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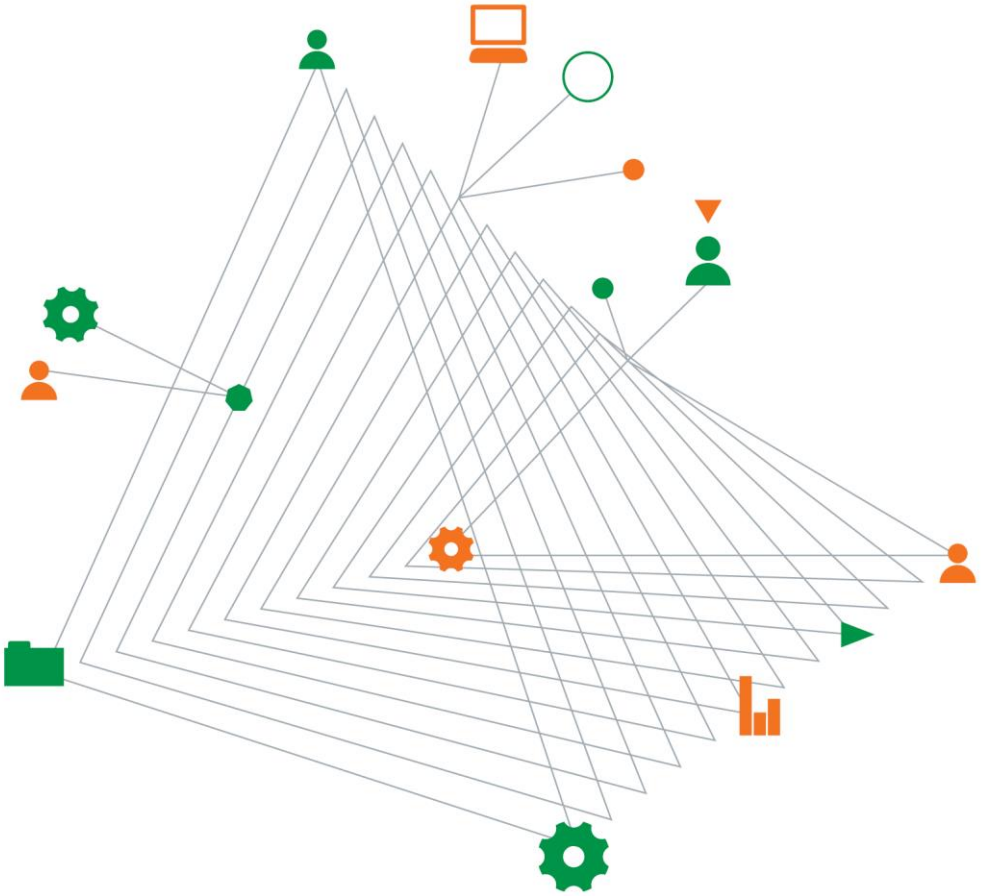
Geotechnical Investigation

Social Sciences & Law Humanities and Arts Building

11 July 2017



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Geotechnical Investigation

Prepared for
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11 July 2017

Attention: University of Wollongong c/o Angela Pavlovic (Donald Cant Watts Corke)

Our ref: 754-WOLGE205371AA-Rev1

Dear Angela,

Coffey Services Australia Pty Ltd (Coffey) is pleased to present this report on Geotechnical investigation in relation to the design of the proposed Social Sciences & Law Humanities and Arts Building at the University of Wollongong.

A Contamination Assessment was undertaken in conjunction with the Geotechnical Investigation and has been reported separately, Ref. 754-WOLGE205371AB.

The attached document titled “Important Information about you Coffey Report” should be read in conjunction with this report.

If you have any questions, please do not hesitate to contact the undersigned.

For and on behalf of Coffey

Jon Thompson CPEng
Principal Geotechnical Engineer

Quality information

Revision history

Revision	Description	Date	Author	Reviewer	Signatory
Rev0	Report	23/06/2017	Michael Biabani	Jon Thompson	Jon Thompson
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1. Introduction

The University of Wollongong (UOW) is proposing to develop the Western Building – Social Sciences & Law Humanities and Arts Building within the Wollongong Campus. The proposed building will be located within the Western Precinct of the Wollongong Campus and opposite building 21 Early Start Facility on the Campus Ring Road. The site currently houses teaching space and general purpose demountable buildings, the majority of which are assigned for relocation prior to this development.

This report presents the results of a geotechnical investigation carried out by Coffey Services Australia (Coffey) for the proposed Social Sciences & Law Humanities and Arts Building.

We understand that the proposed Western Building will include the following:

- A maximum four storey building (plus roof level plant) is identified as allowable on the site in the University's Notional Master Plan for the Campus; and
- A site footprint of approximately 3,500m^2.

2. Objectives

The objectives of the geotechnical investigation were to assess the surface and subsurface conditions over the site and to provide advice and recommendations in relation to the following:

- Confirmation of rock levels, soil conditions and bearing capacities for piles and pad and strip footings;
- Geotechnical design parameters for pile design and / or raft foundation for vertical loads, pile skin friction (both positive and negative), and tension pile;
- An examination of potential site effects under earthquake loading for the proposed development including consideration of appropriate site factors and liquefaction potential;
- Advice on earthworks, excavatability, and on site trafficability after disturbance of the site at excavated levels, including erosion and sediment control guidance;
- Assess shrink / swell characteristics and moisture reactivity classification of soils;
- Groundwater conditions, variability, likely rates of inflow at various depths, and design water table levels;
- Stability criteria for open excavations and advice regarding excavation staging including bench heights. Recommendations for both temporary and permanent batters for various soil and rock strata; and
- Pavement design parameters for proposed vehicle access and provide preliminary pavement designs based on a standard flexible pavement option for the estimated traffic loading.

3. Background information- early start building

Coffey Geotechnics Pty Ltd (Coffey) has carried out a geotechnical investigation for the proposed Early Start Project located opposite the proposed Western Building on the eastern side of the Campus Ring Road at the University of Wollongong. The report documented results of a subsurface investigation, comprising three boreholes CBH01, CBH02 and CBH03 to depths of 10m, 12m and 6.6m respectively. Shallow fill was encountered in boreholes to about 0.5m. The fill was underlain by medium to high plasticity Silty Clay soils to a depth of about 6.70m. Highly to moderately weathered Sandstone was encountered at approximately 7.0m depth. The rock condition at this location is notably different to the rock encountered in the current investigation of the Western Building due to a boundary in the geology occurring between the two sites, with a transition (from east to west) of the Budgong sandstone to the shale and siltstone/claystone/coal/sandstone of the Illawarra Coal Measures.

4. Geotechnical investigation- scope of work

The existing site for the proposed Western Building is predominantly covered by demountable buildings including lecture rooms, storage and carpark pavement. An initial site visit was carried out by a principal environmental engineer and a geotechnical engineer on 22 May 2017 to view the site surface conditions, site access, drilling locations and scan for buried services.

To address the geotechnical investigation objectives outlined above, the scope of work for this investigation included the following:

- Project management, including Dial Before You Dig search and preparation of safety documentation;
- Site observations by a principal geotechnical engineer;
- In conjunction with UOW grounds personnel, an onsite search of buried metallic services based on DBYD and existing underground services provided by UOW, was carried out by an approved services locator;
- Review of relevant existing information and reports of nearby sites;
- Preparation of a safety plan and ESWMS compliant with WHS Act 2011 and environmental management plan. Engaging contractors from our approved suppliers list; and organising Coffey and contractor inductions;
- Subsurface Investigation comprising:
    - Hand augering to a depth of 1.0m where possible to confirm if buried services occurred at the borehole locations. One borehole was abandoned (CBH06) after refusing on concrete or other very dense material as it was thought that the concrete may have been encasing services;
    - Drilling of three (3) deep boreholes (CBH01, CBH03 and CBH04) using a track mounted drilling rig. The boreholes were initially advanced using a tungsten carbide (TC) bit to penetrate through the topsoil/fill, and asphalt/roadbase in the paved area and then continued using a tungsten carbide (TC) bit / hardened steel V bit to refusal on weathered rock at 9.95m, 10.12m and 11.37m in CBH01, CBH03 and CBH04 respectively;
    - At tungsten carbide bit refusal, boreholes CBH01, CBH03 and CBH04 were extended to depths of 15.2m, 17.05m and 16.0m respectively. Rock core was placed in core boxes, photographed and Point Load Strength Index testing was carried out on selected samples of the rock core;
    - Standard Penetration Tests (SPTs) were carried out in the soil profile within the boreholes at regular intervals to check the current soil properties at the test locations;

  - Drilling of one (1) borehole (CBH02) to a maximum depth of 2.95m below existing ground surface to identify fill and upper soil profile and to take sample the soil for chemical testing, shrink-swell index to assess soil reactivity and CBR testing to assist with pavement design;
  - Drilling of three (3) shallow boreholes (CBH05, CBH06 and CBH07) to a maximum depth of 0.8m below existing ground surface to identify the fill and upper soil profile and to take soil samples for chemical testing;
  - On completion of drilling and logging, boreholes were backfilled with cuttings to surface level in grassed areas. In paved areas the boreholes were backfilled with roadbase in the upper 300mm except for the upper 50mm which was covered with coldmix asphalt; and
  - A geotechnical engineer or engineering geologist from Coffey was onsite full time during fieldwork to log the subsurface conditions and direct the fieldwork.

- Laboratory testing of soil samples representative of the subsurface conditions encountered including:

  - Eleven point load tests (Point Load Index Strength Tests) were carried out on selected rock core samples obtained from CBH01, CBH03 and CBH04 to assess rock strength;
  - Two laboratory CBR (California Bearing Ratio) tests were conducted on samples of the material encountered within the upper 0.6m in the shallow boreholes (CBH02 and CBH04), for pavement design purposes;
  - One Atterberg limits test to assess soil reactivity characteristics of the near surface soils; and
  - Chemical testing on two soil samples to assess potential for soil aggressivity to buried concrete or steel structural elements; and

- Provision of a report including the findings of the investigation, discussion of results, and advice and recommendations on the objectives outlined above.

Field activities were performed in general accordance with the procedures outlined in Coffey's Standard Operating Procedures, which are based on accepted industry protocols for geotechnical sampling.

No survey was carried out to record reduced levels of the existing ground surface at the test locations. Sampling locations were located approximately by measurement from existing site features or using hand held GPS. The approximate locations of the boreholes are shown in Figure 1. The engineering logs and core photographs are presented in Appendix A.

5. Results of investigation

5.1. Site surface observations

The site for proposed Social Sciences & Law Humanities and Arts Building is located within the western portion of the University of Wollongong grounds, as shown in Figure 1. The site gradually slopes to the east at approximately 1 to 3 degree and the surrounding land has a similar gently sloping surface. the natural slope of the surrounding area.

The site is currently occupied by several demountable buildings, lecture rooms, and a small parking area. Parts of the site have a mown grass cover. There are many trees over the site including a few large trees with tree roots exposed at the ground surface around some of the trees.

The parking area has a flexible pavement with a thin asphalt wearing course overlying road base. Dense material was encountered below the pavement in the first attempt at drilling in the carpark and this suggests a dense fill material such as slag may be present.

Some local deformation and damage to the asphalt pavement was noted. Pedestrian footpaths constructed of brick pavers occur over parts of the site to provide access to the existing buildings.

The ground surface over the unpaved areas was generally firm under foot with and no obvious wet boggy area or seepages observed on the surface during our fieldwork. However due to rain occurring prior to the fieldwork, some deformation occurred under the drilling rig.

Based on DBYD and existing underground services provided by UOW, there are several buried services within or adjacent to the site, including several electrical cables, sewer and water pipeline occur. Also, a concrete slab was noted on the south-east corners of the site in vicinity of CBH06 and it is possible that this is part of the sewer reticulation.

The following photographs show the existing surface conditions over the site for the proposed development.

Photo 1: View (east to west) of existing carpark located at north-east corner of the site. Drilling rig set up over Borehole CBH01. Access road to western carpark on right side of photo.

Photo 2: View (east to west) of existing carpark located at north-east corner of the site. Note demountable building used for storage and many trees over the site.

Photo 3: View (north to south) of the north-east corner of the site, existing carpark and university ring road.

Photo 4: View (north to south) of the site, adjacent to the western carpark area. Note Pedestrian footpaths constructed of brick pavers.

Photo 5: View (south to north) of the site, adjacent to the university ring road. Note many established trees and demountable building to left.

Photo 6: View (west to east) over southern part of the site. Note many trees including a few large trees.

Photo 7: View (east to west) of the site. Note Pedestrian footpaths constructed of brick pavers.

Photo 8: View (south to north) of the site, adjacent to the University Ring Road.

Photo 9: Existing large tree, located on the west side of the site.

Photo 10: Cracking of the foundation casing of existing demountable buildings.

5.2. Topography

Reference to the 1:25,000 Wollongong Topographic Map second edition (9029-2-S) prepared by the Central Mapping Authority of New South Wales (1989) indicates the site elevation is between 33.5m and 38.5m above Australian Height Datum (AHD). The ground surface over the site falls to the east at about 1 to 3 degrees and is relatively uniform.

The nearest watercourse to the site is a tributary located approximately 100m to the south-southeast of the site which flows into two small bodies of water located 240m south of the site. The nearest major watercourse to the site is Fairy Creek located 550m south of site, which then flows into the Tasman Sea.

5.1. General site geology

The 1:100,000 Wollongong Geological map indicates that the site for the proposed Western Building is mapped as occurring at the boundary of the Illawarra Coal Measures and Quaternary Alluvium overlying the Budgong Sandstone.

The Quaternary Alluvium is described as Alluvium, gravel, swamp, deposits and sand dunes. The geological map also indicates that the underlying bedrock at the Western Building site will likely be the Permian Illawarra Coal Measures group comprising interbedded lithic sandstone, coal, carbonaceous, tuff and chert. The Budgong Sandstone of the Shoalhaven Group is also mapped nearby to the east of this site as occurring below the alluvium, and is described as red, brown and grey volcanic sandstone. The Budgong Sandstone was encountered in the boreholes for The Early Start Building directly to the east of the Western Building.

Based on other geotechnical investigations carried out by Coffey at the University of Wollongong (Main Campus) site, alluvial soil deposits of significant thickness (generally 5m to 10m thickness) overlie rock in the area. The alluvial soil deposits at other locations have been predominantly clayey in nature, stiff in consistency and some gravel bands have been identified within the alluvium.

5.2. Subsurface conditions

The subsurface investigation comprised 6 boreholes, comprising three deep and three shallow boreholes. The general subsurface conditions encountered in boreholes CBH01 to CBH07 are summarised in Table 1. Engineering logs are presented in Appendix A.

The borehole logs and core photos indicate variable weathering of the sandstone/siltstone/coal bedrock from extremely weathered (ie. having soil like properties) to slightly weathered or fresh rock. Rock strength varied from very low to high. Extremely weathered material can occur within zones of highly to moderately weathered rock.

The general subsurface conditions encountered in boreholes CBH01 to CBH07 are summarised as follows:-

Table 1: Summary of subsurface conditions, Boreholes CBH01 to CBH07

Unit	Unit Description	Approximate depth range to top of unit in boreholes (m)	Thickness range of unit (m)
Pavement / Roadbase (Only CBH01)	gravelly Sand, fine to coarse grained sand, fine to coarse angular to sub-angular gravel	Surface to 0.1	0.2 to 0.3
Topsoil/Fill	Clay/silty sand Clay, medium to high plasticity, brown, dark brown, orange mottled, fine to medium sand, trace of rootlets	0.0 to 0.3	0.2 to 0.8
Alluvial	Clay/sandy Clay, medium to high plasticity, brown, orange/grey mottled, fine to medium sand, trace of fine to coarse sub-rounded gravel	0.2 to 1.0	2.7 to 5.5
Residual	sandy Clay, medium plasticity, brown, red/orange mottled, fine to medium sand, trace of fine to coarse sub-angular to sub-rounded gravel	4.5 to 5.8	2.2 to 2.6
Extremely Weathered Material (EW)	Sandy Clay, medium plasticity, grey, brown/orange mottled, trace of fine to medium sub-rounded to sub-angular gravel	7.0 to 8.0	0.5 to 2.3
Extremely to Highly Weathered Material (EW / HW)	Sandy Clay/clayey Sand/Sand, fine to coarse, grey, low to medium plasticity clay, trace of shale	8.25 to 9.8	0.4 to 6.3
Moderately Weathered Rock (MW)	Siltstone/Sandstone, fine to medium grained, grey, dark grey	10.2 to 14.8	1.2 to 3.3
Slightly Weathered to Fresh Rock (SW / Fresh)	Siltstone/Sandstone, fine to medium grained, grey, dark grey	13.5 to 16.0	Unconfirmed – extends to least 15.2m (CBH01), 17.05m (CBH03) and 16.0m (CBH04)

Table 2: Summary of depth ranges for materials encountered in boreholes CBH01 to CBH07

Test site	Depth range of material (m)							
	Pavement / Roadbase	**Topsoil / Fill**	**Alluvial**	**Residual**	**EW material**	**EW / HW material**	**MW rock**	**SW to Fresh rock**
CBH01	0.0 to 0.3 (only CBH01)	0.3 to 1.0	1.0 to 4.9	4.9 to 7.5	7.5 to 9.8	9.8 to 10.2	10.2 to 13.5	13.5 to 15.2*
CBH02	–	0.0 to 0.25	0.25 to 2.95*	–	–	–	–	–
CBH03	–	0.0 to 0.3	0.3 to 5.8	5.8 to 8.0	8.0 to 8.5	8.5 to 14.8	14.8 to 16.0	16.0 to 17.05*
CBH04	–	0.0 to 0.2	0.2 to 4.5	4.5 to 7.0	7.0 to 8.25	8.25 to 12.50	12.5 to 13.9	13.9 to 16.0*
CBH05	–	0.0 to 0.25*	–	–	–	–	–	–
CBH06	–	0.0 to 0.25*	–	–	–	–	–	–
CBH07	–	0.0 to 0.80*	–	–	–	–	–	–

Notes to Table 2: * = End of Borehole

The following Photos 11 to 17 show general views of the borehole locations.

Photo 11: View of the borehole CBH01, drilled using hand auger prior to auger drilling.

Photo 12: Typical alluvial material retrieved from CBH01 at a depth of about 2.0m to 3.0m, showing high plasticity clay.

Photo 13: View of the borehole CBH02. Rigid mattresses used to minimise the damage to the grass.

Photo 14: Drilling of borehole CBH03 in the north-western part of the site.

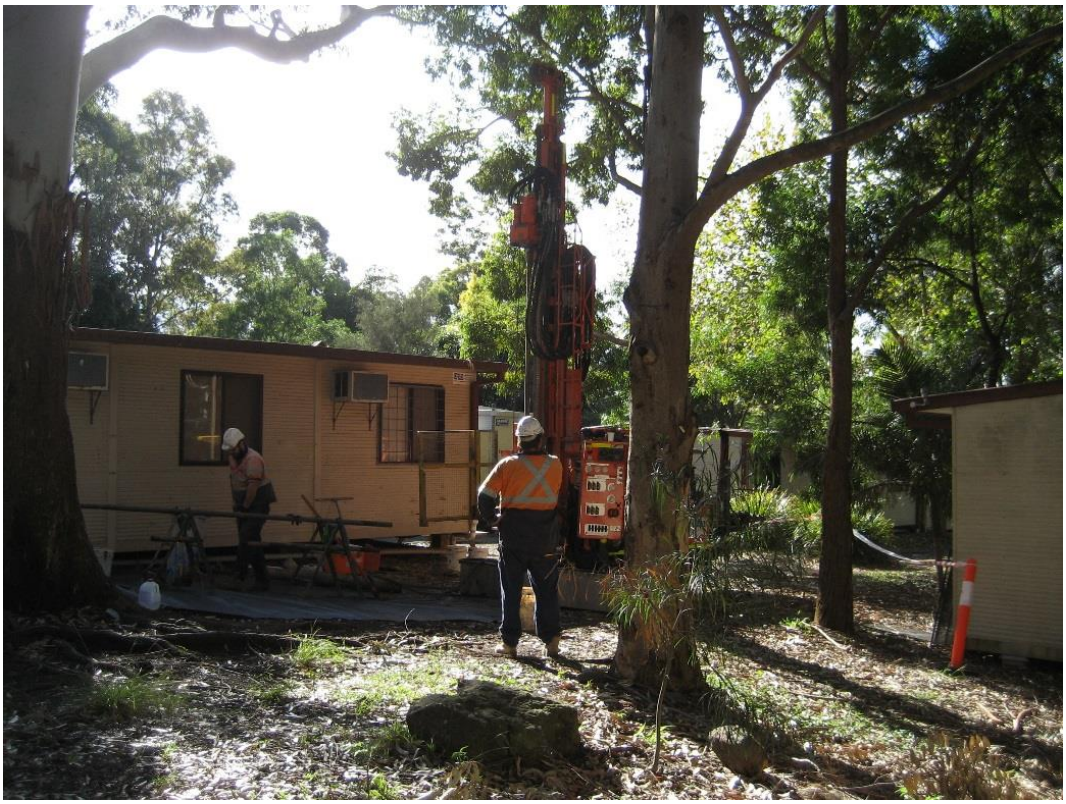


Photo 15: Drilling of borehole CBH04 on the western side of the site.

Photo 16: View of the borehole CBH05. Due to existing several underground services, borehole was drilled only to shallow depth by hand auger.

Photo 17: View of the borehole CBH06 near existing carpark (concrete slab- possible pit). Due to unusual resistance near the ground surface, borehole was drilled only by hand auger and terminated at 0.25m.

5.3. Laboratory test results

Laboratory tests included Point Load Strength Index tests on rock core samples and Atterberg Limits and CBR testing on soil samples.

Point load strength index tests on suitable rock core samples from borehole CBH01, CBH03 and CBH04 were conducted in a Coffey laboratory. The axial and diametral point load strength index results are shown on the borehole logs and in Appendix A.

The point load strength index test results for the rock core samples tested ranged from 0.01 to 2.43 MPa. The point load strength index test provides an index of strength and not a direct strength value. Correlations between Point Load Strength Index and Unconfined Compressive Strength (UCS) are derived statistically for a particular rock type using a number of test results. For the sandstone tested a UCS to point load strength index ratio in the range 10 to 20 would be typical for rock with point load strength index greater than 1.0MPa.

The visual assessment of the rock strength during the borehole drilling indicates RQD (Rock Quality Designation) varied from 0% to 100%. This would suggest that using a ratio of around 14 would be appropriate, therefore the estimated UCS for the rock samples tested ranged from about 0.14MPa UP to 34MPa. The test results indicate the rock encountered in the boreholes ranged from very low to high strength for the samples tested.

Core loss occurred in the rock, indicating very weak, very low strength rock or possible clay seams were encountered during coring.

One sample of the natural clay material below the surface fill was collected from borehole CBH03 and tested in our NATA registered laboratory for Atterberg limits. California Bearing Ratio (CBR) and Standard compaction testing was undertaken on samples of the alluvial clay collected from CBH02 and CBH04.

Testing was carried out at a Coffey NATA registered laboratory. The laboratory test reports are presented in Appendix B. A summary of the laboratory test results is presented in Tables 3 and 4.

Table 3: Summary of laboratory test results- Atterberg Limits

Borehole location and depth of sample	Depth (m)	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)
CBH03	1.05 to 1.75	23	60	37	13.5

The results indicate the clay sample tested is of high plasticity.

Table 4: Summary of CBR test results

Borehole location and depth of sample	Depth (m)	Subgrade Material	Maximum dry density (t/m^3)	Optimum Moisture Content OMC (%)	CBR (%)
CBH02	0.4 to 0.7	Alluvial Clay	1.55	25.1	5 (at 2.5mm)
CBH04	0.4 to 0.7	Alluvial Clay	1.65	16.6	6 (at 5.0mm)

5.4. Soil aggressivity

Chemical testing to assess soil aggressivity including chlorides, Sulphate and pH was undertaken on one sample collected from boreholes CBH01 and CBH02. The laboratory test results indicate that the soil sample tested is in the range of non-aggressive to mildly aggressive to concrete (Table 6.4.2(c), Exposure Classification for Concrete Piles- Piles in Soil) and non-aggressive to moderately-aggressive to steel (Table 6.5.2(c), Exposure Classification for Steel Piles-Piles in Soil), (Reference: AS2159-2009). The test report for aggressivity is presented in Appendix B. A summary of the aggressivity test results is presented in Table 5.

Table 5: Summary of aggressivity test results

Borehole Number	Sample Depth (m)	Chloride (mg/kg)	pH (1:5 Aqueous extract)	Resistivity (ohm.cm)	Sulphate (as SO4) (mg/kg)
CBH01	2.5 to 2.95	190	4.9	160	390
CBH02	1.5 to 1.95	160	4.8	200	370

6. Engineering assessment

6.1. Groundwater levels

Groundwater inflow was encountered drilling fieldwork in borehole CBH01 at depths of 9.5m. However, the depth to groundwater may vary following heavy or prolonged rain prior to construction. Groundwater may also be stored or perched temporarily in permeable soils or in fractures or joints in the rock.

No structural design was provided at time of this reporting. We assume that the main building foundations will likely comprise deep piles socketed into rock. Therefore it is likely that groundwater will be encountered during drilling of bored piles. As weak extremely weathered materials and clay bands are evident in the rock, allowance should be made for casing of bored piles. For fully cased piles allowance should be made in the design for reduced shaft adhesion. The base of bored piles should be cleaned, dewatered and concreted as soon as possible after excavation to reduce the risk of deterioration of the weathered rock within the rock socket or softening of the clay soils or extremely weathered material in the pile walls. Alternatively, the base of piles and footings should be cleaned, dewatered and a blinding layer of concrete should be applied to protect the base if concreting is to be delayed.

Alternatively CFA piles would be suitable, given the potential for groundwater inflows, as this would eliminate the need for casing.

6.2. Site classification to AS2870-2011

The soils encountered at the site comprised shallow fill to a depth of up to 1.0m underlain by medium to high plasticity, stiff to very stiff clay soils of alluvial origin. Residual soil/Extremely weathered material was encountered underlying the clay soils at about 8 to 10 m at test locations below ground surface level. The clay soils within the main campus at the University of Wollongong are generally moderately to highly reactive, and soil reactivity has caused cracking and structural problems in the past for buildings supported on high level footings.

As per AS2870-2011, Residential slabs and footings, as fill thicker than 0.4m has been identified, a site classification of P is applicable. If shallow footings for minor structures are to be founded in the alluvial clay soils, then a site classification of H1 is considered appropriate for the design of footings for these structures in accordance with AS2870 (2011).

Where natural clay soils occur, the site classification is based on soil reactivity and potential characteristic surface movement (Ys), defined as follows:

Table 6: Classification by characteristic surface movement (Ys) as per AS2870-2011

Class	Founding Material	Characteristic Surface Movement, Ys (mm)
A	Most sand and rock sites with little or no ground movement from moisture changes	--
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes	0 < Ys ≤ 20
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes	20 < Ys ≤ 40
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes	40 < Ys ≤ 60
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes	60 < Ys ≤ 75
E	Extremely reactive clay sites, which may experience extreme ground movement from moisture changes	Ys > 75

The site classification is based on the soil reactivity and depth of the underlying soils encountered. Some variations in bearing capacity and soil reactivity may occur over this site. Engineering assessment of footing excavations should be undertaken by the design engineer or geotechnical engineer at the time of construction to confirm that the ground conditions encountered are consistent with those encountered in the boreholes.

6.3. Earthworks

6.3.1. Re-use of excavated material

Earthworks required for the site will typically be associated with site preparation excavations, pavements, footings, service installation and landscaping, it is likely that waste materials will be generated. To minimise the costs associated with off-site disposal of materials, it is preferable to minimise the disturbance of the in situ soils and/or re-use these materials where possible. Some of the fill materials may be suitable for re-use as general fill, however this may involve significant time in separating materials. Topsoil and other mixed materials that are environmentally suitable may be re-used for landscaping or areas other than under pavements or buildings.

Excavated material in the upper 0.3m in existing carpark at the location of CBH01 will generally comprise of asphalt and roadbase material. The roadbase materials could be used as structural fill providing they can be readily separated from topsoil or other materials and is approved on site by the geotechnical engineer. If approved excavated material is used as structural fill it should be compacted to a minimum density ratio of 100% Standard Maximum Dry Density and at a moisture content within 2% of Standard Optimum Moisture Content. The alluvial firm to stiff clay soils are considered suitable for re-use as general fill provided the moisture content can be maintained close to optimum moisture content prior to placement.

6.3.2. General site preparation earthworks and trafficability

No structural design drawings were available at the time of this report. We assume that the building will be supported on bored or CFA piles founded at depths in the order of 10 to 15m below existing surface levels. Excavations may be required for service trenches and will generally encounter fill overlying alluvial clay soils.

Due to the presence of clay soils and clays with some of the fill materials in the upper ten metres, and relatively flat grades, surface water drainage over the site in its current condition will be relatively poor, therefore trafficability during construction is likely to be poor with potential for significant disturbance to the surface materials particularly if clays are exposed to moisture

Allowance should be made for the placement of a working platform in construction vehicle access areas comprising a minimum of 300mm of crushed rock or approved recycled low plasticity or non-plastic material such as crushed concrete or quarry product for general site traffic. For heavy equipment such mobile cranes or piling rigs it will be necessary to assess platform requirements once details of the particular plant are known.
Various ground disturbances are expected over the proposed site for the new development where pavements, demountable buildings and trees are removed. Some of the trees may have extensive root systems and due to the number of trees across the site the upper soil layers may be significantly affected by tree roots. Roadbase materials should be separated during construction for possible re-use as a structural fill material.

Underground service trenches are likely to be encountered in a number of areas over the site within the proposed development footprint. Where disused sewer or drainage pipes are intersected during site excavations they should be checked to ensure that no further flows from these pipes will occur.

6.3.3. Excavation conditions

No structural plans for the proposed development have been provided at this stage. We anticipate that excavation depths for the site preparation earthworks will be relatively shallow, generally less than 1m below existing surface level. In view of the depth to weathered rock over most of this site, site preparation excavations and service trenches will be in clay soils.

Deep foundations will comprise either bored or CFA piles that will extend into the rock, with the extent of embedment dependent on the pile loads and design bearing capacity. Piling rigs should be capable of drilling in high strength rock.

Reference should be made to Table 7 below in regards to the Kirsten classification definitions for excavations in soils and rock. The fill (including flexible pavement materials), residual soils and extremely weathered material should have a Kirsten Classification in the range of Class 2 to 4. Highly to moderately weathered rock will have a Kirsten Classification of Class 4 to 5.

Table 7: Kirsten's eight point excavation classification system

Class	Material type	Description of excavatability
1	Soil / Detritus	Hand spade (Dozer D3)
2		Hand pick and spade
3		Power tools
4	Rock	Easy ripping (Dozer D7)
5		Hard ripping (Dozer D8)

Class	Material type	Description of excavatability
6		Very hard ripping (Dozer D9)
7		Extremely hard ripping / blasting (Dozer D10)
8		Blasting

6.3.4. Potential ground settlement

In general, the site is underlain by fill of variable depths, overlying stiff to very stiff alluvium. As the existing fill materials include zones of firm or looser materials that may consolidate with time, settlement of the fill, if left in place, may be expected. For the current ground conditions settlements in the order of 10mm to 20mm in the deeper fill areas could occur under self-weight. If additional fill is added we would settlement to increase. Due to the unknown history of fill placement and compaction, shallow footings founded within the fill are not recommended.

Services within the fill or any soft or loose soils and pavements around the building may be affected by long term settlement or surface movements due to reactive soils and this should be considered in the design. Service conduits or pipes that are sensitive to differential movement should be designed to allow for some differential settlement where entering buildings using suitable flexible joints or other measures advised by the building services designers.

6.3.5. Unsupported cuts

Unsupported temporary cuts in stiff clay soils should be battered to slopes no steeper than 2H: 1V. These recommendations assume:

- The ground surface is horizontal beyond the crest of the excavation;
- The slopes are well drained with no runoff concentrated behind the crest or behind the retaining walls; and
- No surcharge loads (such as low rise buildings with shallow footings) are located within a horizontal distance of the cut crest equal to the vertical height of the cut.

Where surcharge loads are located within a horizontal distance of the excavation crest equal to the vertical height of the excavation, cut batters should be adopted as follows for the stiff alluvial clay soils:-

- 2.5H:1V for temporary slopes; and
- 3.0H: 1V for permanent slopes.

Alternatively excavation cuts should be structurally retained. These recommendations assume:

- The ground surface is approximately horizontal beyond the crest of the excavation;
- The site is well drained (including surface and subsurface water).

6.4. Estimated soil parameters for retaining walls

Estimated soil parameters for retained materials are provided in Table 8 below. These parameters assume that the soil remains in the state observed during fieldwork at the site and that drainage conditions behind the retaining walls are satisfactory. Allowances for blockage of drainage systems during the design life may be required in the final design.

Table 8: Estimated soil parameters for retained materials

Unit	Unit Weight (kN/m^3)	c' (kPa)	ϕ' (degrees)	K_a	K_0	K_p
Alluvial clay /fill soils	19 to 20	2 to 5	25	0.35 to 0.40	0.5	2.5 to 2.8

Notes in Table 8:

1. *Modified K_0 (rather than in-situ) assuming that at least a small amount of wall movement, (say about 0.1% to 0.3% of the wall height) could occur.*
2. *In-situ k_0 is significantly higher and if required specific testing should be carried out.*

6.4.1. Site surface drainage

In terms of site drainage measures, during and following construction at this site, all exposed soils should be protected from erosion. With generally clayey soils occurring within about 6m to 8m of the ground surface, surface water should be able to be controlled by shallow sumps formed in the clay soils and pumping the collected water to a temporary settlement tank for treatment before discharge to the storm drain system.

Drainage should be provided for all batter slopes. As a minimum, surface drains should be installed at the top of the slope to divert water away from the face. Temporary slopes should also be protected during rainfall by covering with plastic sheeting.

6.5. Building foundations

6.5.1. Suitable footing systems

Due to the presence of deep clay soils which are potentially reactive and the anticipated building loads generated, a deep footing system for the new building is recommended.

A suitable footing system for the proposed Social Sciences & Law Humanities and Arts Building would comprise CFA or bored piles terminated in the weathered rock. A piled raft design could be considered. The founding depth for piles will depend on the rock unit targeted for founding of bored piles, but is likely to occur at depths in the range of 10m to 16m below current ground level.

For lightly loaded or minor surface structures, shallow strip, pad or raft footings terminated in the stiff clay soils will be suitable.

6.5.2. Design parameters

The parameters provided in Table 9 are the indicative ultimate limit state geotechnical design parameters that can be adopted for a non-displacement pile foundation design. For the design of piles, a limit state method must be adopted to comply with the piling code AS2159-2009. The following notations used in the table are defined as follows:

γ_b - Bulk unit weight
f_s - Ultimate skin friction
f_b - Ultimate end bearing capacity for the layer at the tip of the pile
p_y - Ultimate lateral yield pressure
E_{sv}' - Young's modulus for axial response
E_{sh}' - Young's modulus for lateral response

Table 9: Footing design parameters for bored or CFA piles

Unit	γ_b (kN/m^3)	f_s (kPa)	f_b (MPa)	p_y (MPa)	E_{sv}' (MPa)	E_{sh}' (MPa)
HW Rock	20	75	1	1	60	40
MW Rock	21	200	4	2.5	200	150
SW to Fresh Rock	22	500	15	8	500	400

Notes to Table 9:
1. *End bearing pressure for bored or CFA piles should result in settlement less than 1% of the minimum footing width or pile diameter.*
2. *Adopt shaft adhesion values only where the embedded length into the relevant bearing stratum is at least 2 pile diameters.*
3. *For bored or CFA piles, the surface of the pile shaft should be cleaned of clay smear and roughened using a suitable tool fitted to the pile boring rig. Augers and drilling buckets do not clean and roughen sockets adequately unless they are fitted with tools that protrude laterally from the sides of the auger or bucket.*
4. *All footing excavations should be assessed by an experienced geotechnical engineer prior to placement of reinforcement or concrete.*

For shallow strip or pad footings founded in the very stiff alluvial clay soils, an allowable bearing capacity of 150kPa will be suitable for design.

The bases of all shallow floor slab beams, strip or pad footings, and bored piles should be cleaned, dewatered and concreted within 24 hours of excavation to reduce the risk of deterioration of the weathered rock or softening of the clay soils. Alternatively, the base of piles and footings should be cleaned, dewatered and a blinding layer of concrete should be applied to protect the base if concreting is to be delayed. The footings should be cleaned and dewatered again prior to concreting if seepage from the sides of the footing occurs after placement of the blinding layer.

6.5.3. Geotechnical strength reduction factors

Table 9 provides serviceability and ultimate bearing pressures and elastic modulus values for the rock encountered at this site for bored or CFA piles. Ultimate bearing pressures have been recommended based on the Classification System presented in the1998 Paper by Pells et al. If higher end bearing pressures are required, additional investigation would be required to assess the deeper rock profile. A geotechnical engineer should be engaged to inspect footing excavations to assess whether the material exposed at the base of footings is consistent with the geotechnical model and assumed bearing pressures.

For limit state design of a piled footing system a geotechnical strength reduction factor (Φ_g) of 0.4 should be applied to the ultimate capacities provided in Table 9 when designing footings for ultimate limit state, unless pile load testing provides additional data on rock properties to justify a higher value. For uplift design (Φ_g) of 0.5 should be adopted and an additional reduction factor of 0.5 should be applied to the shaft adhesion value. The geotechnical strength reduction factor should be confirmed once the pile system is proposed and redundancy considered, and whether pile load testing is proposed.

In view of the depth to rock and possible variations in depths to rock and quality of the rock, we recommend that piles be assessed during construction by an experienced geotechnical engineer who can assess anomalies in the soil type and rock depths and advise on a course of action.

6.5.4. Site Factor for Earthquake Design

Based on AS 1170.4 – 2007, the Earthquake Hazard Factor, (Z), for the Wollongong region is 0.09, and has Sub-Soil Class Ce - shallow.

6.6. Pavements - carpark and accessways

6.6.1. Design subgrade CBR

The final subgrade levels for pavements is not known at this stage. CBR testing was carried out on a sample of the alluvial clay.

Based on the CBR test results obtained for the alluvial clay sample and the general soil conditions encountered in the boreholes, pavements for the carpark may be designed based on a design subgrade CBR of 5.0%, assuming the upper 300mm of the subgrade is compacted to at least 100% of Standard Maximum Dry Density.

Based on the Wollongong City Council Subdivision Code, and assuming a 20 year design life a design traffic loading of 2 x 10^4 ESAs has been used for the carpark pavement design.
Based on Austroads Pavement Design for Light Traffic. Ref. AP-T36/06, and assuming a design subgrade CBR of 5.0%, a flexible pavement thickness of 250mm including 50mm thick asphalt wearing course is recommended for pavements overlying the clay subgrade. Options for use of select subgrade materials or subgrade stabilisation may be considered to reduce the thickness of subbase. A typical flexible pavement design is as follows:-

Pavement layer	**Material**	**Layer thickness**
Wearing course	AC 14	50mm
Base	DGB20	100mm
Subbase	DGS20 or DGS40	100mm

6.6.2. General pavement construction requirements

The pavement design assumes that the subgrade is at least stiff and free from deleterious materials such as fill, topsoil or root affected soils. If unsuitable materials are encountered, removal and replacement of these materials with a select subgrade material may be required.

Although rigid pavements are less prone to water inflow problems, water inflows may affect subgrade properties and cause cracking or failure of pavements at this site. Adequate surface water collection measures and subsurface drainage should be provided as part of the pavement design at this site.

It is recommended that the exposed subgrade conditions be assessed by an experienced geotechnical engineer / engineering geologist during the construction phase to confirm the suitability of the pavement design.

Construction of flexible pavements should comply with the following recommendations:

- Box out the access road and carparking areas to the required pavement depth;
- Should poor subgrade material be encountered such as local fill material, excavation and removal of these materials may be required;
- The subgrade should then be proof rolled using a 12 tonne static smooth drum roller and assessed by a qualified geotechnical engineer (or senior geotechnician) before any General or Select Fill or pavement material is placed;
- Where General Fill or Select Subgrade is required to achieve the proposed vertical alignment, it should be placed to the required thickness in layers, using either a method specification (if coarse graded materials are used) or using a testing specification (if finer materials are used). If a testing specification is used, granular layers should have a maximum compacted thickness of 200mm. The upper 300mm of the subgrade materials must be compacted to achieve 100% of Standard Maximum Dry Density at a moisture content of -2% to + 2% of OMC;
- Place approved sub-base material, DGS20 or DGS40 to the required sub-base thickness, or to a maximum compacted thickness of 100mm. Compact the sub-base material at a moisture content of -3% to 0% of OMC to 95% of Modified Maximum Dry Density (Austroads Pavement Design);
- Place a minimum 100mm of approved unbound base material, DGB20, over the sub-base at a moisture content of -2% to 0% of OMC and compact to 98% of Modified Maximum Dry Density (Austroads Pavement Design); and
- Provide an appropriate asphalt wearing course to a minimum thickness of 50mm, with a primer initially placed over the base layer.

6.6.3. Subsoil drainage and pavement performance

It is important that subsoil drainage be provided in areas where pavements abut vegetated land. The subsoil drains should be located along the outside edge of the pavement shoulders and be in good contact with the pavement subbase, and any granular select subgrade where required. The collected water must be drained with adequate fall to suitable outlets in the stormwater collection system.

The subsoil drains along roads that are separate to stormwater drains should be 400mm wide and extend at least 400mm below the underside of the pavement subgrade or any granular select subgrade layer.

The subsoil drains should comprise a 100mm slotted PVC pipe (Ag Pipe) surrounded by 20mm clean aggregate and the entire drain should be wrapped in a geotextile fabric (for example Bidim A24 or equivalent). All subsoil drains should fall at a minimum 2% grade to dedicated drainage pits. Surface maintenance of asphalt wearing courses should be periodically carried out. This would include localised infilling of minor surface cracks in the wearing course with emulsion routinely applied as part of normal pavement maintenance measures life of the pavement. Surface and subsoil drainage should also be maintained over the full design life.

Trees and vegetation should be excluded from pavement verge areas or traffic islands if their roots are assessed as likely to enter subgrade areas beneath the pavement during the design life.

6.6.4. Dilapidation surveys and vibration monitoring

The proposed new building will be in close proximity to roads and Early Start Building, therefore we recommend that construction techniques be reviewed to ensure that vibration will not adversely affect these structures. This may include a dilapidation survey of each building. Service providers for any sensitive buried services should also be contacted to assess the likely effects on their services prior to construction commencing.

The structural engineer undertaking the review or dilapidation survey should carefully consider the potential for adverse impacts on the adjacent structures due to site works.

If equipment which generates significant vibrations (e.g. vibratory roller) is to be used, vibration monitoring close to adjacent structures may be required to confirm that vibration levels are within tolerable limits.

6.6.5. Site Maintenance

The performance of a building developed over highly reactive clays can be affected by a number of factors relating to site maintenance. The planting of fast growing trees or trees with aggressive root systems close to buildings should be avoided. Surface water should be drained from the site to minimise ponding around the building walls and floor areas. Surface drains should be maintained free of blockages. Irrigation of landscaped areas should be carefully managed to provide relatively uniform soil moisture content in landscaped areas around the building.

7. Limitations

The site information and recommendations provided within this report relate to development details provided. If details of the proposed development differ from those assumed in the preparation of this report, Coffey should be contacted for further geotechnical advice.

The findings in this report are the result of observations made at discrete borehole locations and observations of the surface conditions at the site. Subsurface conditions could vary significantly across the site. Should different subsurface conditions to those expected be encountered during construction, Coffey should be contacted immediately.

We draw your attention to the attached sheets titled “Important Information about your Coffey Report" which must be read in conjunction with this 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.

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

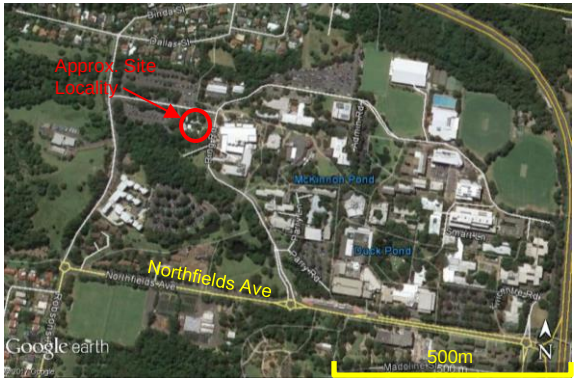
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As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

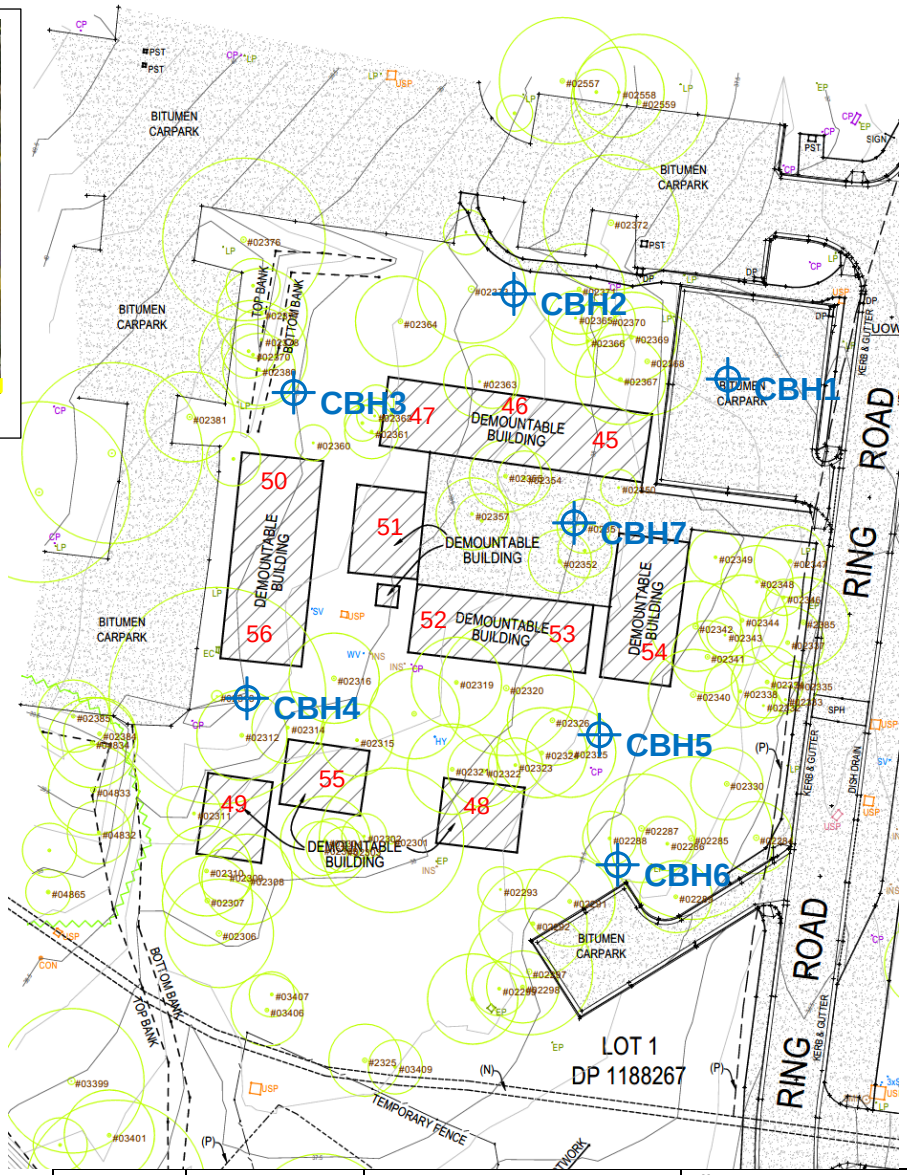
Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, 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.

Figure – Approximate test locations



SITE LOCALITY PLAN



LEGEND

Approximate borehole location

54 Classroom number

0 5 10 15 20 25
Metres

drawn	MF
approved	JPT
date	19/06/2017
scale	AS SHOWN
original size	A4

coffey
A TETRA TECH COMPANY

client: UNIVERSITY OF WOLLONGONG

project: SOCIAL SCIENCES & LAW HUMANITIES AND ARTS BUILDING
Geotechnical Investigation

title: Approximate borehole locations

project no: 754-WOLGE205371-AA

figure no: 1

Appendix A - Borehole Logs, Photos and Explanatory Notes

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 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.

Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES USC (Excluding particles larger than 60 mm and basing fractions on estimated mass)						USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	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
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm				
		SILTS & CLAYS Liquid limit less than 50	**DRY STRENGTH**	**DILATANCY**	**TOUGHNESS**		
			None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to medium	Slow to very slow	Low	CL	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:
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. 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.

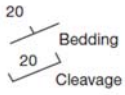
ROCK SUBSTANCE STRENGTH TERMS

Term	Abbre-viation	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:
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.
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.
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 Is(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. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
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.			 (Note 2)
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.			

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.

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
Veneer	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

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coffey

Engineering Log - Borehole

Borehole ID.	***CBH01***
sheet:	1 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***24 May 2017***
principal:	
date completed:	***24 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer 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)	structure and additional observations
AD/T, N		Not Observed			0.0			**PAVEMENT** **Gravelly SAND**: fine to coarse grained, grey, fine to coarse angular to sub-angular gravel.	D	MD		**PAVEMENT** **ROADBASE** PID: 3.1 ppm
					0.5			**CLAY**: medium to high plasticity, brown, orange mottled, trace of fine to medium sub-rounded gravel, trace of rootlets.		F - St		**FILL** PID: 5.1 ppm
								Sandy CLAY: medium plasticity, brown, orange, red mottled, fine grained sand, trace of fine sub-rounded gravel, trace of coal.		St		PID: 2.1 ppm
			SPT 5, 8, 9 N=17		1.0					VSt		**ALLUVIAL** PID: 3 ppm
					1.5			**CLAY**: medium to high plasticity, brown, orange, grey mottled, trace of fine grained sand, trace of fine to medium sub-rounded gravel.				
			SPT 3, 5, 6 N=11		2.0							
					2.5							
					3.0							
					3.5							

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH01***
sheet:	2 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***24 May 2017***
principal:	
date completed:	***24 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer 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/T, N		Not Observed	SPT 5, 6, 7 N=13		4.5			**CLAY**: medium to high plasticity, brown, orange, grey mottled, trace of fine grained sand, trace of fine to medium sub-rounded gravel. *(continued)* - some fine to coarse grained sand bands	D	VSt		**ALLUVIAL**
					5.0			**Sandy CLAY**: medium plasticity, pale brown, red, orange, grey mottled, fine to medium grained sand, trace of fine to coarse sub-angular to sub-rounded gravel.				**RESIDUAL**
			SPT 5, 6, 16 N=22		5.5							
					6.0			**Sandy CLAY /CLAYEY SAND**: medium plasticity, grey, orange, brown mottled, fine to coarse grained sand.				
								Sandy CLAY: medium plasticity, grey, brown, orange, brown mottled, fine to coarse grained sand.				
					6.5							
					7.0					VSt - H		
			SPT 7, 13, 13 N=26		7.5			**Sandy CLAY**: medium plasticity, grey, brown, orange mottled, fine to coarse grained sand, trace of fine to medium sub-rounded to sub-angular gravel.				**EXTREMELY WEATHERED MATERIAL**

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH01***
sheet:	3 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***24 May 2017***
principal:	
date completed:	***24 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer 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/T, N		Not Observed	SPT 18, 15, 30 N=45		8.5			**Clayey SAND /SANDY CLAY**: fine to coarse grained, brown, grey, medium plasticity clay, trace of coal.	D	H		**EXTREMELY WEATHERED MATERIAL**
								Clayey SAND: fine to coarse grained, dark grey, brown, medium plasticity clay, trace of fine to coarse sub-angular to sub-rounded gravel.				
					9.0			**SAND**: fine to medium grained, dark grey, trace of fine to coarse sub-angular to sub-rounded gravel.		VD		
					9.5			**Sandy CLAY**: medium to high plasticity, dark grey, fine to medium grained sand.	>Wp	St		
								SAND: fine to coarse grained, grey, trace of low plasticity clay, trace of extremely weathered to highly weathered rock.		H		**EXTREMELY WEATHERED TO HIGHLY WEATHERED ROCK**
					10.0			Borehole CBH01 continued as cored hole				
					10.5							
					11.0							
					11.5							

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Cored Borehole

Borehole ID.	***CBH01***
sheet:	4 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***24 May 2017***
principal:	
date completed:	***24 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | drilling fluid: none | 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 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
NMLC	Not Observed		10.0		start coring at 9.95m **SILTSTONE**: fine grained, dark grey.	XW to HW			0%		PT, 5 - 10°, PL, RO, Clay - CO SM, Sandy clay PT, 10 - 15°, IR, RO, Clay - CO
					SANDSTONE: fine to medium grained, grey, dark grey mottled.	MW to SW		d=1.11 a=0.77			PT, 15°, IR, RO, CN
			10.5			HW to MW		d=0.10 a=0.19	42%		JT, 45°, ST, RO, CN JT, 30°, PL, RO, CN
			11.0								PT, 10°, ST, RO, VN PT, 10 - 15°, IR, RO, Sand - CO
											PT, 10 - 15°, PL, RO, Sand - CO PT, 10 - 15°, PL, RO, Sand - CO
			11.5			MW					JT, 30°, ST, RO, VN
			12.0					d=0.13 a=0.11	51%		PT, 10°, PL, RO, VN
			12.5		**NO CORE:** 0.24 m						
						HW					
						XW			0%		
			13.0			SW		d=1.89 a=1.46			PT, 10°, PL, RO, VN
			13.5			XW to HW			79%		CS, 10°, ST, RO, CO - Sand SM, Clayey sand, 30 mm
						SW to FR					PT, 10 - 15°, PL - IR, RO, CN

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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
- HA hand auger

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

Borehole ID.	***CBH01***
sheet:	5 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***24 May 2017***
principal:	
date completed:	***24 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | drilling fluid: none | 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 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
NMLC	Not Observed		14.0		- colour change to grey	SW to FR			79%		
			14.5								
			15.0		Borehole CBH01 terminated at 15.20 m						
			15.5								
			16.0								
			16.5								
			17.0								
			17.5								

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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
- HA hand auger

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

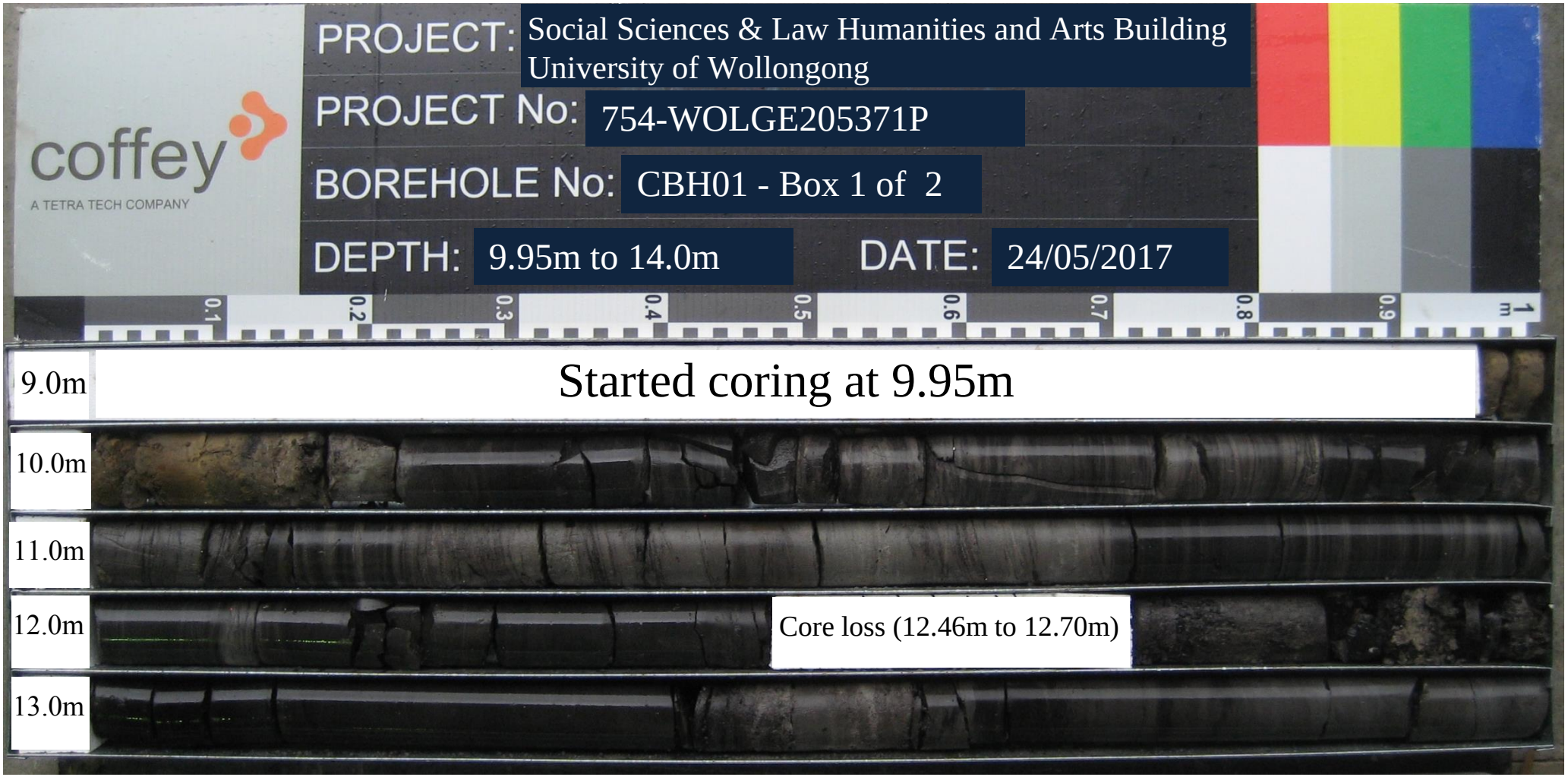
strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

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

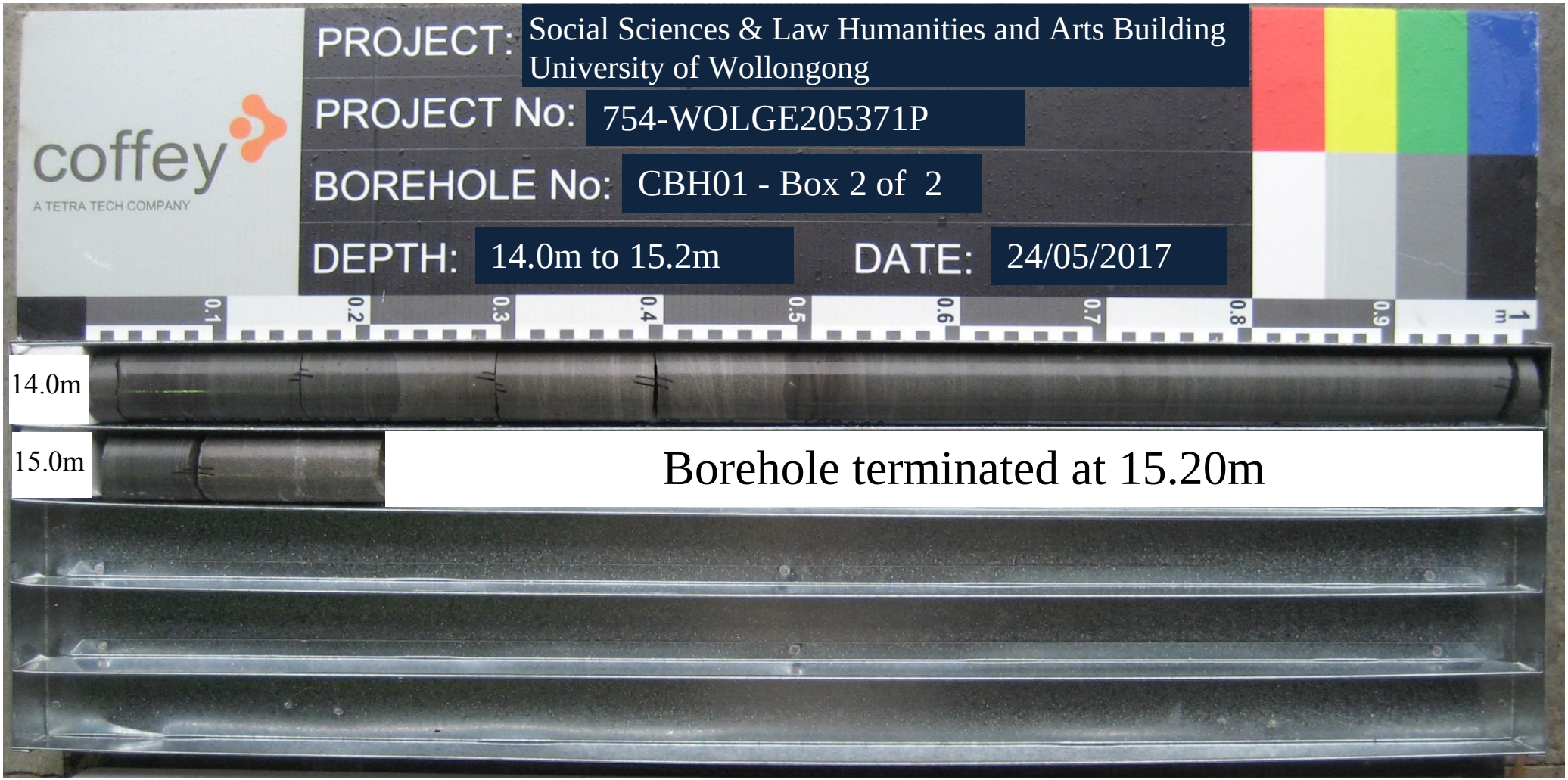
roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

coating
- CN clean
- SN stain
- VN veneer
- CO coating



drawn	**MB**	coffey A TETRA TECH COMPANY	client:	University of Wollongong
approved	**JPT**		project:	Social Sciences & Law Humanities and Arts Building
date	**24/05/2017**		title:	Core photograph CBH01 – Box 1 of 2
scale	**N.T.S.**		project no: 754-WOLGE205371P	figure no:
original size	**A4**			



drawn	**MB**	coffey A TETRA TECH COMPANY	client:	University of Wollongong
approved	**JPT**		project:	Social Sciences & Law Humanities and Arts Building
date	**24/05/2017**		title:	Core photograph CBH01 – Box 2 of 2
scale	**N.T.S.**		project no: 754-WOLGE205371P	figure no:
original size	**A4**			

coffey

Engineering Log - Borehole

Borehole ID.	***CBH02***
sheet:	1 of 1
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***25 May 2017***
principal:	
date completed:	***25 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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/T, N		Not Observed			0.0			**Silty Sandy CLAY**: medium plasticity, dark brown.	M	F		**TOPSOIL / FILL**
												PID: 1.8 ppm
								Sandy CLAY: medium plasticity, fine to medium grained sand.		St		**ALLUVIAL** PID: 1.7 ppm
					0.5							
					1.0							
					1.5					St to VSt		
			SPT 5, 10, 8 N=18		2.0							
			SPT 4, 4, 6 N=10		2.5							
					3.0			Borehole CBH02 terminated at 2.95 m				
					3.5							

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH03***
sheet:	1 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***25 May 2017***
principal:	
date completed:	***25 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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)	structure and additional observations
AD/T, N		Not Observed			0.0			**Silty Sandy CLAY**: medium plasticity, dark brown, fine to medium grained sand, trace of rootlets.	M	F - St		**TOPSOIL / FILL** PID: 2.4 ppm
								CLAY: medium plasticity, brown, pale brown mottled, trace of fine grained sand, trace of organics.	M	St - VSt		**ALLUVIAL** PID: 2.5 ppm
					0.5							
					1.0					VSt		
			SPT 4, 6, 9 N=15									
					1.5			- colour change to dark brown, red, brown mottled				
					2.0							
					2.5			- trace of tree roots				
			SPT 3, 4, 6 N=10									
					3.0							
								Sandy CLAY: medium to high plasticity, brown, orange, red mottled, fine to coarse grained sand, trace of medium to coarse sub-rounded gravel, trace of organics.				
					3.5			- some medium to coarse grained sand (3.75-4.0m)				

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:06

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH03***
sheet:	2 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***25 May 2017***
principal:	
date completed:	***25 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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)	structure and additional observations
AD/T, N		Not Observed	SPT 5, 6, 8 N=14		4.5			**Sandy CLAY**: medium to high plasticity, brown, orange, red mottled, fine to coarse grained sand, trace of medium to coarse sub-rounded gravel, trace of organics. *(continued)*	M	VSt		**ALLUVIAL**
					5.0			- colour changed to grey, brown, red, orange mottled		VSt - H		
			SPT 5, 8, 19 N=27		5.5							
					6.0			**Sandy CLAY /CLAYEY SAND**: medium plasticity, brown grey, medium to coarse grained sand.				**RESIDUAL**
					6.5			**Sandy CLAY**: medium to high plasticity, brown, grey, red mottled, fine to medium grained sand, trace of extremely weathered rock, trace of fine to medium sub-rounded gravel.				
			SPT 7, 12, 18 N=30		7.0							
					7.5							

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:06

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH03***
sheet:	3 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***25 May 2017***
principal:	
date completed:	***25 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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)	structure and additional observations
AD/T		Not Observed						**Sandy CLAY**: medium to high plasticity, brown, grey, red mottled, fine to medium grained sand, trace of extremely weathered rock, trace of fine to medium sub-rounded gravel. *(continued)* - trace of shale	M	VSt - H		**EXTREMELY WEATHERED MATERIAL**
					8.5			**Clayey SAND /SANDY CLAY**: fine to medium grained, dark grey, medium plasticity clay.		H		**EXTREMELY WEATHERED TO HIGHLY WEATHERED ROCK**
			SPT 18, 29, 19 N=R		9.0							
					9.5							
			SPT 28/100mm N=R		10.0							
								Borehole CBH03 continued as cored hole				
					10.5							
					11.0							
					11.5							

N

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Cored Borehole

Borehole ID.	***CBH03***
sheet:	4 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***25 May 2017***
principal:	
date completed:	***25 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | drilling fluid: none | hole diameter :

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 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
NMLC	Not Observed				start coring at 10.12m						
					CARBONACEOUS SILTSTONE: fine to medium grained, dark grey.	XW to HW		a=0.04 d=0.01			SM, Sandy clay PT, 10°, PL, RO, Clay CO PT, 10 - 15°, PL, RO, Clay CO
			10.5								PT, 15°, IR, RO, Sandy clay CO
											PT, 15°, ST, RO, Sandy clay CO
									22%		
			11.0								JT, 30°, IR, RO, Sandy clay CO PT, 10°, PL, RO, Sandy clay CO SM, Sandy clay PT, 15°, IR, RO, Sandy clay CO
			11.5		**NO CORE:** 0.21 m						CS, 10 - 30°, IR, RO, VN
					COAL: fine grained, black.	XW to HW					CS, 10 - 20°, IR, RO, Sand CO JT, 30°, IR, RO, VN
									0%		
			12.0		**CLAYSTONE**: medium plasticity. - colour change to grey						CS, 20 - 30°, IR, RO, Sand CO
											SM, Sandy clay
			12.5					d=0.04 a=0.06			PT, 10°, ST, RO, Clay CO
									73%		
			13.0		**COAL**: fine grained, black.						PT, 10°, IR, RO, Clay CO
						HW					CS, 10°, IR, RO, Sand CO CS, 10°, IR, RO, Sand CO PT, 10 - 15°, IR, RO, Sand CO
			13.5		**NO CORE:** 0.35 m						CS, 10 - 20°, IR, RO, Sand CO
									11%		
			14.0		**SANDSTONE**: fine to medium grained, dark grey.	XW to HW					PT, 15°, ST, RO, VN

CDF_0_9_04BB.GLB Log COF BOREHOLE: CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:06

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
- HA hand auger

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

Borehole ID.	***CBH03***
sheet:	5 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***25 May 2017***
principal:	
date completed:	***25 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | drilling fluid: none | hole diameter :

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 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
NMLC	Not Observed		14.5		**SILTSTONE**: fine to medium grained, dark grey. *(continued)*	XW to HW		a=0.05 d=0.02			PT, 15°, ST, RO, Sandy clay CO
					NO CORE: 0.21 m						SM, Sandy clay
			15.0		**SILTSTONE**: fine to medium grained, dark grey.	MW / SW		d=0.91 a=2.43			CS, 15°, IR, RO, VN
											JT, 30 - 45°, ST, RO, VN
			15.5						58%		JT, 30 - 45°, ST, RO, VN
											PT, 10°, ST, RO, VN
			16.0								JT, 30 - 45°, ST, RO, VN
											PT, 10 - 15°, ST, RO, VN
			16.5								PT, 20°, ST, RO, VN
			17.0		Borehole CBH03 terminated at 17.05 m Refusal						
			17.5								
			18.0								

CDF_0_9_04BB.GLB Log COF BOREHOLE: CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:06

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
- HA hand auger

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

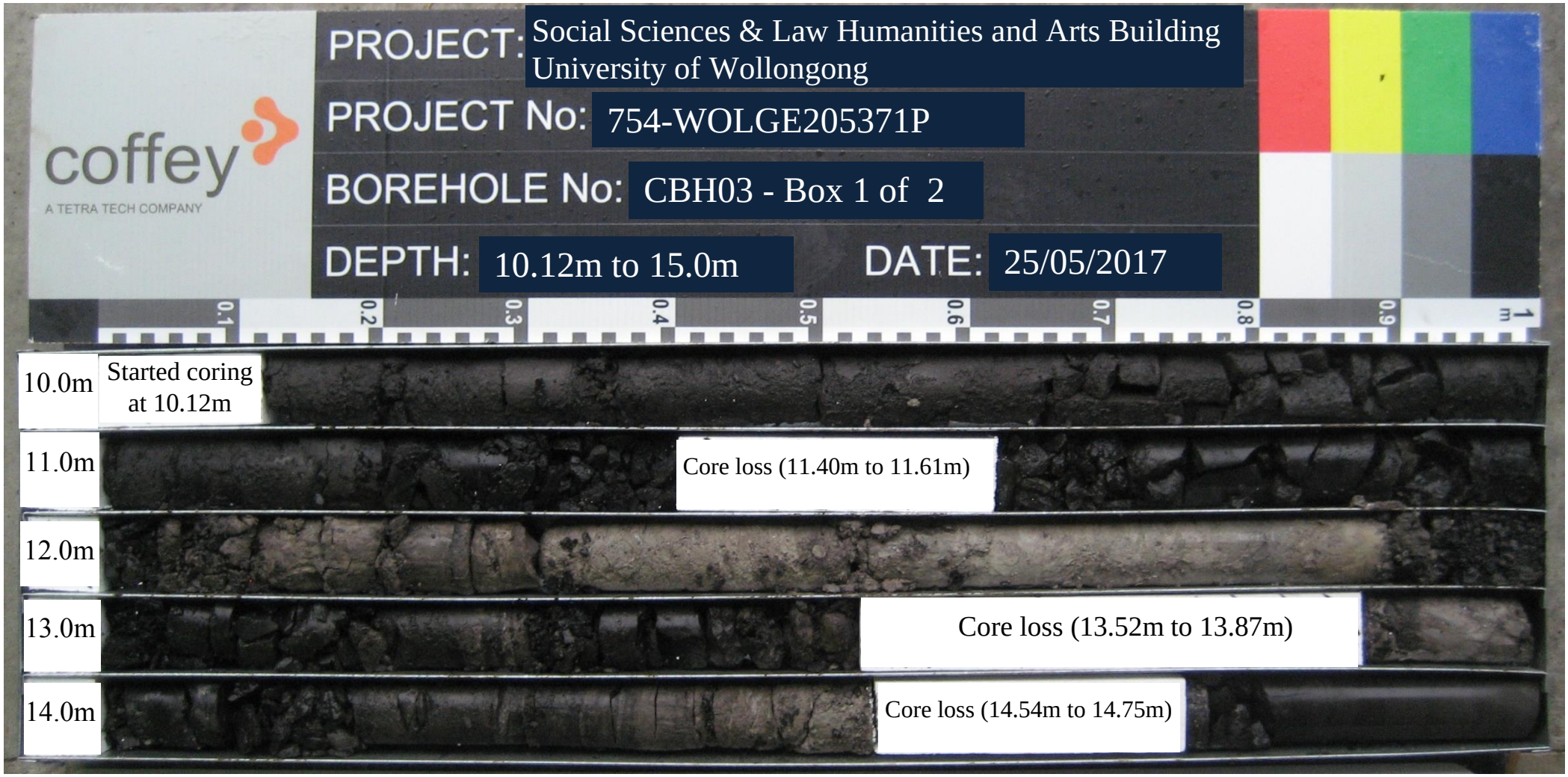
strength
- VL very low
- L low
- M medium
- H high
- VH very high
- EH extremely high

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

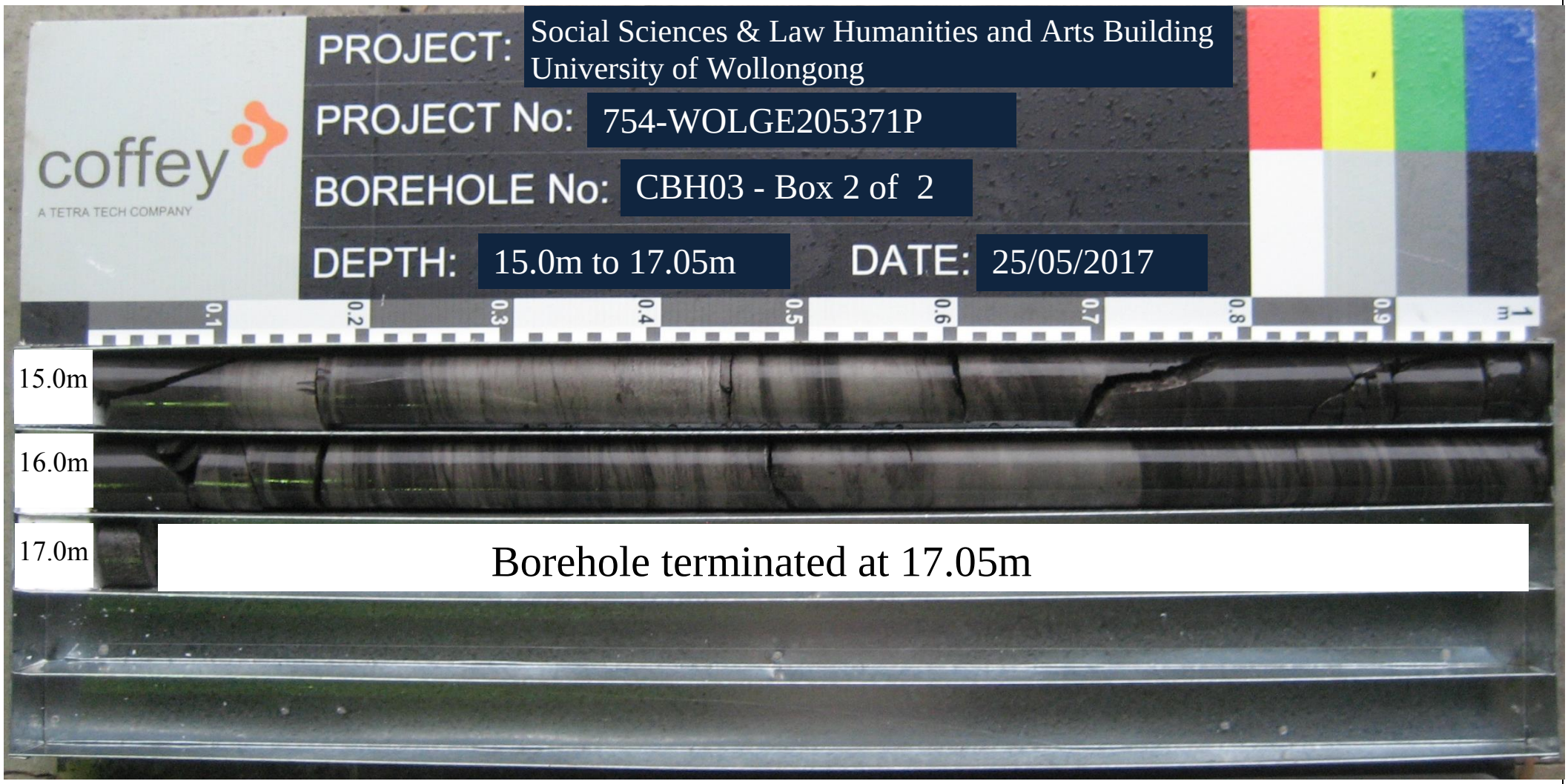
roughness
- SL slickensided
- POL polished
- SO smooth
- RO rough
- VR very rough

planarity
- PL planar
- CU curved
- UN undulating
- ST stepped
- IR Irregular

coating
- CN clean
- SN stain
- VN veneer
- CO coating



drawn	MB	coffey A TETRA TECH COMPANY	client:	University of Wollongong
approved	JPT		project:	Social Sciences & Law Humanities and Arts Building
date	25/05/2017		title:	Core photograph CBH03 – Box 1 of 2
scale	N.T.S.		project no: 754-WOLGE205371P	figure no:
original size	A4			



drawn	**MB**	coffey A TETRA TECH COMPANY	client:	University of Wollongong
approved	**JPT**		project:	Social Sciences & Law Humanities and Arts Building
date	**25/05/2017**		title:	Core photograph CBH03 – Box 2 of 2
scale	**N.T.S.**		project no: 754-WOLGE205371P	figure no:
original size	**A4**			

coffey

Engineering Log - Borehole

Borehole ID.	***CBH04***
sheet:	1 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***26 May 2017***
principal:	
date completed:	***26 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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)	structure and additional observations
AD/T, N		Not Observed			0.0			**Silty Sandy CLAY**: medium plasticity, dark brown, fine to coarse grained sand, some rootlets.	M	F - St		**TOPSOIL / FILL**
								Sandy CLAY: medium plasticity, dark brown, brown, orange mottled, fine to coarse grained sand, some 20-50mm tree roots.	D	St		**ALLUVIAL** PID: 3.2 ppm
					0.5							
					1.0					VSt		
			SPT 9, 9, 13 N=22					- colour change to grey, orange, red mottled				PID: 3.1 ppm
					1.5			**Sandy CLAY /CLAYEY SAND**: medium plasticity, brown, dark brown mottled, fine to coarse grained sand, trace of organics, trace of fine to coarse sub-rounded gravel, trace of tree roots, trace of coal.				
					2.0			**Clayey SAND**: fine to coarse grained, brown, orange mottled, low to medium plasticity clay, trace of coal, trace of fine to coarse sub-rounded to sub-angular gravel, trace of organics.				
			SPT 6, 9, 12 N=21		2.5							
					3.0			**Sandy CLAY /CLAYEY SAND**: medium plasticity, brown, grey, orange mottled, medium to coarse grained sand, trace of medium to coarse sub-angular to sub-rounded gravel, trace of coal.				
					3.5							

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:07

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH04***
sheet:	2 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***26 May 2017***
principal:	
date completed:	***26 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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)	structure and additional observations
AD/T, N		Not Observed	SPT 6, 15, 25 N=40					**Sandy CLAY /CLAYEY SAND**: medium plasticity, brown, grey, orange mottled, medium to coarse grained sand, trace of medium to coarse sub-angular to sub-rounded gravel, trace of coal. *(continued)*	D	H		**ALLUVIAL**
					4.5			**Sandy CLAY**: medium plasticity, brown, fine to medium sand, trace of fine to medium sub-rounded gravel, trace of coal.				**RESIDUAL**
			SPT 10, 12, 16 N=28		5.0							
					5.5							
					6.0							
					6.5							
			SPT 7, 12, 26 N=38		7.0			**Sandy CLAY**: medium plasticity, grey, brown, orange mottled, fine to medium grained sand, trace of fine to medium sub-rounded to sub-angular gravel.	M	H		**EXTREMELY WEATHERED MATERIAL**
					7.5			- trace of shale				

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:07

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH04***
sheet:	3 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***26 May 2017***
principal:	
date completed:	***26 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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)	structure and additional observations
AD/T, N		Not Observed							M	H		**EXTREMELY WEATHERED MATERIAL**
								Sandy CLAY: medium to high plasticity, dark grey, fine to medium grained sand.				**EXTREMELY WEATHERED TO HIGHLY WEATHERED ROCK (SHALE)**
			SPT 15, 26, 37 N=63		8.5							
					9.0							
					9.5							
			SPT 15, 26, 34 N=60		10.0							
					10.5							
					11.0							
					11.5			Borehole CBH04 continued as cored hole				

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:07

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Cored Borehole

Borehole ID.	***CBH04***
sheet:	4 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***26 May 2017***
principal:	
date completed:	***26 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | drilling fluid: none | hole diameter :

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 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
					start coring at 11.37m						
NMLC	Not Observed		11.5		**CARBONACEOUS SILTSTONE**: fine grained, dark grey, some clay band.	XW to HW					SM, Sandy clay CS, IR, RO, VN - CO PT, 20°, PL, RO, Sandy clay - CO SM, Sandy clay PT, 20°, PL, RO, VN PT, 15 - 20°, IR, RO, Clay - CO
						XW					CS, 5°, IR, RO, Sandy clay - CO
			12.0		**NO CORE:** 0.23 m						SM, Sandy clay
					SANDSTONE: fine to medium grained, grey, dark grey.	XW to HW					
			12.5			HW to MW					CS, IR, RO, Sand - CO
					- colour change to grey	MW to SW		a=0.53 d=0.49	67%		JT, 30 - 45°, PL, RO, Sand - CO PT, 10 - 20°, ST, RO, VN
			13.0								PT, 15°, IR, RO, VN
											PT, 10°, ST, RO, VN
			13.5			SW		a=0.71 d=0.04			PT, 10 - 15°, PL, RO, VN
					- distinctly bedded						PT, 10 - 15°, PL, RO, VN
			14.0						100%		
			14.5								PT, 10 - 15°, PL, RO, VN
			15.0					a=0.48 d=0.05			

CDF_0_9_04BB.GLB Log COF BOREHOLE: CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:11

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
- HA hand auger

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

Borehole ID.	***CBH04***
sheet:	5 of 5
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***26 May 2017***
principal:	
date completed:	***26 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | drilling fluid: none | hole diameter :

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 (X = axial; O = diametral) VL L M H VH EH	samples, field tests & Is(50) (MPa) a = axial; d = diametral	core run & RQD	defect spacing (mm) 30 100 300 1000 3000	additional observations and defect descriptions (type, inclination, planarity, roughness, coating, thickness, other) particular / general
NMLC	Not Observed		15.5		**SANDSTONE**: fine to medium grained, grey, dark grey. *(continued)*	SW					
			16.0		Borehole CBH04 terminated at 16.00 m Refusal						
			16.5								
			17.0								
			17.5								
			18.0								
			18.5								
			19.0								

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
- HA hand auger

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

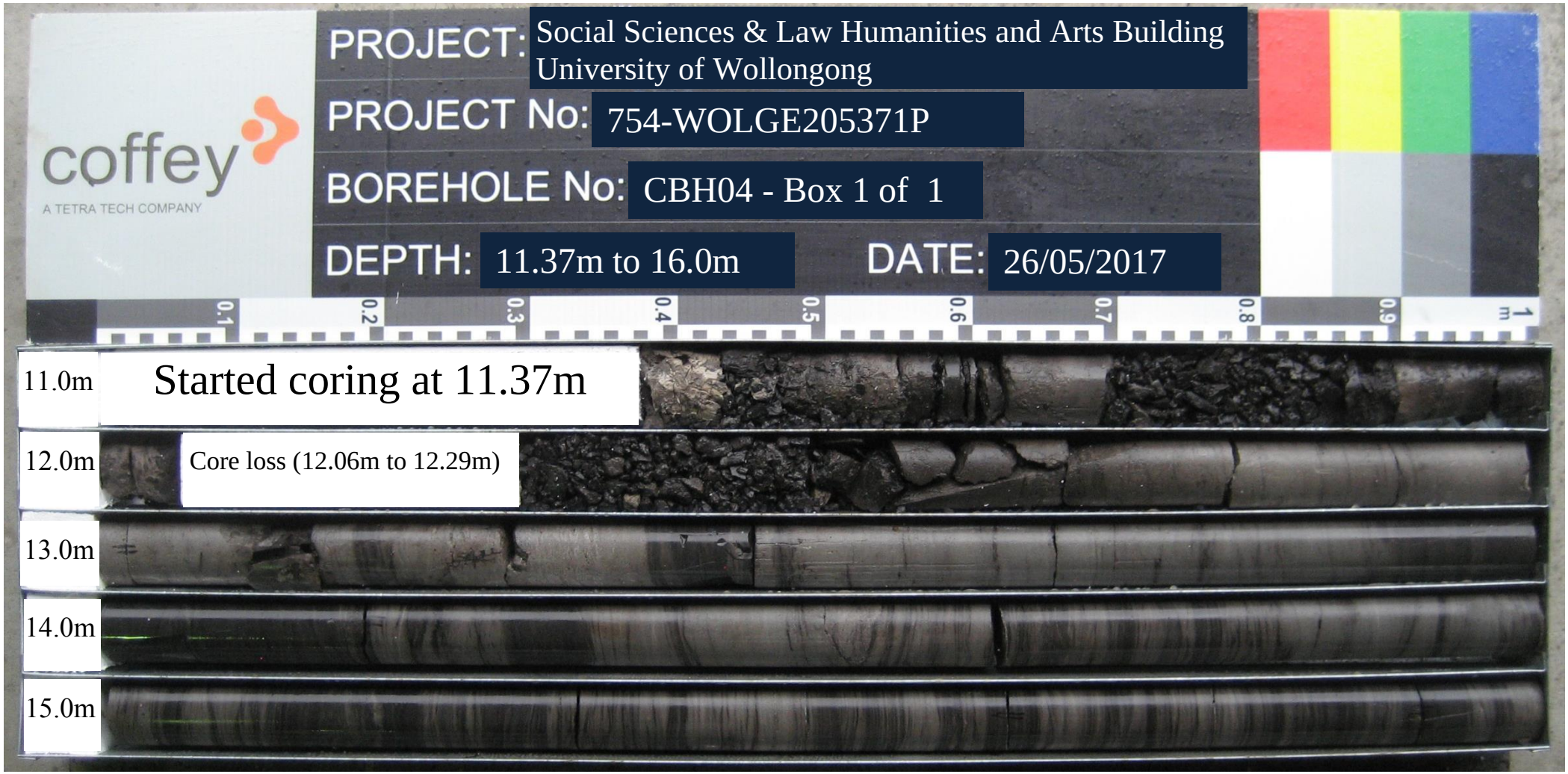
defect type
- PT parting
- JT joint
- SZ shear zone
- SS shear surface
- CS crushed seam
- SM seam
- DB drilling break

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

CDF_0_9_04BB.GLB Log COF BOREHOLE: CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:11



drawn	MB	coffey A TETRA TECH COMPANY	client:	University of Wollongong
approved	JPT		project:	Social Sciences & Law Humanities and Arts Building
date	26/05/2017		title:	Core photograph CBH04 – Box 1 of 1
scale	N.T.S.		project no: 754-WOLGE205371P	figure no:
original size	A4			

coffey

Engineering Log - Borehole

Borehole ID.	***CBH05***
sheet:	1 of 1
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***26 May 2017***
principal:	
date completed:	***26 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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)	structure and additional observations
HA — N —		Not Observed						**Sandy CLAY**: medium plasticity, brown, dark brown mottled, fine to medium grained sandstone, trace of rootlets.	M	F - St		**TOPSOIL**
								Borehole CBH05 terminated at 0.25 m Refusal				PID: 3.6 ppm

0.5 1.0 1.5 2.0 2.5 3.0 3.5

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:07

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

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

support
- M mud
- C casing
- N nil

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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH06***
sheet:	1 of 1
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***26 May 2017***
principal:	
date completed:	***26 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***MB***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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
HA — N		Not Observed						**Silty Sandy CLAY**: medium plasticity, dark brown, fine to medium grained sand, trace of rootlets.		F - St		**TOPSOIL / FILL**
								Borehole CBH06 terminated at 0.25 m Refusal				PID: 2.6 ppm
					0.5							
					1.0							
					1.5							
					2.0							
					2.5							
					3.0							
					3.5							

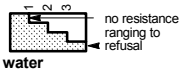
CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED 754-WOLGE205317.GPJ <<DrawingFile>> 20/06/2017 18:07

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

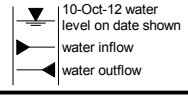
* bit shown by suffix e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration



water



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

coffey

Engineering Log - Borehole

Borehole ID.	***CBH07***
sheet:	1 of 1
project no.	***754-WOLGE205317***
client:	***University of Wollongong (Donald Cant Watts Corke)***
date started:	***24 May 2017***
principal:	
date completed:	***24 May 2017***
project:	***Social Sciences & Law Humanities & Arts Buildings***
logged by:	***IL***
location:	***University of Wollongong***
checked by:	***JPT***

position: Not Specified | surface elevation: Not Specified | angle from horizontal: 90°

drill model: Hanjin DB08, Trailer mounted | hole diameter :

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
HA N		Not Observed			0.0			**Sandy SILT**: brown, fine to medium grained sand, trace rootlets.	M	F		**TOPSOIL / FILL**
					0.5			**Silty CLAY**: low to medium plasticity, grey, brown, trace of fine to medium angular to sub-angular gravels, trace of rootlets.		St		
					1.0			Borehole CBH07 terminated at 0.8 m Refusal				
					1.5							
					2.0							
					2.5							
					3.0							
					3.5							

CDF_0_9_04BB.GLB Log COF BOREHOLE: NON CORED 754-WOLGE205317.GPJ <<DrawingFile>> 23/06/2017 09:08

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

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

support
- M mud
- C casing
- N nil

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

Appendix B - Laboratory Test Reports

South Nowra Laboratory

Coffey Services Australia Pty Ltd
ABN 55 139 460 521
43 Quinns Lane
South Nowra NSW 2541

Phone: +61 2 4429 5000
Fax: +61 2 4429 5099

A TETRA TECH COMPANY

Material Test Report

Report No: SNOW17S-00842-1
Issue No: 1

Client:	Coffey Services Australia Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	University of Wollongong.
Project No.:	754-SNOW00045AA
Project Name:	754-WOLGE205371 - UoW - New Building Sites
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Russell Booth
(Project Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 20/06/2017

Sample Details

Sample ID:	SNOW17S-00842
Client Sample:	
Date Sampled:	
Source:	
Material:	Refer to Test Pit Logs
Specification:	No Specification
Sampling Method:	Submitted by client
Project Location:	Wollongong. NSW.
Sample Location:	CBH03 Depth: 1.05-1.75m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	21.1	
Date Tested		14/06/2017	
Sample History	AS 1289.1.1	Oven-dried	
Preparation	AS 1289.1.1	Dry Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	13.5	
Mould Length (mm)		250	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	60	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	23	
Plasticity Index (%)	AS 1289.3.3.1	37	
Date Tested		16/06/2017	

Comments

N/A

South Nowra Laboratory

Coffey Services Australia Pty Ltd
ABN 55 139 460 521
43 Quinns Lane
South Nowra NSW 2541

Phone: +61 2 4429 5000
Fax: +61 2 4429 5099

California Bearing Ratio Test Report

Report No: CBR:SNOW17S-00840
Issue No: 1

Client:	Coffey Services Australia Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	University of Wollongong.
Project No.:	754-SNOW00045AA
Project Name:	754-WOLGE205371 - UoW - New Building Sites
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing.

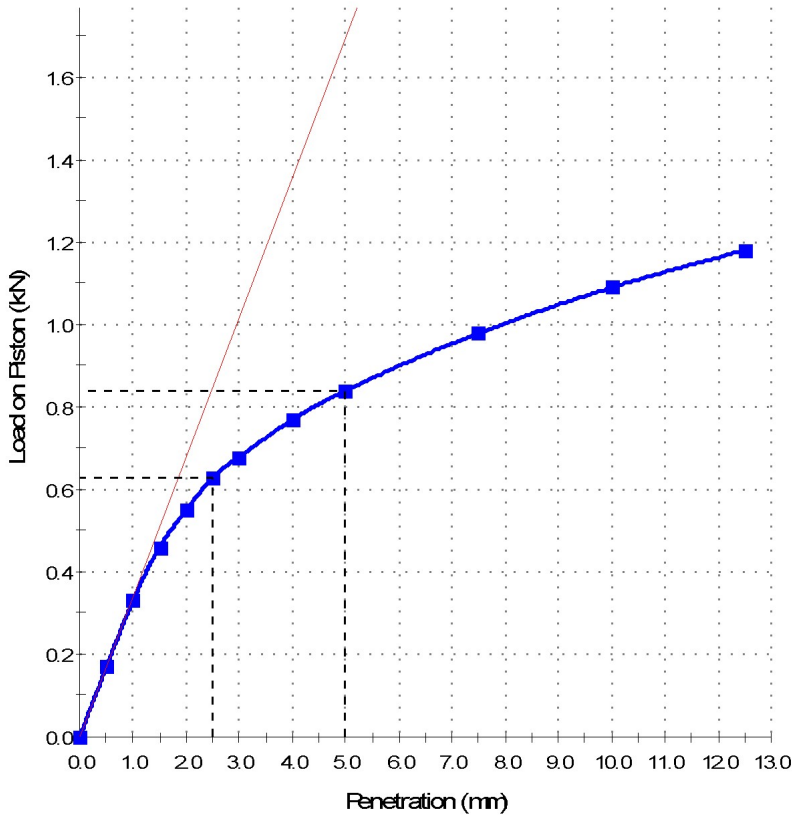
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Russell Booth
(Project Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 20/06/2017

Sample Details

Sample ID:	SNOW17S-00840	**Sampling Method:**	Submitted by client
Date Sampled:		**Material:**	Refer to Test Pit Logs
Date Submitted:	14/06/2017	**Source:**	
Date Tested:	19/06/2017	**Specification:**	No Specification
Project Location:	Wollongong. NSW.		
Sample Location:	CBH02, Depth: 0.4-0.7m		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 2.5mm (%):	**5.0**
Maximum Dry Density (t/m³):	1.55
Optimum Moisture Content (%):	25.1
Dry Density before Soaking (t/m³):	1.51
Density Ratio before Soaking (%):	97
Moisture Content before Soaking (%):	25.6
Moisture Ratio before Soaking (%):	102
Dry Density after Soaking (t/m³):	1.49
Density Ratio after Soaking (%):	96
Swell (%):	1.0
Moisture Content of Top 30mm (%):	33.3
Moisture Content of Remaining Depth (%):	29.1
Compactive Effort:	Standard
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Comments

South Nowra Laboratory

Coffey Services Australia Pty Ltd
ABN 55 139 460 521
43 Quinns Lane
South Nowra NSW 2541

Phone: +61 2 4429 5000
Fax: +61 2 4429 5099

A TETRA TECH COMPANY

California Bearing Ratio Test Report

Report No: CBR:SNOW17S-00841
Issue No: 1

Client:	Coffey Services Australia Pty Ltd (Wollongong) 118 Auburn Street Wollongong NSW 2500
Principal:	University of Wollongong.
Project No.:	754-SNOW00045AA
Project Name:	754-WOLGE205371 - UoW - New Building Sites
Lot No.:	**TRN:**

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing.

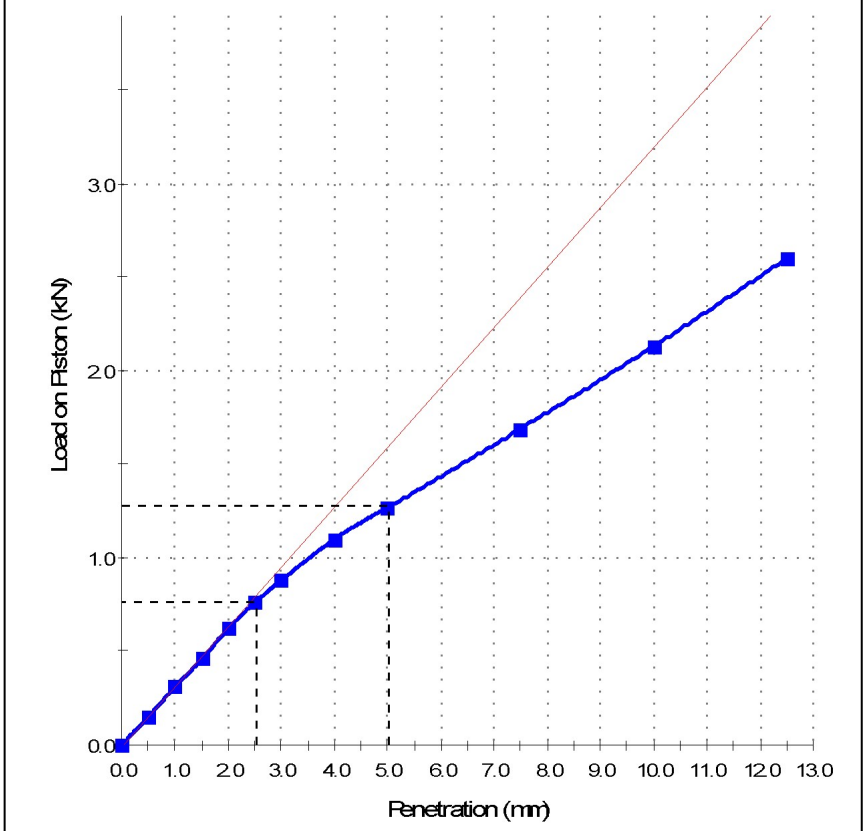
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Approved Signatory: Russell Booth
(Project Manager)
NATA Accredited Laboratory Number:431
Date of Issue: 20/06/2017

Sample Details

Sample ID:	SNOW17S-00841	**Sampling Method:**	Submitted by client
Date Sampled:		**Material:**	Refer to Test Pit Logs
Date Submitted:	14/06/2017	**Source:**	
Date Tested:	19/06/2017	**Specification:**	No Specification
Project Location:	Wollongong. NSW.		
Sample Location:	CBH04, Depth: 0.4-0.7m		

Load vs Penetration



Test Results

AS 1289.6.1.1

CBR At 5.0mm (%):	**6**
Maximum Dry Density (t/m³):	1.65
Optimum Moisture Content (%):	16.6
Dry Density before Soaking (t/m³):	1.65
Density Ratio before Soaking (%):	100
Moisture Content before Soaking (%):	16.8
Moisture Ratio before Soaking (%):	101
Dry Density after Soaking (t/m³):	1.62
Density Ratio after Soaking (%):	98
Swell (%):	2.0
Moisture Content of Top 30mm (%):	25.7
Moisture Content of Remaining Depth (%):	21.8
Compactive Effort:	Standard
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Oversize Material (%):	0.0

Comments

Certificate of Analysis

Coffey Environments Pty Ltd Wollongong
118 Auburn Street
Wollongong
NSW 2500

NATA Accredited
Accreditation Number 1261
Site Number 18217

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

Attention: **Jon Thompson**

Report **549166-S**
Project name SOIL ANALYSIS
Received Date Jun 06, 2017

Client Sample ID			**CBH01_2.5-2.95m**	**CBH02_1.5-1.95m**
Sample Matrix			**Soil**	**Soil**
Eurofins | mgt Sample No.			**S17-Jn05916**	**S17-Jn05917**
Date Sampled			**Jun 06, 2017**	**Jun 06, 2017**
Test/Reference	LOR	Unit		
Chloride	10	mg/kg	190	160
pH (1:5 Aqueous extract)	0.1	pH Units	4.9	4.8
Resistivity*	0.5	ohm.m	160	200
Sulphate (as SO4)	10	mg/kg	390	370
% Moisture	1	%	22	22

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results (regarding both quality and NATA accreditation).

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Chloride	Sydney	Jun 08, 2017	28 Day
- Method: E045 /E047 Chloride			
pH (1:5 Aqueous extract)	Sydney	Jun 08, 2017	7 Day
- Method: LTM-GEN-7090 pH in soil by ISE			
Sulphate (as SO4)	Sydney	Jun 08, 2017	28 Day
- Method: E045 Sulphate			
% Moisture	Sydney	Jun 06, 2017	14 Day
- Method: LTM-GEN-7080 Moisture			

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NATA # 1261
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Company Name: Coffey Environments Pty Ltd Wollongong
Address: 118 Auburn Street
Wollongong
NSW 2500

Project Name: SOIL ANALYSIS

Order No.:
Report #: 549166
Phone: 02 4201 1400
Fax: 02 4201 1401

Received: Jun 6, 2017 4:16 PM
Due: Jun 9, 2017
Priority: 3 Day
Contact Name: Jon Thompson

Eurofins | mgt Analytical Services Manager : Nibha Vaidya

Sample Detail						Chloride	pH (1:5 Aqueous extract)	Resistivity*	Sulphate (as SO4)	Moisture Set
Melbourne Laboratory - NATA Site # 1254 & 14271										
Sydney Laboratory - NATA Site # 18217						X	X	X	X	X
Brisbane Laboratory - NATA Site # 20794										
Perth Laboratory - NATA Site # 18217										
External Laboratory										
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**					
1	CBH01_2.5-2.95m	Jun 06, 2017		Soil	S17-Jn05916	X	X	X	X	X
2	CBH02_1.5-1.95m	Jun 06, 2017		Soil	S17-Jn05917	X	X	X	X	X
Test Counts						2	2	2	2	2

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil results are reported on a dry basis, unless otherwise stated.
3. All biota results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the Sample Receipt Advice.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram

mg/L: milligrams per litre

ug/L: micrograms per litre

ppm: Parts per million

ppb: Parts per billion

%: Percentage

org/100mL: Organisms per 100 millilitres

NTU: Nephelometric Turbidity Units

MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands. In the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
Batch Duplicate	A second piece of analysis from a sample outside of the clients batch of samples but run within the laboratory batch of analysis.
Batch SPIKE	Spike recovery reported on a sample from outside of the clients batch of samples but run within the laboratory batch of analysis.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 50-150%-Phenols & PFASs

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Chloride	mg/kg	< 10			10	Pass	
Sulphate (as SO4)	mg/kg	< 10			10	Pass	
LCS - % Recovery							
Chloride	%	98			70-130	Pass	
Sulphate (as SO4)	%	103			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
				Result 1					
Chloride	S17-Jn05917	CP	%	110			70-130	Pass	
Sulphate (as SO4)	S17-Jn05917	CP	%	110			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1	Result 2	RPD	Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
				Result 1	Result 2	RPD			
pH (1:5 Aqueous extract)	S17-Jn05978	NCP	pH Units	8.2	8.2	pass	30%	Pass	
Resistivity*	S17-Jn01529	NCP	ohm.m	45	46	3.0	30%	Pass	
% Moisture	S16-De11424	NCP	%	22	23	5.0	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Chloride	S17-Jn05917	CP	mg/kg	160	160	<1	30%	Pass	
Sulphate (as SO4)	S17-Jn05917	CP	mg/kg	370	370	1.0	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

Nibha Vaidya	Analytical Services Manager
Ryan Hamilton	Senior Analyst-Inorganic (NSW)
Ryan Hamilton	Senior Analyst-Metal (NSW)

Glenn Jackson
National Operations Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.