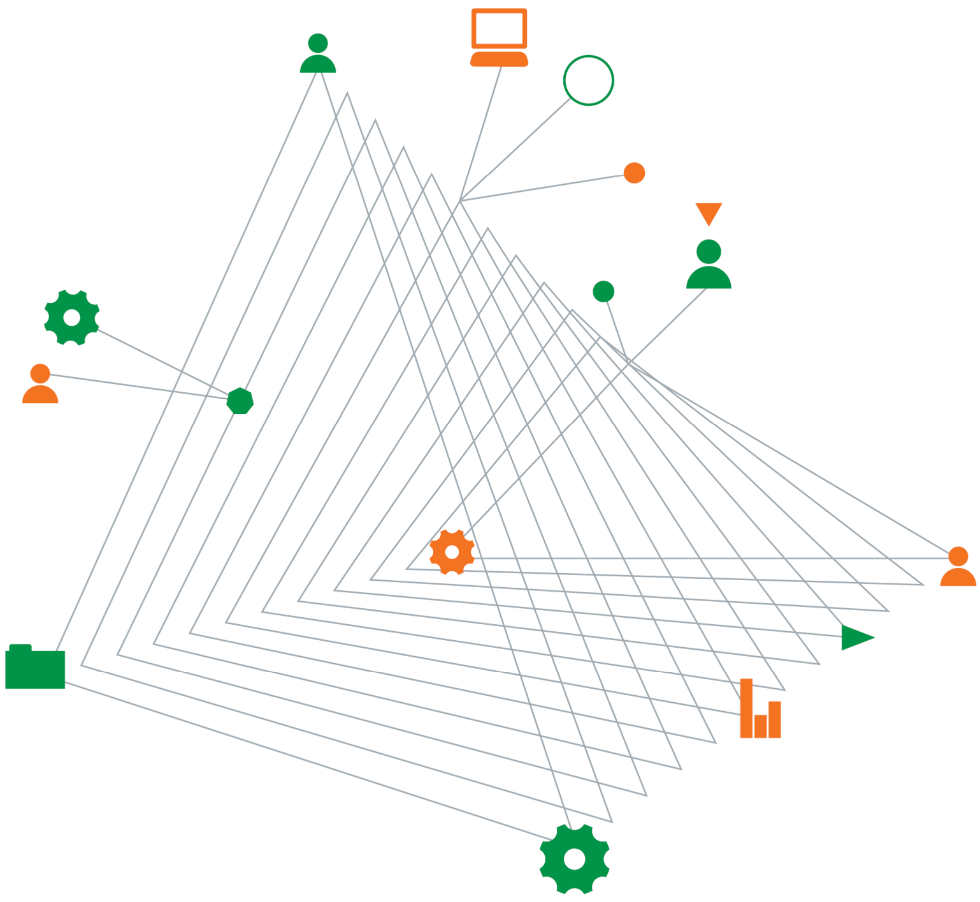
Wenona School

Wenona Archimedes Building

Geotechnical Investigation

29 April 2015



Experience
comes to life
when it is
powered by
expertise

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Wenona Archimedes Building

Prepared for
Wenona School
c/o APP Corporation Pty Ltd
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North Sydney NSW 2060

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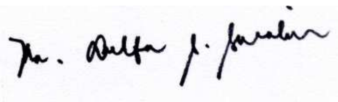
29 April 2015

Document authorisation

Our ref: GEOTLCOV25333AA-AC

For and on behalf of Coffey



Delfa Sarabia
Senior Geotechnical Engineer

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
Rev 0	Original Issue	24.4.2015	DS	RT	DS
Rev 1	Minor edits	29.4.2015	DS	RT	DS

Distribution

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Rev 0	1	PDF	Hugh Irving - APP Corporation Pty Ltd Mark Ellerington, Richard Green – Taylor Thomson Whitting (NSW) Pty Ltd	24.4.2015
Rev 1	1	PDF	Hugh Irving - APP Corporation Pty Ltd Mark Ellerington, Richard Green – Taylor Thomson Whitting (NSW) Pty Ltd	29.4.2015

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1. Introduction

This report presents the results of a geotechnical investigation carried out by Coffey Geotechnics Pty Ltd (Coffey) for the proposed Wenona Archimedes Building to be located at 255-265 Miller Street North Sydney. The investigation was carried out within the main part of the development at 263-265 Miller Street. The investigation was commissioned by APP Corporation Pty Ltd on belhalf of Wenona School and carried out in general accordance with our proposal (Ref: GEOTLCOV25333AA-AA, dated 27 February 2015).

The proposed development will involve the demolition of existing structures and the construction of of a three storey mixed-use (sport/pool/recreation and education) building over two to four level basement. The design floor level for the lowest basement level is RL 73.5 m AHD, requiring excavation of approximately 11 m depth on the Miller Street site boundary, and about 6 m depth at the Elliott Street site boundary.

The objective of this investigation is to provide geotechnical data to support the design of the proposed structure.

In conjunction with the geotechnical investigation, a Phase 1 Contamination Assessment was also carried out by Coffey and the results are presented in a separate report.

2. Method of investigation

2.1. Borehole drilling

Fieldwork for the geotechnical investigation was carried out on 15-16 April 2015 and comprised the drilling of 2 boreholes (BH1 and BH2). BH1 along Miller Street side was drilled to 16 m below the existing ground surface and BH2 along Elliott Street was drilled to 11 m below the existing ground surface. The borehole locations were measured relative to existing site features and the reduced levels were interpolated from supplied survey drawing. Figure 1 shows the approximate borehole locations.

The boreholes were drilled using a limited access, rubber track mounted, XC drill rig and were advanced using diatube in pavement and using solid flight augers with a Tungsten Carbide (TC) drill in soil. Standard Penetration Tests (SPT) was carried out at selected intervals to assess soil strength and to obtain samples for logging. Rock was cored to target depth, using NMLC coring techniques. Rock core was boxed on site, photographed and transported to our laboratory for strength testing.

On completion, BH1 was backfilled to the ground surface and BH2 was backfilled with concrete plug on the surface. Fieldwork was observed by a Coffey Geotechnical Engineer who was present throughout the drilling operations to undertake sampling and testing, record test results, photograph rock cores, and log materials encountered.

2.2. Geological mapping

In addition to borehole drilling, geological observation and mapping were conducted to map the exposed rock faces within the basement of the adjacent school building at 255 Miller Street to the south of the site.

The approximate location of these rock faces is shown in Figure 1.

2.3. Laboratory testing

Point Load Strength Index tests were carried out on rock cores at approximately 1m intervals.

3. Results of investigation

3.1. Site description

The site is rectangular in shape, about 20 m wide (north to south) and 53 m long (west to east). The site is bounded by Miller Street to the west, two to five storey apartment building to the north, Elliott Street to the east and 3 storey school building to the south.

At the time of our investigation, the site was occupied by the following structures:

- One to two storey child care building and a single storey garage (263 Miller Street); and
- Three storey school building (265 Miller Street).

The ground surface falls from west to east with difference in elevation of about 5 m.

3.2. Local geology and previous investigation

The Sydney 1:100,000 Geological Sheet indicates that the site is underlain by Hawkesbury Sandstone described as medium to coarse grained quartz sandstone with very minor shale and laminite lenses.

Available geotechnical information in the site vicinity includes Coffey geotechnical investigation on the adjacent apartment building (267-269 Miller Street) and investigation done by others on the adjacent school building (245-261 Miller Street). These previous investigations encountered subsurface conditions of varying thicknesses of fill and residual soils overlying Hawkesbury Sandstone bedrock.

3.3. Subsurface conditions

The engineering borehole logs and rock core photographs are presented in Appendix A, together with Coffey soil and rock explanation sheets. Interpreted cross section through site (west to east direction) is presented in Figure 2. The section presents that the sandstone steps down the slope. From experience, the dipping of sandstone is typically on a stepped profile rather than on a smooth slope.

Table 1 below shows a summary of the geotechnical conditions encountered in the boreholes and the mapping of the exposed rock face.

Table 1: Inferred Geotechnical Model

Unit	Material/Origin	Description	Approximate Thickness[b] (m)	Depth to Top of Unit[b] (m)	RL to Top of Unit[b] (m AHD)
1	Fill[c]	Concrete and Sandy Silt	1.3 – 1.8	Ground surface	79.2 – 84.5
2a	Sandstone Class V[a]	Sandstone, extremely to highly weathered, very low to low strength	1.5 – 2.4	1.3 – 1.8	75.9 – 80.8
2b	Sandstone Class IV[a]	Sandstone, moderately weathered to fresh, medium strength on upper 1 m to 2 m but low to medium strength below, some high strength bands in iron indurated zones.	2.4 – 4.6	3.3 – 3.7	75.9 – 80.8
2c	Sandstone Class III[a] or better	Sandstone, moderately weathered to fresh, medium to high strength	Not Penetrated	5.7 – 8.3	73.5 – 76.2

Notes:

a) Rock classified as sandstone in accordance with Pells et al (1998) "Foundations on Sandstone and Shale in the Sydney Region" Aust. Geomech. Jnl, Dec 1998. This is a rock mass classification and stonger or weaker bands may occur.

b) The depth/RL and layer thicknesses provided in the above table are based on subsurface conditions observed at the borehole locations and may not be representative of all areas of the site.

c) Residual soil was encountered in the boreholes drilled for the adjacent sites. For this site, residual soil was not encountered in the boreholes drilled. There may be a possibility that residual soil is present on site. We expect that residual soil layer is relatively thin and design parameters for Unit 1 Fill presented below can be used for the residual soil layer.

3.4. Mapping of the exposed rock faces

Appendix B presents photographs of the exposed rock faces observed within basement of the adjacent school building. The photographs were sequenced from the eastern end of the northern wall to the eastern end of the exposed rock at the southern wall.

The northern and western walls are retained by a soldier pile wall with sandstone bedrock exposed between piles. The southern wall is a vertical cut sandstone.

The exposed sandstone is typically fine to coarse grained, slightly weathered to fresh, low to medium strength, usually cross bedded. Overall the bedding ranges from sub-horizontal to an apparent dip to south approximately 10-20°. Exposed rock surfaces h ave become oxidised and discoloured. Seepage staining and roots attached to rock surfaces were observed at the northern and western walls and also at the south western corner. The north western and south western corners are damp/wet from seepage. The southern wall is generally dry. Sandstone erosion was observed at the southern wall.

The exposed sandstone is similar to the rock encountered in BH1 which is classified as Class IV sandstone.

3.5. Groundwater

Groundwater was not able to be measured during the investigation as water was used as drilling fluid while coring the rock.

As discussed above groundwater seepages were observed in the adjacent basement specifically at the north western and south western corner of the basement. Bedrock seepage in sandstone typically occurs along sub-horizontal bedding planes and sub-vertical joints. Groundwater seepage could also be expected at the base of fill and the soil/rock interface.

3.6. Laboratory testing results

The Point Load Strength Index test results are included in the respective borehole logs in Appendix A.

4. Discussions and recommendations

4.1. Excavation conditions

Based on excavation level of RL 73.5 m AHD, excavations will penetrate through Unit 1 Fill and into Units 2a to 2b Sandstone Class V and IV and will be terminated within Unit 2c Sandstone Class III or better.

Unit 1 Fill and Unit 2a Sandstone Class V should be readily excavated using conventional earthmoving plant such as a large excavator. High powered excavation plant fitted with rippers and rock breakers would typically be required for the excavations in Units 2b to 2c, medium to high strength sandstone. Rotary rock grinder or rock saw attachments to the hydraulic excavator may be required to avoid both over break and excessive vibrations below shoring and adjacent to vibration sensitive structures.

Excavation contractors should be provided with the core logs and photographs and be required to make their own assessment of the suitability and productivity of particular excavation plant.

4.2. Groundwater consideration

Groundwater seepages were observed in the adjacent basement. Groundwater inflow may occur at the soil/bedrock interface and in rock defects such as joints, bedding planes and weathered seams. We would anticipate that seepage into open excavations should be able to be controlled by pumping from sumps.

In the long term, seepage will occur and provision will need to be made for permanent and effective drainage unless retaining walls and floor slabs are designed to resist hydrostatic pressures. Drainage systems should be designed to allow for access to flushing to remove chemical deposits that may build up over time.

Permission from the relevant authorities will be required to discharge water collected in basements and may require chemical analysis to determine whether treatment is required.

4.3. Excavation support

4.3.1. General

The proposed excavation footprint will extend to site boundaries. Excavations in Unit 1 Fill and Units 2a Sandstone Class V would require support and is discussed below.

The underlying Unit 2b and 2c Sandstone Class IV and III or better should be able to be cut vertically. However, if adverse jointing or weathering is encountered support in the form of rock bolts to support individual blocks, and possibly where poor rock is present, mesh and shotcrete may be required. Typically the requirement for such support measures would be assessed as excavation progresses and joint and bedding defects and orientations are exposed. An experienced geotechnical engineer/engineering geologist should carry out regular visits as excavation progresses (at least every 2 m depth of excavation).

It should be noted that in the adjacent basement, the Unit 2b Sandstone Class IV was supported by soldier piles on two sides of the basement wall (northern and western) but unsupported on the southern wall. We understand that it is proposed to create a sandstone wall feature in the proposed basement. This appears to be feasible. However, erosion and staining of the existing exposed sandstone in adjacent basement should be noted. If adverse jointing are also present bolts, mesh and shotcrete will be required to be installed on the face of the sandstone.

4.3.2. Shoring

Shoring will be required to support Units 1 and 2a. Shoring systems that could be considered for the site include:

- soldier piles with steel walers and shotcrete and mesh infill panels;
- semi-contiguous piles spaced to avoid the need for walers or infill panels;
- contiguous piles.

Piles for these types of walls should be socketed and/or anchored at toe level into Unit 2b to provide toe stability to the wall. Piles will have to be specifically sized and designed to support adjacent structures that surcharge the wall. Depending on the retained height and surcharge, anchors installed progressively as excavation proceeds may be required for lateral stability.

Table 2 provides parameters for retaining wall design

Table 2: Earth Pressure Coefficients for Retaining Wall Design

Geotechnical Unit	Bulk Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Effective Friction Angle	Active Earth Pressure Coefficient (Ka)	At Rest Earth Pressure Coefficient (K_0)	Passive Earth Pressure Coefficient (Kp)
Unit 1 Fill	18	0	25	0.4	0.5	2.5
Unit 2a Sandstone Class V	23	30	35	0.27	0.5	3.7

Notes: Ka and Kp values apply for a horizontal ground surface.

K_0 are modified K_0 rather than in-situ K_0 values, assuming that at least a small amount of wall movement (say about 0.1 to 0.3% of the wall height) occur. In-situ K_0 values may be significantly higher, particularly in weathered rock units. If in-situ K_0 values are required for detailed soil-structure analysis, specific testing should be carried out.

Retaining structures should be designed for hydrostatic water pressures, unless effective drainage is provided behind the retaining structures.

If temporary rock anchors are required they should be inclined downwards to anchor into more competent sandstone. The working bond stresses in Table 3 can be adopted for anchors with the provision that bond lengths are between 3 m and 7 m and anchors are to be proof loaded to at least 1.4 times their design working load.

Table 3: Recommended Anchor Bond Stresses

Unit	Allowable (Working) Bond Stress (kPa)
Unit 2b – Sandstone Class IV	200
Unit 2c – Sandstone Class III	500

Anchor designs should be based on allowing effective bonding to be developed behind an ‘active zone’ determined by drawing a line at 45^{o} from the base of the soldier pile to intersect the ground surface behind the excavated face.

The permission of adjacent landowners will be required to install support such as rock anchors and rock bolts, where the support extends beyond site boundaries.

4.4. Potential impacts on adjacent structure/services

The proposed development is surrounded by buildings. These existing structures should be taken into account when planning and designing the proposed structures.

In order to adequately assess potential risks to adjacent structures arising from excavation for the proposed basements, the following will need to be assessed prior to formulation of excavation and construction methodology:

- Size, location and nature (including basement construction) of the existing adjacent structures and whether these are likely to be affected by vertical or lateral ground movement as a result of the proposed basement excavation.
- Location depth and nature of any existing services immediately behind the basement perimeter.

Appropriate investigation, design, and monitoring is required to assess the footings of existing adjacent structures and services and to protect them from adverse impacts from loss of support due to excavation ground movements arising from excavation and vibrations due to excavation plant. To manage the risks to adjacent structures and services consideration to retention systems and excavation methods would need to be explored.

We recommend that prior to the commencement of the bulk excavation works dilapidation surveys of the adjacent structures be carried out to provide a baseline for excavation monitoring and management works.

4.5. Excavation induced ground movements

The proposed excavation could induce ground movements due to removal of lateral support including stress relief. Within the retained soil and weathered rock profile, the magnitude of adjacent ground movements will depend on the ground conditions, design lateral pressure, shoring system adopted, construction sequence and workmanship. Documented data has shown that for well-constructed shoring, vertical and lateral movements in soils and Class V rock may be in the order of 0.1% to 0.3% of the retained height. If this aspect is critical, numerical analysis should be carried out to assess likely ground movements when designing the shoring system.

Based on experience of deep basements in Sydney, typical lateral movements due to excavation in Class IV or better rock (i.e. stress relief) are of the order of 0.5 mm to 2 mm per metre of excavation, depending on rock quality and presence of bedding seams. Lateral ground movements due to stress relief have been observed extending to 1.5 to 2 times the basement depth from the edge of excavations. Stress relief ground movements are unlikely to be significant at distances greater than twice the excavation depth. The potentially damaging effects of stress redistribution on structures in the vicinity of the proposed basement excavation should be assessed as part of the detailed design process. Empirical data and observations suggest that most of the movement would occur shortly after excavation completion.

Where it is important to limit adjacent ground movements due to the presence of nearby structures supported on high level footings, the use of a relatively stiff shoring with bracing and/or tie-back anchors designed to resist higher than active earth pressures may be required. We suggest that such cases be specifically addressed during detailed design when details of adjacent footings and loadings are known.

4.6. Vibrations

The use of hydraulic rock breakers for bulk and detail excavation may cause vibrations that could affect any nearby sensitive structures and services. Rotary rock saws may be required limit excessive vibrations and overbreak.

The vibration limits in Table 4 are commonly recommended in Sydney to reduce the risk of vibration damage to sensitive receptors.

Table 4: Ground Vibration Limits for Various Types of Structures

Type of Structure	Peak Particle Velocity (mm/s)
Historic buildings or monuments	2
Residential or low rise buildings in good condition	10
Reinforced concrete commercial and industrial buildings in good condition	25

Dilapidation surveys should be carried out on neighbouring structures or sensitive services prior to commencing excavation. Vibration trials should be carried out to assess appropriate distances for the plant to be used on site to limit vibrations. Vibration monitoring should continue during site works to confirm that the limits are not exceeded.

To control damage it is recommended that the limit is specifically selected considering the structure of concern. It should be noted that limits set by the relevant authorities may override these recommendations.

4.7. Foundations

It is expected that excavation to 73.5 m AHD will expose Unit 2c Sandstone Class III or better. For preliminary design, pad or strip footings with nominal embedment of 0.3 m into Sandstone Class III may be designed for an allowable (serviceability) bearing pressure of up to 6,000 kPa. For this bearing pressure, settlements should be less than 1% of the least footing width.

Rock quality should be assessed during construction to verify that rock quality is consistent with design assumptions. To adopt the above allowable bearing pressure, allowance should be made for a geotechnical engineer to observe footing excavations and to carry out spoon testing in a sufficient number of footings to confirm rock classifications. Allowance should be made initially for spoon testing at one third of pad footings, to be reviewed once footing layouts and exposed rock quality can be assessed. Alternatively, design pressures may need to be downgraded if a lesser amount of verification is specified.

4.8. Seismic Design Parameter

Based on AS 1170.4 – 2007, the Earthquake Hazard Factor, Z, for the Sydney region is 0.08. The site is generally classified as Sub-Soil Class Be - Rock Site (based on rock with compressive strengths of 1 MPa to 50 MPa).

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

5. Safe Design

Coffey's input to date has included provision of geotechnical design advice in accordance with industry practice, relevant Codes of Practice and Standards. There remain design and construction risks associated with unforeseen ground conditions, variations in actual conditions to those adopted for design, and implementation of the design during construction and maintenance that should be considered by you in conjunction with your designer and other parties. The guidance for effective safe design outcomes is provided in the model Codes of Practice for Safe Design of Structures and Safe Design, Manufacture Import and Supply of Plant. These codes were developed with the close involvement of Consult Australia, the industry association for professional services firms in the built environment sector.

Coffey is happy to contribute in addressing the Safe Design requirements for this project and can meet with you, your designers and any other relevant party to confirm that geotechnical aspects are satisfactorily addressed in the Safe Design process in collaboration with those who have expertise in construction safety.

6. Limitations

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 verify that 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

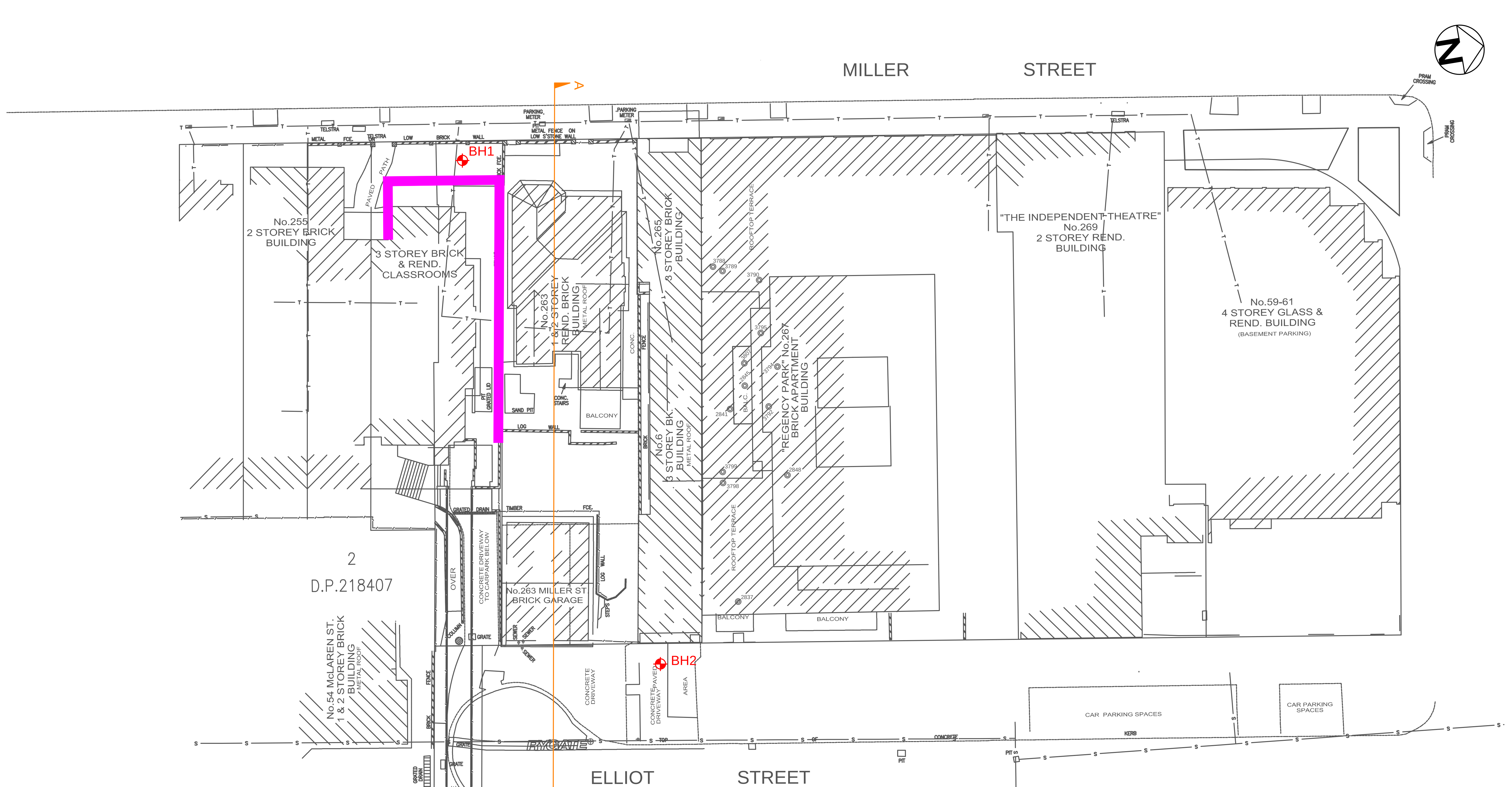
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As 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



LEGEND

- APPROXIMATE BOREHOLE LOCATION
- SECTION LINE
- MAPPED EXPOSED ROCK FACE IN THE BASEMENT

5 0 5 10 15 20

Horizontal Scale (metres) 1:400

revision

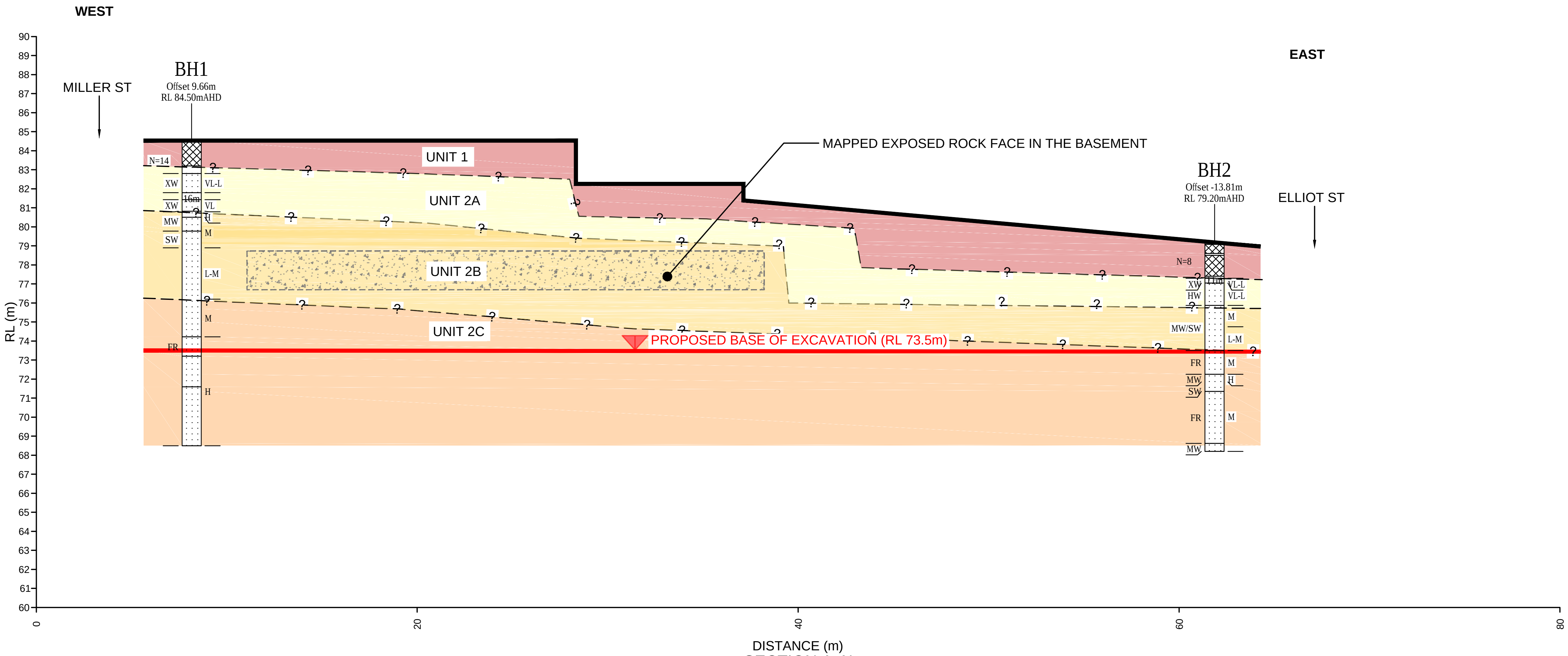
no.	description	drawn	approved	date
A	ORIGINAL ISSUE			

drawn	DS / JP
approved	DS
date	20 / 04 / 2015
scale	AS SHOWN
original size	A3

coffey

client:	WENONA SCHOOL
project:	WENONA ARCHIMEDES BUILDING 263-265 MILLER STREET NORTH SYDNEY
title:	BOREHOLE LOCATION PLAN
project no:	GEOTLCOV25333AA
figure no:	FIGURE 1
rev:	A

PLOT DATE: 24/04/2015 1:45:40 PM DWG FILE: F:\GEOTECHNICS\1 PROJECTS\GEOTLCOV253\GEOTLCOV25333AA WENONA ARCHIMEDES BUILDING\CAD\GEOTLCOV25333AA.DWG



SECTION A-A'

LEGEND

FILL					UNIT 1 - FILL
SANDSTONE	IV	ROCK CLASSIFICATION (PELLS ET AL, 1998)			UNIT 2A - SANDSTONE CLASS V
NO CORE	DX	SANDSTONE, FINE, FINE TO MEDIUM GRAINED			UNIT 2B - SANDSTONE CLASS IV
CONCRETE	N*=17	STANDARD PENETRATION TEST RESULT			UNIT 2C - SANDSTONE CLASS III OR BETTER
SANDY SILT					

revision

no.	description	drawn	approved	date
A	ORIGINAL ISSUE			

2.5 0 5 10
Horizontal Scale (metres) 1:250

2.5 0 5 10
Vertical Scale (metres) 1:250

drawn	DS / JP
approved	DS
date	20 / 04 / 2015
scale	AS SHOWN
original size	A3

coffey

client:	WENONA SCHOOL
project:	WENONA ARCHIMEDES BUILDING 263-265 MILLER STREET NORTH SYDNEY
title:	SECTION A-A'
project no:	GEOTLCOV25333AA
figure no:	FIGURE 2
rev:	A

Appendix A - Engineering Borehole Logs, Core Photographs and Explanation Sheets

coffey

Engineering Log - Borehole

Borehole ID.	**BH1**
sheet:	1 of 3
project no.	**GEOTLCOV25333AA**

client:	***Wenona School***	date started:	***15 Apr 2015***
principal:		date completed:	***15 Apr 2015***
project:	***Wenona Archimedes Building***	logged by:	***IL***
location:	***263-265 Miller Street North Sydney***	checked by:	***DS***

position: E: 334182; N: 6254822 (WGS84 Zone 56) surface elevation: 84.50 m (AHD) angle from horizontal: 90°

drill model: XC DRILL, Track mounted hole diameter : 100 mm

drilling information / **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
AD/V, CASING		Not Observed		84				**FILL: Sandy SILT**: low liquid limit, black to brown, fine grained sand, some fine grained, subangular gravels, trace rootlets. 0.4 m: some cobbles 0.5 m: tree root 0.8 m: becoming less sand and gravels	M			**FILL**
			SPT 1, 4, 10 N=14		1.0							
				83				**SANDSTONE**: fine grained, yellow-brown / red-brown / pale grey, extremely weathered, very low strength.				**WEATHERED BEDROCK**
								Borehole BH1 continued as cored hole				
					2.0							
				82								
					3.0							
				81								
					4.0							
				80								
					5.0							
				79								
					6.0							
				78								
					7.0							
				77								

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED GEOTLCOV25333AA.GPJ <<DrawingFile>> 23/04/2015 15:35

method
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore

* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud N nil
C casing

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

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

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Engineering Log - Cored Borehole

Borehole ID.	**BH1**
sheet:	2 of 3
project no.	**GEOTLCOV25333AA**
date started:	**15 Apr 2015**
date completed:	**15 Apr 2015**
logged by:	**IL**
checked by:	**DS**

client: ***Wenona School***
principal:
project: ***Wenona Archimedes Building***
location: ***263-265 Miller Street North Sydney***

position: E: 334182; N: 6254822 (WGS84 Zone 56) surface elevation: 84.50 m (AHD) angle from horizontal: 90°
drill model: XC DRILL, Track mounted drilling fluid: hole diameter : 100 mm

method & support	water	RL (m)	depth (m)	material description (ROCK TYPE: grain characterisics, colour, structure, minor components)	weathering & alteration	samples, field tests & Is(50) (MPa) (a = axial; d = diametral)	core run & RQD	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)
		84, 83	1.0	start coring at 1.70m				
	Not Observed	82	2.0	**SANDSTONE**: fine to coarse grained, pale grey and red-brown, some iron indurated zones, massive.	XW	a=0.04 d=0.20	78%	JT, 40°, PL, RO, CN
			3.0	**NO CORE:** 0.37 m				
		81		**SANDSTONE**: fine to medium grained, pale grey, massive.	XW			PT, 0°, PL, RO, CN
			4.0	**SANDSTONE**: fine to coarse grained, red-brown with some orange, distincly bedded 0-20°.	MW	a=1.58 d=1.26; a=0.85 d=0.34	83%	
		80		**SANDSTONE**: fine to medium grained, red-brown to pale grey, distinctly bedded 0-20°. becoming more coarse grained				SM, 10 - 20°, CL Clay, 25 mm
		79	5.0	**SANDSTONE**: fine to coarse grained, pale grey, distinctly bedded 0-20°.	SW	a=0.72 d=0.59		SM, 10°, CL Clay, 40 mm; SM, 0 - 5°, CL Clay, 110 mm
		78	6.0		FR	a=0.29 d=0.18	93%	SM, 30°, CL Clay, 100 mm
		77	7.0			a=0.11 d=0.10		

CDF_0_9_04BB.GLB Log COF BOREHOLE: CORED GEOTLCOV25333AA.GPJ <<DrawingFile>> 23/04/2015 15:35

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run & RQD
barrel withdrawn
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CS crushed seam
SM seam
DB drilling break

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

coating
CN clean
SN stain
VN veneer
CO coating

coffey

Engineering Log - Cored Borehole

project no. **GEOTLCOV25333AA**

client:	***Wenona School***	date started:	***15 Apr 2015***
principal:		date completed:	***15 Apr 2015***
project:	***Wenona Archimedes Building***	logged by:	***IL***
location:	***263-265 Miller Street North Sydney***	checked by:	***DS***

position: E: 334182; N: 6254822 (WGS84 Zone 56) surface elevation: 84.50 m (AHD) angle from horizontal: 90°
drill model: XC DRILL, Track mounted drilling fluid: hole diameter : 100 mm

drilling information | **material substance** | **rock mass defects**

method & support	water	RL (m)	depth (m)	graphic log	material description ROCK TYPE: grain characterisics, colour, structure, minor components	weathering & alteration	estimated strength & Is50	samples, field tests & Is(50) (MPa)	core run & RQD	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)
	Not Observed	76			**SANDSTONE**: fine to coarse grained, pale grey, distincly bedded 0-20°. *(continued)*	FR		a=0.25 d=0.26	93%	SM, 0 - 5°, CL Clay, 10 mm
		75	9.0					a=0.87 d=0.84		
			10.0					a=1.07 d=0.89	98%	
		74			**SANDSTONE**: fine to medium grained, pale grey, distinctly to indistinctly bedded at 0-15°, trace cabonaceous lenses.					PT, 0°, PL, RO, CN
		73	11.0		**SANDSTONE**: fine to coarse grained, pale grey, distinctly bedded 0-20°, some carbonaceous lenses.			a=2.42 d=1.37		
		72	12.0					a=1.25 d=1.27	99%	PT, 20°, PL, RO, CN PT, 0°, PL, RO, CN
		71	13.0		**SANDSTONE**: fine to coarse grained, pale grey, distinctly bedded at 0-20°, trace cabonaceous flecks.			a=1.85 d=1.44		
		70	14.0					a=1.52 d=1.44		
		69	15.0		15.3 to 15.4 m: carbonaceous lenses			a=1.39 d=1.35	100%	
					Borehole BH1 terminated at 16.00 m Target depth					

Estimated strength scale: VL L M H VH EH; × = axial; ○ = diametral. Samples: a = axial; d = diametral. Defect spacing (mm): 30 100 300 1000 3000.

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run & RQD
barrel withdrawn
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CS crushed seam
SM seam
DB drilling break

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

coating
CN clean
SN stain
VN veneer
CO coating

PointID : BH1 Depth Range: 1.70 - 6.00 m

drawn	DS	coffey	client:	Wenona School
approved	DS		project:	Wenona Archimedes Building 263-265 Miller Street North Sydney
date	22/04/2015		title:	**CORE PHOTOGRAPH BH1**
scale	N.T.S.		project no: GEOTLCOV25333AA	fig no: **FIGURE 1** rev:
original size	A4			

PointID : BH1 Depth Range: 6.00 - 11.00 m

drawn	DS	coffey	client:	Wenona School
approved	DS		project:	Wenona Archimedes Building 263-265 Miller Street North Sydney
date	22/04/2015		title:	**CORE PHOTOGRAPH** **BH1**
scale	N.T.S.		project no: GEOTLCOV25333AA	fig no: **FIGURE 2** rev:
original size	A4			

PointID : BH1 Depth Range: 11.00 - 16.00 m

drawn	DS	coffey	client:	Wenona School
approved	DS		project:	Wenona Archimedes Building 263-265 Miller Street North Sydney
date	22/04/2015		title:	**CORE PHOTOGRAPH** **BH1**
scale	N.T.S.		project no: GEOTLCOV25333AA	fig no: **FIGURE 3** rev:
original size	A4			

coffey

Engineering Log - Borehole

Borehole ID.	**BH2**
sheet:	1 of 3
project no.	**GEOTLCOV25333AA**
date started:	**16 Apr 2015**
date completed:	**16 Apr 2015**
logged by:	**IL**
checked by:	**DS**

client: **Wenona School**

principal:

project: **Wenona Archimedes Building**

location: **263-265 Miller Street North Sydney**

position: E: 334239; N: 6254836 (WGS84 Zone 56) surface elevation: 79.20 m (AHD) angle from horizontal: 90°

drill model: XC DRILL, Track mounted hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE: plasticity or particle characteristic, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	structure and additional observations
AD/V CASING		Not Observed		79				**CONCRETE**: 0.12m.				**FILL**
								FILL: Sandy SILT: low liquid limit, black to brown, fine grained, some fine-coarse grained sub-angular gravels. 0.3 m: concrete rubble	M			
								CONCRETE: 0.10m.				
			SPT 1, 3, 5 N=8	78	1.0			**FILL: Sandy SILT**: low liquid limit, black to brown, becoming brown-orange, some fine-grained, sub angular gravel.	M			
				77	2.0			**SANDSTONE**: fine grained, pale grey-yellow brown, extremely weathered, very low strength.				**WEATHERED BEDROCK**
								Borehole BH2 continued as cored hole				
				76	3.0							
				75	4.0							
				74	5.0							
				73	6.0							
				72	7.0							

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED GEOTLCOV25333AA.GPJ <<DrawingFile>> 23/04/2015 15:35

method
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore
* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud N nil
C casing

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

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

classification symbol & soil description
based on Unified Classification System

moisture
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

Engineering Log - Cored Borehole

Borehole ID.	**BH2**
sheet:	2 of 3
project no.	**GEOTLCOV25333AA**
date started:	**16 Apr 2015**
date completed:	**16 Apr 2015**
logged by:	**IL**
checked by:	**DS**

client: ***Wenona School***

principal:

project: ***Wenona Archimedes Building***

location: ***263-265 Miller Street North Sydney***

position: E: 334239; N: 6254836 (WGS84 Zone 56) | surface elevation: 79.20 m (AHD) | angle from horizontal: 90°

drill model: XC DRILL, Track mounted | drilling fluid: | hole diameter : 100 mm

drilling information | **material substance** | **rock mass defects**

method & support	water	RL (m)	depth (m)	material description — ROCK TYPE: grain characterisics, colour, structure, minor components	weathering & alteration	samples, field tests & Is(50) (MPa) (a = axial; d = diametral)	core run & RQD
		79 – 77.3	0.0 – 1.90	start coring at 1.90m			
NMLC	Not Observed		1.90 – 2.25	**SANDSTONE**: fine to coarse grained, pale grey to brown, massive.	XW		
			2.25 – 3.35	**SANDSTONE**: fine to medium grained, pale grey to red, distinctly to indistinctly bedded at 0-20°, some iron indurated zones.	HW	a=0.07 d=0.06	77%
			3.35 – 5.7	**SANDSTONE**: fine to coarse grained, pale-grey brown with some orange, distinctly bedded at 0-20°, some iron induration and banding.	MW / SW	a=0.51 d=0.43; a=0.23 d=0.24; d=0.22	79%
			5.7 – 6.95	**SANDSTONE**: fine to medium grained, pale grey, distinctly bedded at 0-20°, trace carbonaceous lenses.	FR	a=0.66 d=0.78 a=0.64 d=0.66	
			6.95 – 7.85	**SANDSTONE**: fine to coarse grained, red-brown, massive to indistinctly bedded at 0-20°, some iron induration. becoming pale grey	MW; SW; FR	a=2.33 d=1.61	91%

estimated strength & Is50: × = axial; ○ = diametral; VL L M H VH EH

defect spacing (mm): 30 100 300 1000 3000

additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) — particular / general

- JT, 80°, IR, RO, CN
- PT, 0°, PL, RO, CN
- JT, 40°, PL, RO, CN
- PT, 0°, PL, RO, CN
- JT, 40°, PL - IR, RO, CN
- SM, 5°, PL, RO, Clay, 2 mm
- SM, 25°, PL, RO, Clay, 2 mm
- PT, 20°, PL, RO, CN
- SM, 70°, PL, RO, Clay CO, 15 mm
- JT, 40°, PL, RO, CN
- SM, 5°, PL, RO, Clay, 30 mm
- PT, 20°, PL, RO, Fe SN
- PT, 20°, PL, RO, Fe SN
- PT, 20°, PL, RO, Fe SN
- JT, 0 - 5°, PL, RO, Fe SN
- JT, 0 - 5°, PL, RO, Fe SN
- JT, 0 - 5°, PL, RO, Fe SN - healed
- JT, 0 - 5°, PL, RO, Fe SN - healed
- JT, 0 - 5°, PL, RO, Fe SN - healed
- JT, 0 - 5°, PL, RO, Fe SN - healed
- JT, 0 - 5°, PL, RO, Fe SN - healed
- PT, 5°, PL, RO, Fe SN
- PT, 5°, PL, RO, Fe SN
- SM, 5°, PL, RO, Clay, 7 mm
- PT, 5°, PL, RO, Fe SN
- PT, 0°, PL, RO, Fe SN
- SM, 0 - 5°, PL, RO, Clay, 10 mm
- PT, 5°, PL, RO, CN
- PT, 10°, PL - IR, RO, CN
- JT, 20°, PL, RO, CN
- SM, 0°, PL, RO, Clay, 20 mm
- SM, 0°, PL, RO, Clay, 20 mm
- PT, 5°, PL, RO, Clay CO
- SM, 0°, PL, RO, Clay, 5 mm
- PT, 0°, PL, RO, Fe SN

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL — water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run & RQD
barrel withdrawn
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CS crushed seam
SM seam
DB drilling break

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

coating
CN clean
SN stain
VN veneer
CO coating

coffey

Engineering Log - Cored Borehole

Borehole ID.	**BH2**
sheet:	3 of 3
project no.	**GEOTLCOV25333AA**
date started:	**16 Apr 2015**
date completed:	**16 Apr 2015**
logged by:	**IL**
checked by:	**DS**

client: ***Wenona School***

principal:

project: ***Wenona Archimedes Building***

location: ***263-265 Miller Street North Sydney***

position: E: 334239; N: 6254836 (WGS84 Zone 56) surface elevation: 79.20 m (AHD) angle from horizontal: 90°

drill model: XC DRILL, Track mounted drilling fluid: hole diameter : 100 mm

method & support	water	RL (m)	depth (m)	material description: ROCK TYPE: grain characterisics, colour, structure, minor components	weathering & alteration	samples, field tests & Is(50) (MPa) (a = axial; d = diametral)	core run & RQD	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other)
NMLC	Not Observed	71		**SANDSTONE**: fine to medium grained, pale grey, distinctly bedded at 0-20°, trace carbonaceous lenses. *(continued)*	FR	a=0.80 d=0.79	91%	PT, 20°, PL, RO, CN
		70	9.0			a=0.66 d=0.63		SM, 0°, PL - IR, RO, Clay, 20 mm SM, 0°, PL, RO, Clay, 30 mm SM, 15°, PL - IR, RO, Clay, 5 mm
		69	10.0			a=0.77 d=0.63	100%	PT, 5°, PL, RO, Fe SN SM, 0°, PL, RO, Clay, 70 mm PT, 0°, PL, RO, Fe SN CS, 0°, PL, RO, Clay - Sand, 50 mm
				SANDSTONE: fine to coarse grained, pale grey-red, indistinctly bedded at 0-20°.	MW			
		68	11.0	Borehole BH2 terminated at 11.00 m Target depth				
		67	12.0					
		66	13.0					
		65	14.0					
		64	15.0					

method & support
AS auger screwing
AD auger drilling
CB claw or blade bit
W washbore
NMLC NMLC core (51.9 mm)
NQ wireline core (47.6mm)
HQ wireline core (63.5mm)
PQ wireline core (85.0mm)
SPT standard penetration test

water
10/10/12, water level on date shown
water inflow
complete drilling fluid loss
partial drilling fluid loss
25uL water pressure test result (lugeons) for depth interval shown

graphic log / core recovery
core recovered (graphic symbols indicate material)
no core recovered

core run & RQD
barrel withdrawn
RQD = Rock Quality Designation (%)

weathering & alteration*
RS residual soil
XW extremely weathered
HW highly weathered
DW distinctly weathered
MW moderately weathered
SW slightly weathered
FR fresh
*W replaced with A for alteration

strength
VL very low
L low
M medium
H high
VH very high
EH extremely high

defect type
PT parting
JT joint
SZ shear zone
SS shear surface
CS crushed seam
SM seam
DB drilling break

roughness
SL slickensided
POL polished
SO smooth
RO rough
VR very rough

planarity
PL planar
CU curved
UN undulating
ST stepped
IR Irregular

coating
CN clean
SN stain
VN veneer
CO coating

PointID : BH2 Depth Range: 1.90 - 6.00 m

drawn	DS	coffey	client:	Wenona School	
approved	DS		project:	Wenona Archimedes Building 263-265 Miller Street North Sydney	
date	22/04/2015		title:	**CORE PHOTOGRAPH BH2**	
scale	N.T.S.				
original size	A4		project no: GEOTLCOV25333AA	fig no: **FIGURE 1**	rev:

PointID : BH2 Depth Range: 6.00 - 11.00 m

drawn	DS	coffey	client:	Wenona School		
approved	DS		project:	Wenona Archimedes Building 263-265 Miller Street North Sydney		
date	22/04/2015		title:	**CORE PHOTOGRAPH BH2**		
scale	N.T.S.					
original size	A4		project no: GEOTLCOV25333AA	fig no:	**FIGURE 2**	rev:

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coffey

Soil Description Explanation Sheet (1 of 2)

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

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600 μm
	fine	75 μm to 200 μm

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

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

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

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.

coffey

Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)

(A 0.075 mm particle is about the smallest particle visible to the naked eye)

Soil group	Fraction	Fines	Field identification	USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	GRAVEL
			Predominantly one size or a range of sizes with more intermediate sizes missing.	GP	GRAVEL
		GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	SILTY GRAVEL
			Plastic fines (for identification procedures see CL below)	GC	CLAYEY GRAVEL
	SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes	SW	SAND
			Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).	SM	SILTY SAND
			Plastic fines (for identification procedures see CL below).	SC	CLAYEY SAND

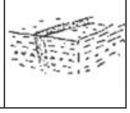
IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.

Soil group	Subgroup	DRY STRENGTH	DILATANCY	TOUGHNESS	USC	PRIMARY NAME
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm	SILTS & CLAYS Liquid limit less than 50	None to Low	Quick to slow	None	ML	SILT
		Medium to High	None	Medium	CL	CLAY
		Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
	SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium	MH	SILT
		High	None	High	CH	CLAY
		Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS		Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	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.	
JOINT	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 <0.2 m in length.	
SHEARED ZONE	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.	
SHEARED SURFACE	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.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance 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.

Defect Discontinuity or break in the continuity of a substance or substances.

Mass 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:

ROCK NAME Simple rock names are used rather than precise geological classification.

PARTICLE SIZE Grain size terms for sandstone are:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm

FABRIC Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:

Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

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 or 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 XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbreviation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular 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 $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

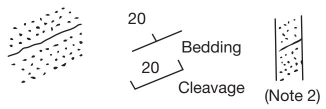
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term | Definition | Diagram | Map Symbol | Graphic Log (Note 1)

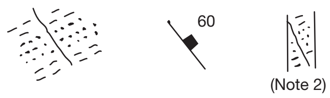
Parting

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.



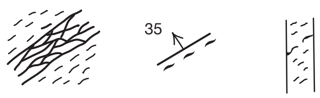
Joint

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.



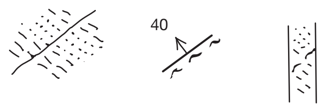
Sheared Zone (Note 3)

Zone of rock substance with roughly parallel near planar, curved 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.



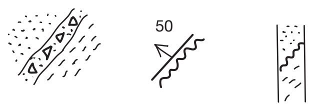
Sheared Surface (Note 3)

A near planar, curved or undulating surface which is usually smooth, polished or slickensided.



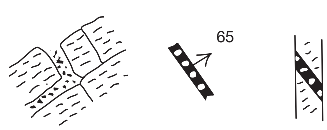
Crushed Seam (Note 3)

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.



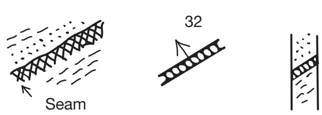
Infilled Seam

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.



Extremely Weathered Seam

Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.



DEFECT SHAPE — TERMS

Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

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 greate than cross section

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.

Appendix B - Exposed Rock Face Photographs

Photo 1: Northern wall east end – 1 of 5

Photo 1: Northern wall – 2 of 5

Photo 3: Northern wall – 3 of 5

Photo 4: Northern wall – 4 of 5

Photo 5: Northern wall near the western end– 5 of 5

Photo 6: Western wall northern end– 1 of 3

Photo 7: Western wall – 2 of 3

Photo 8: Western wall southern end – 3 of 3

Photo 9: Southern wall western end – 1 of 3

Photo 10: Southern wall – 2 of 3

Photo 11: Southern wall eastern end– 3 of 3

Photo 12: Close up of sandstone erosion at the southern wall