquake design

Based on AS1170.4-2007 “Structural design actions Part 2: Earthquake actions in Australia” the following parameters should be adopted for seismic design:

- Seismic Hazard Factor ($Z$) 0.08
- Sub-Soil Class $B_e$

The Earthquake Design Category could then be assessed based on a Probability Factor, $k_p$, (which is related to an Annual Probability of being Exceeded) as defined in Table 3.1 of AS 1170.4 – 2007).

6. Closure

Subsurface conditions can be complex, vary over relatively short distances and over time. The inferred geotechnical model and recommendations in this report are based on limited subsurface investigations at discrete locations. The engineering logs describe subsurface conditions only at the investigation locations.

Additional investigations may be required to support detailed design due to factors such as scope limitations and changes to the nature of the project. A geotechnical engineer should be engaged to assist with detailed design and/or to review designs. During construction a geotechnical engineer should check if the conditions exposed are consistent with design assumptions.

The attached document entitled “Important Information about Your Coffey Report” forms an integral part of this report and presents additional information about the uses and limitations of the report.
Important information about your Coffey Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

**Your report is based on project specific criteria**

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report’s recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

**Subsurface conditions can change**

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

**Interpretation of factual data**

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

**Your report will only give preliminary recommendations**

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report’s recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

**Your report is prepared for specific purposes and persons**

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

**Interpretation by other design professionals**

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.
Important information about your Coffey Report

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to “Guidelines for the Provision of Geotechnical information in Construction Contracts” published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.
Figures
FIGURE 2

AS SHOWN PHASE 1 BOREHOLE LOCATION PLAN

APPROXIMATE BOREHOLE LOCATION
(DOUGLAS 2016)

APPROXIMATE BOREHOLE LOCATION WITH
STANDPIPE INSTALLED (DOUGLAS 2016)

APPROXIMATE BOREHOLE LOCATION
(COFFEY CURRENT INVESTIGATION)

APPROXIMATE BOREHOLE LOCATION WITH STANDPIPE
INSTALLED (COFFEY CURRENT INVESTIGATION)

LEGEND

PHASE 1 DEVELOPMENT

AERIAL IMAGERY COPYRIGHT: ©Land and Property Information (2015)
LICENSED UNDER CC BY 3.0 AU  (https://creativecommons.org/licenses/by/3.0/au/legalcode)
Appendix A – Borehole logs and explanatory notes
## Engineering Log - Borehole

**client:** Health Infrastructure  
**project:** Concord Hospital Phase 1 Redevelopment  
**location:** Hospital Road, Concord, NSW  
**Borehole ID:** BH101  
**date started:** 23 Nov 2017  
**date completed:** 23 Nov 2017  
**logged by:** TW/JJ  
**checked by:** DS  

### Drilling Information

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<th>Depth (m)</th>
<th>Support</th>
<th>Water</th>
<th>samples &amp; field tests</th>
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<td>ASPHALT: 50mm.</td>
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<td>sub-rounded.</td>
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Borehole BH101 continued as cored hole

### Additional Observations

- ASPHALT FILL
  - E Sample PID = 1.4ppm
  - E Sample PID = 1.5ppm
  - No staining or odour
### Engineering Log - Cored Borehole

**Client:** Health Infrastructure  
**Project:** Concord Hospital Phase 1 Redevelopment  
**Location:** Hospital Road, Concord, NSW  
**Borehole ID:** BH101  
**Date Started:** 23 Nov 2017  
**Date Completed:** 23 Nov 2017  
**Logged by:** TW/JJ  
**Checked by:** DS

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**Drilling Information**

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<tr>
<th>Depth (m)</th>
<th>Method &amp; Support</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>10/10/12, water</td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td>NMLC core (51.9 mm)</td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>NMLC core (47.6 mm)</td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>NMLC core (63.5 mm)</td>
<td></td>
</tr>
<tr>
<td>4.0</td>
<td>NMLC core (85.0 mm)</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Wireline core (47.6 mm)</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>Wireline core (63.5 mm)</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>Wireline core (85.0 mm)</td>
<td></td>
</tr>
<tr>
<td>0.0</td>
<td>NMLC core (51.9 mm)</td>
<td></td>
</tr>
</tbody>
</table>

---

**Material Substance**

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Rock Type</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>SHALE</td>
<td>dark grey, brown, iron stained along bedding at 0°.</td>
</tr>
<tr>
<td>0.11</td>
<td>NO CORE</td>
<td>0.11 m</td>
</tr>
<tr>
<td>0.05</td>
<td>SHALE</td>
<td>dark grey, brown, iron stained along bedding at 0°.</td>
</tr>
<tr>
<td>2.69</td>
<td>SHALE</td>
<td>dark grey, brown, iron stained along bedding at 0°.</td>
</tr>
<tr>
<td>2.69</td>
<td>2.69 m: becoming less iron stained</td>
<td></td>
</tr>
</tbody>
</table>

---

**Defects**

- **Defect Type:** PT, JT, SM, RO, CN, SN, XW
- **Defect Description:** Partialing, Joint, Seams, Roughness, Contact, Seam

---

**Weathering & Alteration**

- **Estimated Strength:**
  - Very Low (VL): 0.68 MPa
  - Low (L): 0.90 MPa
  - Medium (M): 0.99 MPa
  - High (H): 1.11 MPa
  - Very High (VH): 1.21 MPa
  - Extremely High (EH): 1.49 MPa

---

**Graphical Log**

- **Core Run & RQD:**
  - barrel withdrawn
  - Refusal

---

**Core Recovery**

- **Samples, Field Tests:** 90% 
- **Defect Spacing:** (mm)
  - 0% 
  - 10% 
  - 90% 
- **Estimated Strength & %: 50**
  - a = 0.68
  - d = 0.90
  - a = 1.21
  - d = 0.99
  - a = 1.55
  - d = 0.99
  - a = 1.55
  - d = 0.99

---

**Additional Observations and Defect Descriptions**

- **Type:** Partialing, Joint, Seams, Roughness, Contact, Seam
- **Planarity:** PL, CU, RO, CN
- **Roughness:** VL, L, M, H, V, EH
- **Coating:** CN, clean
- **Coating:** SN, stain
- **Coating:** VN, vernier
- **Coating:** RO, rough
- **Coating:** CO, coating
BH101 1.00 - 5.97 m

client: Health Infrastructure

project: Concord Hospital Phase 1 Redevelopment
Hospital Road, Concord, NSW

title: CORE PHOTOGRAPH
BH101

project no: SYDGE211253
fig no: FIGURE 1

drawn | AW
-- | --
approved | DS

date | 9/01/2018

scale | N.T.S.

original size | A4
**Piezometer Installation Log**

**client:** Health Infrastructure  
**project:** Concord Hospital Phase 1 Redevelopment  
**location:** Hospital Road, Concord, NSW

<table>
<thead>
<tr>
<th>Drilling Information</th>
<th>Material Substance</th>
<th>Piezometer Construction Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>method &amp; support:</td>
<td>water</td>
<td>bore construction license:</td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>drilling company:</td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>driller:</td>
</tr>
<tr>
<td></td>
<td>water</td>
<td>driller's permit no.:</td>
</tr>
</tbody>
</table>

- **position:** E: 323,541.05; N: 6,254,211.55 (MGA94)  
- **surface elevation:** 8.60 m (AHD)  
- **angle from horizontal:** 90°  
- **equipment type:** Hanjin DB8, Track mounted  
- **drilling fluid:** BH101, SYDGE211253  
- **hole diameter:** 125 mm

**Drilling Information**

<table>
<thead>
<tr>
<th>RL (m)</th>
<th>depth (m)</th>
<th>material name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
<td>ASPHALT</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>FILL</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>ASPHALT</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>FILL</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>GROUT</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>BENTONITE</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>SAND</td>
</tr>
</tbody>
</table>

**Relative Levels (AHD)**

<table>
<thead>
<tr>
<th>water level</th>
<th>installation date</th>
<th>tip depth</th>
<th>water level</th>
<th>Relative Levels (AHD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.63</td>
<td>5.97 m</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Core Recovery**

- BH101: standpipe piezo.

**Core recovered (graphic symbols indicate materials):**

- No core recovered

**Graphic Log / Core Recovery**

- Water pressure test result (lugeons) for depth interval shown

**Drilling Fluid Log**

- Water inflow
- Complete drilling fluid loss
- Partial drilling fluid loss

**Logging Information**

- **Hole ID:** BH101  
- **date started:** 23 Nov 2017  
- **date completed:** 23 Nov 2017  
- **logged by:** TW/JJ  
- **checked by:** DS
### Engineering Log - Borehole

**client:** Health Infrastructure  
**project:** Concord Hospital Phase 1 Redevelopment  
**location:** Hospital Road, Concord, NSW

**Borehole ID:** BH102  
**project no.:** SYDGE211253  
**date started:** 14 Dec 2017  
**date completed:** 14 Dec 2017  
**logged by:** AM  
**checked by:** DS

---

**position:** E: 323,559.02; N: 6,254,200.12 (MGA94)  
**surface elevation:** 8.30 m (AHD)  
**angle from horizontal:** 90°  
**drill model:** Hanjin DB8, Track mounted  
**drilling fluid:**  
**hole diameter:** 125 mm

---

**method:**  
- AD: auger drilling  
- AS: auger screwing  
- HA: hand auger  
- W: washbore  
- N: nil  
- V: V-bit

**support:**  
- M: mud  
- N: nil

**penetration:**  
- N: no resistance ranging to refusal  
- T: no resistance to refusal  
- D: dry  
- W: wet

**water:**  
- 10-Oct-12 water level on date shown  
- Water inflow  
- Water outflow

**classification symbol & soil description:**  
- Based on Unified Classification System

**samples & field tests:**  
- B: bulk disturbed sample  
- D: disturbed sample  
- E: environmental sample  
- SS: split spoon sample  
- U#: undisturbed sample #2mm diameter  
- HP: hand penetrometer (kPa)  
- N: standard penetration test (SPT)  
- N*: SPT - sample recovered  
- NC: SPT with solid cone  
- VS: vane shear; peak/remoulded (kPa)  
- R: refusal  
- HB: hammer bouncing

**material description:**  
- SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components

**material substance:**  
- material description  
- structure and additional observations

---

**SOIL TYPE:**  
- ASPHALT: 50mm.  
- FILL: Sandy SILT: fine to coarse grained, low liquid limit, yellow-brown, trace of gravel.  
- Silty CLAY: low plasticity, pale yellow-brown.  
- SHALE: yellow-brown, dark red, extremely weathered, very low strength.

---

**additional information:**  
- Borehole BH102 continued as cored hole

---

**moisture:**  
- dry  
- moist  
- wet

**consistency / relative density:**  
- VS: very soft  
- S: soft  
- F: firm  
- ST: stiff  
- VST: very stiff  
- H: hard  
- Fb: brittle  
- VL: very loose  
- L: loose  
- MD: medium dense  
- D: dense  
- VE: very dense
<table>
<thead>
<tr>
<th>drawn</th>
<th>AW</th>
<th>client</th>
<th>Health Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>approved</td>
<td>DS</td>
<td>project</td>
<td>Concord Hospital Phase 1 Redevelopment</td>
</tr>
<tr>
<td>date</td>
<td>9/01/2018</td>
<td>title</td>
<td>Hospital Road, Concord, NSW</td>
</tr>
<tr>
<td>scale</td>
<td>N.T.S.</td>
<td>project no</td>
<td>SYDGE211253</td>
</tr>
<tr>
<td>original size</td>
<td>A4</td>
<td>fig no</td>
<td>FIGURE 2</td>
</tr>
</tbody>
</table>
BH102 6.00 - 8.00 m

PROJECT: CONCORD HOSPITAL
PROJECT No: SYDGE211253
BOREHOLE No: BH102
DEPTH: 6.00 - 8.00 m, DATE: 14/12/17

SYDGE211253
N.T.S.
9/01/2018
DS
Concord Hospital Phase 1 Redevelopment Hospital Road, Concord, NSW
CORE PHOTOGRAPH
BH102

client: Health Infrastructure
project: Concord Hospital Phase 1 Redevelopment Hospital Road, Concord, NSW
title: CORE PHOTOGRAPH
project no: SYDGE211253
fig no: FIGURE 3
rev:
**Piezometer Installation Log**

**client:** Health Infrastructure  
**principal:**  
**project:** Concord Hospital Phase 1 Redevelopment  
**location:** Hospital Road, Concord, NSW

<table>
<thead>
<tr>
<th>Drilling Information</th>
<th>Material Substance</th>
<th>Piezometer Construction Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>method &amp; support</td>
<td>water</td>
<td>bore construction license:</td>
</tr>
<tr>
<td>water</td>
<td></td>
<td>10-Oct-12, water level on date shown</td>
</tr>
<tr>
<td>RL (m)</td>
<td></td>
<td>water inflow</td>
</tr>
<tr>
<td>depth (m)</td>
<td></td>
<td>complete drilling fluid loss</td>
</tr>
<tr>
<td>graphic log</td>
<td>material name</td>
<td>partial drilling fluid loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>water pressure test result</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(lugeons) for depth</td>
</tr>
<tr>
<td>8</td>
<td>ASPHALT</td>
<td>BH102</td>
</tr>
<tr>
<td>7</td>
<td>FILL</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RESIDUAL SOIL</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>WEATHERED BEDROCK</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Grout</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Bentonite</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Sand</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Borehole BH102 terminated at 8.00 m

**graphic log / core recovery**  
- core recovered  
- no core recovered  

<table>
<thead>
<tr>
<th>ID</th>
<th>type</th>
<th>installation date</th>
<th>stick up (m)</th>
<th>tip depth (m)</th>
<th>water level (m)</th>
<th>Relative Levels (AHD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH102</td>
<td>standpipe piezo.</td>
<td>8.00 m</td>
<td></td>
<td></td>
<td></td>
<td>0.30</td>
</tr>
</tbody>
</table>

**equipment type:** Hanjin DB8, Track mounted  
**drilling fluid:** BH102 SYDGE211253 14 Dec 2017  
**hole diameter:** 125 mm

**equipment type:** Hanjin DB8, Track mounted  
**drilling fluid:** BH102 SYDGE211253 14 Dec 2017  
**hole diameter:** 125 mm  

**surface elevation:** 8.30 m (AHD)  
**angle from horizontal:** 90°  
**position:** E: 323,559.02; N: 6,254,200.12 (MGA94)
Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°-10°.

1.27-1.57m: B5°, 0°-5°, cly co, 5-10mm
1.4-1.45m: J (x2) 45°, pl, ro, fe
1.6-1.65m: cly
1.8m: J25°, pl, ro, fe
2.15m: B0°, cly, 5mm
2.4 & 2.55m: J (x2) 35°, pl, ro, fe
2.65-2.9m: J (x4) 40°-50°, pl, ro, fe
3.05m: J25° & 80°, st, ro, fe
3.2m: J45°, pl, ro, fe
3.47-3.8m: J (x4) 30°, pl, ro, fe
4.3m: J45°, pl, sm, fe
3.9m: J45°, pl, sm, fe
4.1m: J90°, pl, ro, cln
4.3m: J90°, pl, ro, cln
4.4-4.85m: J (x4) 45°-55°, pl, ro, e
5.1m: J45°, pl, sm, cln
5.2-5.3m: J45°-90°, cu, ro, fe
5.55m: J45°, pl, ro, fe
5.7-5.85m: J (x3) 45°- 60°, pl, ro, fe
5.9m: J90°, pl, ro, fe
6.1m: J90°, pl, ro, fe

Bore discontinued at 6.1m
**DEFINITION:**
In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

**CLASSIFICATION SYMBOL & SOIL NAME**
Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

**PARTICLE SIZE DESCRIPTIVE TERMS**

<table>
<thead>
<tr>
<th>NAME</th>
<th>SUBDIVISION</th>
<th>SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulders</td>
<td></td>
<td>&gt;200 mm</td>
</tr>
<tr>
<td>Cobbles</td>
<td>coarse</td>
<td>63 mm to 200 mm</td>
</tr>
<tr>
<td></td>
<td>medium</td>
<td>20 mm to 63 mm</td>
</tr>
<tr>
<td></td>
<td>fine</td>
<td>6 mm to 20 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.36 mm to 6 mm</td>
</tr>
<tr>
<td>Gravel</td>
<td>coarse</td>
<td>600 μm to 2.36 mm</td>
</tr>
<tr>
<td></td>
<td>medium</td>
<td>200 μm to 600 μm</td>
</tr>
<tr>
<td></td>
<td>fine</td>
<td>75 μm to 200 μm</td>
</tr>
</tbody>
</table>

**MOISTURE CONDITION**

- **Dry**
  Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

- **Moist**
  Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

- **Wet**
  As for moist but with free water forming on hands when handled.

**CONSISTENCY OF COHESIVE SOILS**

<table>
<thead>
<tr>
<th>TERM</th>
<th>UNDRAINED STRENGTH $s_u$ (kPa)</th>
<th>FIELD GUIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Soft</td>
<td>&lt;12</td>
<td>A finger can be pushed well into the soil with little effort.</td>
</tr>
<tr>
<td>Soft</td>
<td>12 - 25</td>
<td>A finger can be pushed into the soil to about 25mm depth.</td>
</tr>
<tr>
<td>Firm</td>
<td>25 - 50</td>
<td>The soil can be indented about 5mm with the thumb, but not penetrated.</td>
</tr>
<tr>
<td>Stiff</td>
<td>50 - 100</td>
<td>The surface of the soil can be indented with the thumb, but not penetrated.</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>100 - 200</td>
<td>The surface of the soil can be marked, but not indented with thumb pressure.</td>
</tr>
<tr>
<td>Hard</td>
<td>&gt;200</td>
<td>The surface of the soil can be marked only with the thumbnail.</td>
</tr>
<tr>
<td>Friable</td>
<td></td>
<td>Crumbles or powders when scraped by thumbnail.</td>
</tr>
</tbody>
</table>

**DENSITY OF GRANULAR SOILS**

<table>
<thead>
<tr>
<th>TERM</th>
<th>DENSITY INDEX (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very loose</td>
<td>Less than 15</td>
</tr>
<tr>
<td>Loose</td>
<td>15 - 35</td>
</tr>
<tr>
<td>Medium Dense</td>
<td>35 - 65</td>
</tr>
<tr>
<td>Dense</td>
<td>65 - 85</td>
</tr>
<tr>
<td>Very Dense</td>
<td>Greater than 85</td>
</tr>
</tbody>
</table>

**MINOR COMPONENTS**

<table>
<thead>
<tr>
<th>TERM</th>
<th>ASSESSMENT GUIDE</th>
<th>PROPORTION OF MINOR COMPONENT IN:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace of</td>
<td>Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coarse grained soils:</td>
<td>Less than 5%</td>
</tr>
<tr>
<td>With some</td>
<td>Presence easily detected by feel or eye, soil properties little different to general properties of primary component.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coarse grained soils:</td>
<td>5 - 12%</td>
</tr>
</tbody>
</table>

**SOIL STRUCTURE**

<table>
<thead>
<tr>
<th>ZONING</th>
<th>CEMENTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layers</td>
<td>Continuous across exposure or sample.</td>
</tr>
<tr>
<td>Lenses</td>
<td>Discontinuous layers of lenticular shape.</td>
</tr>
<tr>
<td>Pockets</td>
<td>Irregular inclusions of different material.</td>
</tr>
<tr>
<td></td>
<td>Weakly cemented</td>
</tr>
<tr>
<td></td>
<td>Moderately cemented</td>
</tr>
</tbody>
</table>

**GEOLOGICAL ORIGIN**

**WEATHERED IN PLACE SOILS**

- Extremely weathered material
  Structure and fabric of parent rock visible.
- Residual soil
  Structure and fabric of parent rock not visible.

**TRANSPORTED SOILS**

- Aeolian soil
  Deposited by wind.
- Alluvial soil
  Deposited by streams and rivers.
- Colluvial soil
  Deposited on slopes (transported downslope by gravity).
- Fill
  Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
- Lacustrine soil
  Deposited by lakes.
- Marine soil
  Deposited in ocean basins, bays, beaches and estuaries.
## Soil Description Explanation Sheet (2 of 2)

### Soil Classification Including Identification and Description

#### Field Identification Procedures

<table>
<thead>
<tr>
<th>Field Identification Procedures</th>
<th>USC</th>
<th>Primary Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse Grained Soils (More than 50% of material &lt; 63 mm)</td>
<td>Wide range in grain size and substantial amounts of all intermediate particle sizes</td>
<td>GW</td>
</tr>
<tr>
<td>Predominantly one size or a range of sizes with more intermediate sizes missing.</td>
<td>GP</td>
<td>GRAVEL</td>
</tr>
<tr>
<td>Coarse Grained Soils (More than 50% of material &lt; 63 mm)</td>
<td>Non-plastic fines (for identification procedures see ML below)</td>
<td>GM</td>
</tr>
<tr>
<td>Plastic fines (for identification procedures see CL below)</td>
<td>GC</td>
<td>CLAYEY GRAVEL</td>
</tr>
<tr>
<td>Fine Grained Soils (Material &lt; 2.36 mm)</td>
<td>Wide range in grain sizes and substantial amounts of all intermediate sizes</td>
<td>SW</td>
</tr>
<tr>
<td>Predominantly one size or a range of sizes with some intermediate sizes missing.</td>
<td>SP</td>
<td>SAND</td>
</tr>
<tr>
<td>Identifications Procedures on Fractions &lt; 0.2 mm.</td>
<td>Non-plastic fines (for identification procedures see ML below).</td>
<td>SM</td>
</tr>
<tr>
<td>Plastic fines (for identification procedures see CL below).</td>
<td>SC</td>
<td>CLAYEY SAND</td>
</tr>
</tbody>
</table>

#### Highly Organic Soils

- Readily identified by colour, odour, spongy feel and frequently by fibrous texture.

**Common Defects in Soil**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTING</td>
<td>A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.</td>
<td><img src="image_url" alt="SOFTENED ZONE" /></td>
</tr>
<tr>
<td>JOINT</td>
<td>A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term ‘fissure’ may be used for irregular joints &lt;0.2 m in length.</td>
<td><img src="image_url" alt="TUBE" /></td>
</tr>
<tr>
<td>SHEARED ZONE</td>
<td>Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.</td>
<td><img src="image_url" alt="TUBE CAST" /></td>
</tr>
<tr>
<td>SHEARED SURFACE</td>
<td>A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.</td>
<td><img src="image_url" alt="INFILLED SEAM" /></td>
</tr>
</tbody>
</table>

- Low plasticity – Liquid Limit w_L less than 35%.
- Medium plasticity – w_L between 35% and 50%.
- High plasticity – w_L greater than 50%.
The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

**DEFINITIONS:**
- **Rock Substance:** Rock substance, defect and mass are defined as follows:
  - In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
  - Discontinuity or break in the continuity of a substance or substances.

- **Defect:** Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

**SUBSTANCE DESCRIPTIVE TERMS:**

<table>
<thead>
<tr>
<th>ROCK NAME</th>
<th>PARTICLE SIZE</th>
<th>FABRIC</th>
<th>CLASSIFICATION OF WEATHERING PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Term</td>
</tr>
<tr>
<td>Residual Soil</td>
<td>Coarse grained</td>
<td>Massive</td>
<td>Residual</td>
</tr>
<tr>
<td>Extremely Weathered Material</td>
<td>Medium grained</td>
<td>Indistinct</td>
<td>Extremely</td>
</tr>
<tr>
<td></td>
<td>Fine grained</td>
<td>Distinct</td>
<td>Highly Weathered Rock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderately Weathered Rock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Slightly Weathered Rock</td>
</tr>
<tr>
<td>Fresh Rock</td>
<td></td>
<td></td>
<td>Fresh Rock</td>
</tr>
</tbody>
</table>

**Notes on Rock Substance Strength:**
1. In anisotropic rocks the field guide to strength applies to the strength perpendicularly to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index I_{500}. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

**Notes on Weathering:**
1. AS1726 suggests the term “Distinctly Weathered” (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW and it is judged that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term “altered” may be substituted for “weathering” to give the abbreviations KA, HA, MA, SA and DA.
### COMMON DEFECTS IN ROCK MASSES

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Diagram</th>
<th>Map Symbol</th>
<th>Graphic Log (Note 1)</th>
<th>DEFECT SHAPE</th>
<th>TERMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parting</td>
<td>A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.</td>
<td><img src="20.png" alt="Diagram" /></td>
<td><img src="20.png" alt="Bedding Cleavage" /></td>
<td>![Analytic Log](Note 2)</td>
<td>Planar</td>
<td>The defect does not vary in orientation</td>
</tr>
<tr>
<td>Joint</td>
<td>A surface or crack across which the rock has little or no tensile strength, but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.</td>
<td><img src="20.png" alt="Diagram" /></td>
<td><img src="20.png" alt="Joint" /></td>
<td>![Analytic Log](Note 2)</td>
<td>Planar</td>
<td>Curved: The defect has a gradual change in orientation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Undulating: The defect has a wavy surface</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>Stepped: The defect has one or more well defined steps</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Irregular: The defect has many sharp changes of orientation</td>
</tr>
<tr>
<td>Sheared Zone (Note 3)</td>
<td>Zone of rock substance with roughly parallel or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.</td>
<td><img src="35.png" alt="Diagram" /></td>
<td><img src="35.png" alt="Sheared Zone" /></td>
<td>![Analytic Log](Note 2)</td>
<td>Planar</td>
<td></td>
</tr>
<tr>
<td>Sheared Surface (Note 3)</td>
<td>A near planar, curved or undulating surface which is usually smooth, polished or slickensided.</td>
<td><img src="40.png" alt="Diagram" /></td>
<td><img src="40.png" alt="Sheared Surface" /></td>
<td>![Analytic Log](Note 2)</td>
<td>Planar</td>
<td></td>
</tr>
<tr>
<td>Crushed Seam (Note 3)</td>
<td>Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.</td>
<td><img src="50.png" alt="Diagram" /></td>
<td><img src="50.png" alt="Crushed Seam" /></td>
<td>![Analytic Log](Note 2)</td>
<td>Planar</td>
<td></td>
</tr>
<tr>
<td>Infilled Seam</td>
<td>Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.</td>
<td><img src="65.png" alt="Diagram" /></td>
<td><img src="65.png" alt="Infilled Seam" /></td>
<td>![Analytic Log](Note 2)</td>
<td>Planar</td>
<td></td>
</tr>
<tr>
<td>Extremely Weathered Seam</td>
<td>Seam of soil substance, often with gradational boundaries. Formed by weathering of the rock substance in place.</td>
<td><img src="32.png" alt="Diagram" /></td>
<td><img src="32.png" alt="Extremely Weathered Seam" /></td>
<td>![Analytic Log](Note 2)</td>
<td>Planar</td>
<td></td>
</tr>
</tbody>
</table>

**Notes on Defects:**

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

**ROUGHNESS TERMS**

- **Slickensided:** Grooved or striated surface, usually polished
- **Polished:** Shiny smooth surface
- **Smooth:** Smooth to touch. Few or no surface irregularities
- **Rough:** Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
- **Very Rough:** Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

**COATING TERMS**

- **Clean:** No visible coating
- **Stained:** No visible coating but surfaces are discoloured
- **Veneer:** A visible coating of soil or mineral, too thin to measure; may be patchy
- **Coating:** A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

**BLOCK SHAPE TERMS**

- **Blocky:** Approximately equidimensional
- **Tabular:** Thickness much less than length or width
- **Columnar:** Height much greater than cross section