Report on Geotechnical Investigation

Bioresources Facility, University of Newcastle

82218015

Prepared for
University of Newcastle

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Cardno
Shaping the Future

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1 Introduction

1.1 Overview

This report presents the results of a geotechnical investigation undertaken by Cardno for the proposed Bioresources Facility at the University of Newcastle, Callaghan.

The investigation was commissioned by Mr Rhys Edwards of The University of Newcastle on the 03 of August 2017 via email correspondence and was generally undertaken in accordance with Cardno's proposal 48980518-0123.1 dated 21 of July 2017.

The geotechnical investigation works were performed in conjunction with a preliminary (contamination) site investigation which is reported separately ref "Preliminary Site Investigation", Job No. 82218015.002.0, dated 27 October 20017.

Along with the Request for Quotation (RFQ), a set of requirements and site plans were provided (Segment C) to Cardno and were utilised for the investigation.

A geotechnical investigations Ref. *' Report on Geotechnical Investigation – Proposed Anatomy Building'* Project No. 49652, Revision 1, dated 23/10/2010 [1] have been performed previously by Douglas Partners for an adjacent site. This investigation aimed to provide subsurface conditions, foundation recommendation and geotechnical parameters, comments on excavatability and site-sub soils classification.. Results of the Douglas Partners report have been utilised to provide relevant recommendations contained herein.

1.2 Proposed Development

With reference to the supplied RFQ documents, it is understood that the new, rectangular-shaped Bioresources facility is proposed to be situated in the location of the existing Biological Sciences Glass Houses and associated facilities with approximate footprint of 27m by 69m.

Reference to preliminary architectural plans provided as part of the tender documentation (Job No UON_1050, dated 31/01/2017 and attached in Appendix A), it is understood that the proposed development will likely comprise a two storey concrete building comprising traditional concrete column and suspended slab arrangement with one basement level that will likely be benched at ground level.

As previously mentioned the rectangular-shaped STEM+M Bio-resources facility will likely comprise a two storey concrete building.

1.3 Objectives

This geotechnical report outlines the investigation findings, provides comments on the implication of the geotechnical conditions as well as design and construction implications comprising:

> Providing earthwork procedures and guidelines including site preparations and excavatability of the site soils as well as bedrock and excavation conditions;

> Comments and recommendations on the founding condition and foundation design requirements;

> Comment on the requirements of the temporary and permanent excavation support strategies;

> Sub-soil classification for earthquake design in accordance with AS 1170.4-2007 *Structural Design Actions: Earthquake actions in Australia* [2]; and

> Aggressivity assessment to buried structural elements.

2 Site Description

The site is situated within the Western portion of the Callaghan Campus, University of Newcastle, Callaghan.. The proposed rectangular building envelope is bounded by;

> An existing carpark, paved access road and associated multistorey Medical Science buildings to the north;

> An existing carpark, access road and Science & Chemistry Building structures to the south;

> Mature trees and existing multistorey concrete structures to the east including the biological sciences building and Auchumuty Library; and

> Ring Road to the west.

Topographically, the site is situated within regionally gentle undulating terrain, positioned on foot slopes of an hill located to the south of the site. Overall site slopes generally trend north-west with gradients in the range of approximately 3 – 7˚ although, much of the site has been levelled and filled to provide a building platform for the existing structures.

The following features were also observed at the time of site investigation:

> Existing glass houses and associated facilities are located within the proposed building envelope. They were observed to be currently operational and bound by a large steel security fence.

> Minimal vegetation including small gardens, grassed areas, gardens between existing glass houses was encountered across the site due to the paved, developed surroundings. Some scattered mature trees were observed predominantly to the south and east of the site outside the extent of the investigation areas.

3 Investigation Methodology

3.1 Site Investigation

The investigation was undertaken on the 29th of September, 2017 and comprised the following:

> Location of services and marking out of borehole locations by an accredited service locator accompanied by a Cardno Geotechnical Engineer.

> Drilling of two boreholes (BH01- BH02) with a truck mounted scout rig using a combination of 300mm solid flight augers, 150mm solid flight augers with a TC bit and NMLC rock coring techniques. Auguring using solid flight auger techniques was performed to 4.2 and 3.3 m below ground level (BGL) in BH01 and BH02 m respectively. Following, NMLC rock coring techniques were conducted to depths of approximately 10.2 m and 7.1 m BGL respectively. The approximate borehole locations are shown in the attached site plan drawing DW01, attached in Appendix A.

> Standard Penetration Tests (SPT) were performed at 1.5m intervals where possible to assess the sub-ground strength and consistency.

> Bulk and disturbed samples of the site representative soils were collected from boreholes for subsequent laboratory testing and geotechnical log quality assurance.

> Cardno also performed contamination assessment simultaneous with geotechnical investigation which comprised the excavation of six (6) hand augers to depths of up to 0.8m BGL within the proposed building envelope. Due to the presence of services, confined spaces and concrete foundations associated with the surrounding structures, the testing locations were limited and are depicted in drawing DW01, attached in Appendix A.

All fieldwork including logging of subsurface profiles and collection of samples was carried out by an experienced geotechnical engineer from Cardno. Subsurface conditions are summarised in Section 4.1 and detailed in engineering logs of boreholes and hand augers are attached in Appendix B, together with explanatory notes.

3.2 Laboratory Testing

Geotechnical laboratory testing on selected samples recovered during the site investigation comprised the following:

> Two Shrink Swell tests to measure soil volume change over an extreme soil moisture content range.

> One Particle Size Distribution (PSD) test to aid in soil classification.

> Three Atterberg Limits tests to aid in soil classification.

> One California Bearing Ratio (CBR) test to aid in pavement design.

> Four Aggressivity tests to indicate aggressivity to buried structural elements.

> Point load testing on the selected rock core sections.

The geotechnical testing was conducted at Cardno's NATA accredited construction materials testing laboratory, and the environmental testing at an external NATA accredited laboratory. Test report sheets are attached in Appendix C.

4 Investigation Findings

4.1 Published Data

Reference to the Newcastle 1:250,000 Geological Series Sheet SI 56-2 [3], indicates that the site is situated within the Tomago Coal measures. Geologically, these areas are known to comprise of shale, mudstone, sandstone, tuff, coal and residual soils derived from the weathering of these rocks.

4.2 Subsurface Conditions

The subsurface profile encountered across the site in the two boreholes are generally summarised as follows:

> **UNIT F - PAVEMENT/FILL**: BH01 and BH02 consisted of pavement material and associated filling to depths of 0.25 m and 0.4 m BGL respectively. Both pavements were surfaced by a 35 mm thick asphalt wearing course. BH01 consisted of a Sandy GRAVEL containing fine to coarse, sub rounded to sub angular gravels to a depth of 0.25 m. BH02 consisted of a fine to coarse Sandy GRAVEL pavement material comprising rounded to sub-angular gravels. Material was observed to be dry to moist condition at the time of investigation; overlying

> **UNIT R - RESIDUAL SOIL**: Medium to high plasticity Silty CLAY was encountered below fill/pavement layer to approximately 4.2 m and 6.7 m BGL within boreholes BH01and BH02 respectively. The material was observed to be moist of plastic limit to a depth of 2.5m BGL where subsurface moisture decrease and material was judged dry of plastic limit. The residual clays were observed to grade to extremely weathered siltstone extremely low to very low strength, becoming more competent with depth. In general; the residual clays were found to be stiff in consistency from approximately 0.25 – 1.0 m, grading to very stiff to hard at depths below 1.0m BGL; overlying

> **UNIT T - SILTSTONE**: Extremely weathered to distinctly weathered, thinly laminated siltstone of Tomago formation was encountered in BH01 and BH02 at depths of approximately 4.2 m and 3.3 m to the depth of 10.18 m and 7.09 m BGL respectively. Consistent defects included parallel bed partings as well as thin carboniferous seams. The siltstone bedrock was assessed to be initially of very low strength although increase to low to medium strength as depth increased. Strength was estimated based on the point load index and tactile assessment in the field.

The subsurface conditions within the proposed building envelope encountered within the hand augers generally consisted of GRAVEL, Silty SAND and SAND FILL materials to depths up to 0.7m overlying Residual Silty CLAY. Hand augers HA4 and HA5 were not excavated into the underlying soil due to the potential presence of services. Many of the fill materials encountered are thought to be associated with service backfill.

Groundwater levels were not observed at the time of the drilling due to the presence of drilling fluid although were noted at depths in the Douglas Partners Report [1] within a layer of sandstone that is thought to be overlain by the siltstone rock encountered on the proposed site (at depths beyond the current investigation limits). It should be noted that groundwater levels are likely to fluctuate with variations in climatic and site conditions; however, it is considered unlikely that significant amounts of groundwater will be encountered during construction.

The subsurface profiles encountered in the boreholes and test bores are presented in the engineering logs attached in Appendix B together with explanatory notes.

5 Laboratory Test Results

5.1 PSD & Atterberg Limits Testing

The results of the Particle size distribution and Atteberg limits testing undertaken on representative site soils encountered are summarised below in Table 5-1 with report sheets attached in Appendix C.

Table 5-1 Summary of PSD & Atteberg testing Results

Location	Depth (m)	Material description	LL (%)	PL (%)	PI (%)	%Passing 0.075mm	%Passing 2.36mm
BH02	0.6 - 0.85	Silty CLAY; red mottled grey	47	16	31	-	-
BH02	3.4 - 3.7	Silty CLAY; Pale grey mottled red and light-brown	66	19	47	-	-
BH02	4.3 – 4.6	Silty CLAY; grey-dark grey bedding mottled red	52	24	28	-	-
BH02	0.2-0.4	Sandy GRAVEL; light brown	-	-	-	45	18

Notes to table:
LL – Liquid Limit
PL – Plastic Limit
PI – Plasticity Index

5.2 Shrink Swell Test Results

The results of the laboratory shrink swell tests undertaken on representative clayey soils of the site are summarised below in Table 5-2 with the test report sheets attached in Appendix C.

Table 5-2 Summary of Shrink Swell Test Results

Hole ID	Depth (m)	Sample Type	Soil Type	Swelling Strain (Esw %)	Shrinkage Strain (Esh %)	Shrink/Swell Index (Iss %)
BH01	1.0 - 1.28	U50	Silty CLAY; Pale grey mottled orange	4.2	1.9	2.9
BH02	1.5 - 1.78	U50	Silty CLAY; Pale grey mottled orange	2.1	1.8	1.7

Notes to table:
U50: Testing undertaken on thin walled 50mm diameter tube

5.3 California Bearing Ratio Test Results

The results of the CBR testing undertaken on representative subgrade materials encountered are summarised below Table 5-3 in with the report sheets attached in Appendix C.

Table 5-3 Summary of CBR Testing

Hole ID	Depth	Material Description	W (%)	SMDD (t/m³)	SOMC (%)	Swell (%)	CBR (%)
BH01	0.3-0.5	Silty CLAY	21.4	1.71	19.0	1.5	4.5

Notes to table:
W: Field Moisture
SMDD: Standard Maximum Dry Density
SOMC: Standard Optimum Moisture Content

5.4 Soil Aggressivity Test Results

The results of the soil aggressivity test undertaken on representative site soils encountered are summarised below in Table 5-4 with the report sheets attached in Appendix C.

Table 5-4 Summary of Soil Aggressivity Test Results

Hole ID	Depth (m)	Soil Type and (Groundwater Condition)	pH(1:5)	EC (µS/cm)	Resistivity (Ωcm)	Sulphate (mg/kg), Classification	Chloride (mg/kg), Classification
BH01	2.5 - 2.95	Silty CLAY (B)	6.2	420	2400	820	180
BH01	4.0 - 4.2	Silty CLAY (B)	7.2	400	2500	380	190
BH02	1.0 – 1.45	Silty CLAY (B)	4.7	540	1900	480	360
BH02	2.5 - 2.95	Silty CLAY (B)	4.8	850	1200	740	630

Notes to table:
-Exposure classification calculated in respect to both steel & concrete guidelines outlined in AS2159-2009

Non Aggressive
Mildly Aggressive
Moderately Aggressive
Severely Aggressive
Very Severely Aggressive
– Not Tested/ Not Applicable

5.5 Point Load Test Results

The results of the axial and diametric point load testing undertaken on selected rock core samples obtained from BH01 & BH02 are presented in Appendix D. A summary of point load testing results and discussion on associate rock strengths can be found in Section 10.

6 Material Disposal & Reuse Options

6.1 Material Disposal Options – Waste Classification

A preliminary waste classification of slag and pavement material that are likely to be generated during the works is provided below based on environmental laboratory testing conducted.

The laboratory tests results were compared against the NSW DECCW, Waste Classification Guidelines – Part 1: Classifying Waste, 2014 [4] (Waste Classification Guidelines), and are presented in the summary tables attached in Appendix C.

The Waste Classification Guidelines [4] presents contaminant threshold concentrations (CT1 & CT2) for classifying waste. If CT1 and CT2 concentrations are exceeded, toxicity characteristic leaching procedure (TCLP) testing may be undertaken to determine the mobility of the contaminant. In such cases, TCLP and specific contaminant concentrations (SCC1 and SCC2) threshold concentrations are adopted in place of CT threshold values. The Waste Classification Guidelines [4] have been adopted to classify the waste as either general solid, restricted or special waste for potential off-site disposal at a licenced waste disposal facility.

The results with reference to the Waste Classification Guidelines [4] are summarised as follows.

> All material analysed meet CT1 criteria for general solid waste

TCLP testing was undertaken on the slag sample as a precaution, although not required for the purpose of the waste classification. The resultant classifications with reference to the SCC limits would remain as general solid waste for the pavement material containing slag from BH001.

The following should be considered with regard to waste classification of the existing pavement materials:

> Gross contamination has been identified in similar slag affected materials within Newcastle LGA; and

> Testing conducted was targeted on likely contaminated materials based on the field investigation and previous experience with similar projects, and conducted on samples from bores within the street pavement (i.e. not in verge areas).

Considering the above factors, it is recommended all pavement materials containing a component of slag either remain on site or are disposed of as **General Solid Waste**. Additional testing and supervision by a qualified environmental consultant would be required during construction in pavement materials being disposed of as General Solid Waste to confirm contaminant concentrations are below the appropriate guidelines. Laboratory testing and assessment is also recommended if artificial materials or signs of contamination are encountered in verge materials during the works.

It should be noted that Waste disposal should be conducted at a suitably licenced waste disposal facility.

Excavated materials other than slag containing material and pavement materials are likely to be suitable to be classified as Excavated Natural Material (ENM); however, specific testing of the material should be undertaken at the time of removal to confirm this.

6.2 Material Reuse Options

Preliminary assessment has been conducted to inform potential on-site reuse of materials generated during construction. The assessment comprised comparison of test results with the National Environment Protection (Assessment of Site Contamination) Measure 1999 as amended 16 May 2013 [5] (NEPM Guidelines 2013).

It should be noted that the material assessment and comparison against NEPM Guidelines 2013 [5] is preliminary only in nature and an unexpected finds protocol shall be implemented during construction. See the accompanying preliminary contamination site investigation report ref “Preliminary Site Investigation“, Job No. 82218015.002.0, dated 27 October 20017 for further details.

The following guidelines have been adopted for assessment of materials that could be generated from the works and potentially reused during construction. It is noted that the materials could either be reused in road pavement or verge areas, and the most conservative residential land use criteria has been considered.

Health-based Criteria

> Residential land use with garden / accessible soil health investigation levels (HIL A), considering the existing fruit tree and possibility for residents to plant fruit or vegetables in the verge;

> Soil Health Screening Levels (HSL) for vapor intrusion recommended for Residential A land use (HSL A); and

> Management Limits for TPH fractions F1-F4 in soil for Residential, Parkland and Open Space land use.

Ecological Criteria

> Ecological Screening Levels (ESLs) for TPH fractions F1-F4, BTEX and Benzo(a)Pyrene in soil for Residential A land use; and

> Ecological investigation levels (EILs) criteria for urban residential / public open space land-use.

It is noted that pH, CEC and clay content testing can be conducted to calculate appropriate EILs. In the absence of the testing the most conservative EIL from Tables 1B(1) to 1B(3) from NEPM Guidelines 2013 [5] has been adopted.

There were no exceedances to samples of pavement materials including slag when assessed against the guidelines noted above. Based on geotechnical assessment and limited contamination testing conducted, existing pavement and slag materials excavated during the works are **not considered suitable for reuse on site in structural areas.**

Encountered materials other than the slag or pavement materials are considered suitable for reuse subject to specific assessment by a geotechnical engineer during construction.

7 Preliminary Acid Sulfate Soil Assessment

A preliminary ASS assessment has been conducted to assess the presence of potential acid sulfate soils (PASS) or actual acid sulfate soils within the anticipated soil disturbance area.

The preliminary assessment conducted comprised the following.

> A review of available published geological data and acid sulfate soil risk maps, which indicates no known occurrence of acid sulfate soil materials throughout the site.

Due to the significant distance from any known occurrence of acid sulfate soils, analysis was not required and utilisation of an ASSMP during the works is not considered necessary.

The assessment is preliminary in nature only, and if indications of acid sulfate soils are encountered during the works further testing and assessment would be required.

8 Site Sub-Soil Classification for Earthquakes

For the purposes of earthquake design, the site has been given a site sub-soil classification of **Class C_e – Shallow Soil Site** in accordance with AS1170.4 – 2007 [2]. Although rock is present at between 3.3 and 6.0m depth beneath the site, the overlying residual clay means that the site is a shallow soil site. If the building is founded on the rock then **Class B_e – Rock Site** would need to be adopted. The hazard factor (Z) for Newcastle, NSW is 0.11 as seen also in AS1170.4 – 2007 [2].

9 Earthworks

Preliminary information indicates that the basement floor will like be situated approximately on grade on the northern end of the site and in up to 1.0-2.0m of cut on the southern end of the site. Considering the likely foundation levels necessary for the construction of the Bioresources Facility, earthworks are expected to comprise shallow excavations and some minor filling.

Subsurface conditions expected to be encountered within the shallow excavation depths in the base of the building envelope are expected to comprise of loose to medium dense gravel & sand fill to depths of up to 0.7m overlying firm to stiff residual clays to depths of approximately 1.0m below existing ground levels grading to very stiff residual clay and as such excavations should be readily undertaken using conventional earthmoving equipment such as a backhoe or medium sized (10-15tonne) excavator.

Excavations or trenches in the residual stiff or better soils would be expected to stand close to vertical in the short-term. Where personnel are to enter excavations, options for short-term excavations include benching or battering back of the excavations at 1H:1V or the support of excavations within the residual soil. Permanent batters in this material should be battered at 3H:1V or flatter and protected against erosion by vegetation.

Minor filling where required that is to be subject to structural loading must be placed and compacted in accordance with AS 3798-2007 *Guidelines on Excavation for Commercial and Residential Structures* [7]. The following procedure should be adopted for construction of filling on sloping ground:

> Filling should be placed on stripped surfaces which are free of filling, topsoil or other deleterious material.

> The fill material must be free of vegetation such as tree stumps, roots, root fibres or other organic matter.

> Fill should not comprise material with particle sizes of greater than 100 mm or 2/3 of the compacted layer thickness.

> Benching of the slopes where fill is to be placed with slopes steeper than 8H:1V will be required. This should comprise horizontal benches with adequate width (minimum 1.0m) to accommodate the nominated compaction equipment.

> Placement of fill in uniform horizontal layers with compaction of each layer to a minimum dry density ratio of 95% Standard Compaction (Australian Standard AS 1289 Clause 5.1.1) at moisture contents of in the order of 85 - 115% of SOMC or ±2% but generally as close to SOMC as practical.

> Refer to Section 12 of this report for construction of filling under the pavement formation requirements.

10 Foundation Conditions & Design Recommendations

Based on our internal structural assessment of the expected column loads, column loads are expected to be in the order of 2000 kN under serviceability conditions and in the order of 2700 kN under ultimate load conditions.

Based on a review of the borehole logs, expected geotechnical conditions, foundation levels and likely column loads, it is expected that high level shallow foundations supported on the very stiff residual clay or pile foundations embedded into the underlying siltstone bedrock would be required to support the proposed Bioresources building.

General design parameters and recommendations are presented in the following sections and should be used as guidance for the design. The detailed design of the foundations should consider the appropriate structural loads against serviceability and ultimate limit state criteria.

10.1 Aggressivity

Based on the summary of analytical results presented in Table 5-4 and on the basis of Chlorides, Sulfates, pH and resistivity, it was found that the residual clay soils were predominantly non aggressive towards potential buried concrete and steel elements.

The pH levels for samples taken from BH02 just fell within the exposure classification for mildly aggressive soil conditions for concrete structures as per AS2159 (pH between 4 and 5).

10.2 Site Classification

Australian Standard AS 2870-2011 [6] establishes performance requirements and specific designs for common foundation conditions as well as providing guidance on the design of footing systems using engineering principles. Site classifications however are not strictly applicable to this site due to the development consisting of a two level development with basement and a likely regrade in the order of 1.0-2.0m of cut. Therefore, the following site classification should be used as guidance only.

Site classification of foundation soil reactivity provides an indication of the relativity of the ground surface with seasonal variation in moisture. The site classification is based on procedures presented in AS2870-2007 [6], the typical soil profiles found during investigation and the results of the laboratory testing.

The laboratory shrink swell summarised in Table 5-2 indicate that the soils are moderately to highly reactive, with Iss values in the range of 1.7% to 2.9%.

The classification of sites with fill of depths greater than 0.4m (deep fill) comprising of material other than sand would be Class P. An alternative classification may however be given to sites with controlled fill where consideration is made to the potential for movement of the fill and underlying soil based on the moisture conditions at the time of construction and the long term equilibrium moisture conditions.

The following classification is provided under the assumption that fill materials contained within the site and deleterious materials are removed prior to construction.

Based on the subsurface profiles encountered during the investigation and laboratory shrink swell test results, and in accordance with the AS2870-2011 [1], and in the absence of abnormal moisture conditions would be classified aa Class H1 Classification, with a characteristic surface movement in the order of 50-60mm.

10.3 Foundation Design

Design of proposed foundations should be undertaken in accordance with the requirements of the following:

> AS 2159 (2009) Piling – Design & Instillation [8]

> AS 5100 (2017) Bridge Design Set [9]

> Other relevant Australian and international standards

> Engineering principals

For the pile foundations, AS 2159-2009 [8] requires that the ultimate design geotechnical strength ($R_{d,g}$) is not less than the design action effect (E_d). The design geotechnical strength is calculated as the ultimate geotechnical strength ($R_{d,ug}$) multiplied by a geotechnical strength reduction factor (ϕ_g).

The value of the geotechnical strength reduction factor is influenced by the following factors:

> ϕ_{gb} – Basic geotechnical strength reduction factor, which is influenced by an assessment of the various risk factors relating to the site, design methodology and the method of pile instillation.

> ϕ_{tf} – Intrinsic testing factor based on the type of pile testing to be undertaken; and

> K – Testing benefit factor dependant on the percentage of piles to be tested.

The assessment of individual risk ratings for risk factors as set out in Table 4.3.2 (A) of AS 2159-2009 [8] will need to be undertaken by the designer of the foundations. However, to assist in the design of foundations, an assessment of the average risk rating has been undertaken based on the following factors and assumptions:

> A level and quality of the geotechnical investigation that has been undertaken to date which includes in-situ testing including boreholes, rock coring and laboratory assessment of the rock strength properties;

> No pile testing will be undertaken;

> Similar experience with the design of foundations with socket into very stiff clays and siltstone bedrock; and

> A competent and locally experienced piling contractor to install the piles.

Based on the assessment of the above factors and assumptions, an Average Risk Rating (ARR) for the design of the foundations into the weathered bedrock of 3.41 could be adopted.

Based on Table 4.3.2 (C) of AS 2159-2009 [8], an ARR of 3.0 to 3.5 is defined as moderate risk. The basic geotechnical strength reduction factor (ϕ_g) for single isolated piles (low redundancy system) founded into the weathered bedrock profile within the site is assessed to be 0.48. This reduction factor should also be applied for ultimate limit state design of the shallow foundations.

An increase in the geotechnical strength reduction factor could be adopted by adopting the following procedures:

> Inspection and certification of pile sockets by a suitably experienced geotechnical engineer.

> Pile testing regime depending on the type and extent of the testing. Dynamic testing of bored piles is not typically undertaken due the magnitude of column loads. Therefore, an increase on the basic geotechnical strength reduction factor by dynamic testing is not recommended. Osterberg, static or statnamic tests could be utilised to increase the geotechnical reduction factor.

For all piles where the basic geotechnical strength reduction factor is greater than 0.4, AS2159-2009 [8] requires the integrity of the pile shaft to be assessed by testing and inspection.

Ultimate and serviceability limit state of the piles, pile groups and shallow foundations should be undertaken during the detailed design phase of the proposed development.

10.3.1 Foundation Conditions

The site in its current condition is generally underlain by minor thickness of pavement and filling followed by 4.0 – 6.0m of residual silty clay underlain by siltstone as previously descried. SPTs were undertaken at each borehole location for the purpose of providing information on the subsurface soils strength and consistency. The testing was undertaken from 1.0m BGL and at approximately 1.5m spacing's where suitable until practical refusal. SPT results indicated that the silty clay was generally very stiff in consistency with refusal occurring at 4.2m in BH01 on weathered siltstone rock.

Pocket penetrometer testing was also undertaken on representative samples from the upper 1.0m of silty clay and indicated that the material was stiff (90-100 kPa) in consistency. The decrease in strength near the

surface was assumed to be influenced by the increase in soil moisture. It was observed that the material in the upper 1.0m was largely wet of its plastic limit, with moisture generally decreasing with depth.

Figure 10-1 below provides a comparison of Axial and Diametrical Is(50) values with respect to elevations for the rock core sample recovered from BH01.

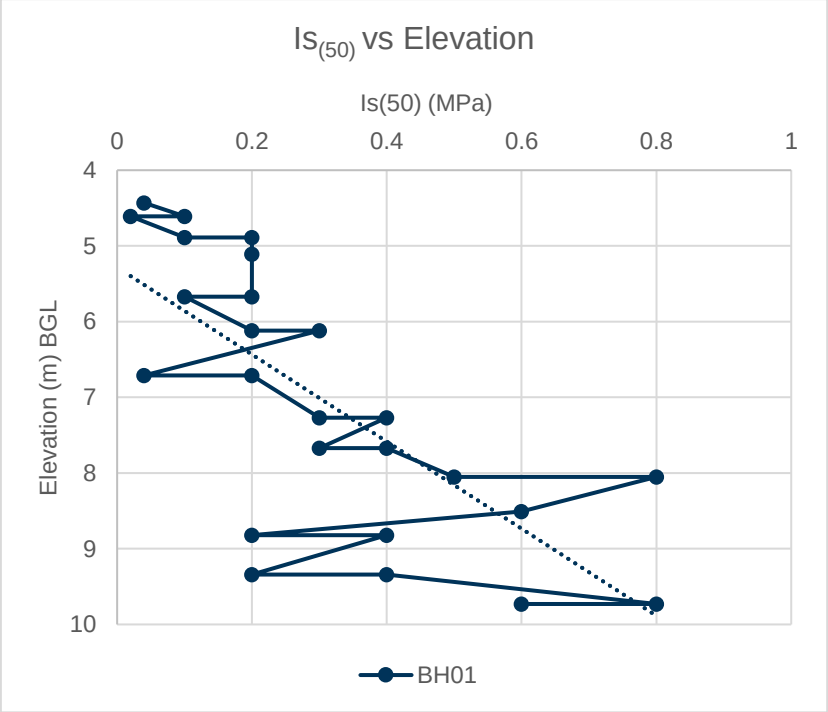

Figure 10-1 Comparison of $Is_{(50)}$ Values vs Elevation Depth for BH01

The above assessment indicates some variably in the strength throughout the weathered rock profile, although it can be seen that the bedrock generally increases in strength with increase in depth. Generally the rock ranges from low to medium strength with bands of very low strength weathered material.

BH02, located in the southern, elevated portion of the site, returned core samples of insufficient rock strength to perform adequate point load testing to depths of approximately 5.90 m. Samples of rock core tested from below 5.90 m BGL indicated the rock was of low strength which was comparable to the rock strengths encountered at similar elevations in BH01.

Based on previous experience with greater Sydney basin sandstone & siltstone and reference to Substance Unconfined Compressive Strength (UCS) of Sydney basin sandstone & siltstone is generally between 15 to 30 times the point load $I_{S(50)}$ values. Although this correlation has been suggested based on the laboratory testing of Hawksbury Sandstone, it has been widely used for correlation of UCS and point load testing results of sandstones of other geological formations.

A conservative site correlation factor of 13 for the site siltstone has been adopted based on experience with Tomago siltstone of the site locality. Based on this assumption, a representative UCS value of 1.0 MPa has been adopted for the extremely weathered siltstone from 4.0m to depths of up to 7.0m BGL (Unit T1)and a representative UCS value of 4.5 MPa for the distinctly weathered siltstone from depths greater than 7.0m BGL (Unit T2)has been adopted for design purposes.

The extremely weathered siltstone bedrock present to depths up to 7.0m BGL can be classified as Class V (T1) shale/siltstone based on the recommendations presented in P.J.N Pells et al [9], Foundations on Sandstone and Shale in the Sydney Region. The distinctly weathered siltstone bedrock presents at depths greater than 7.0m BGL can be classified as Class III shale/siltstone (T2).

10.3.2 Foundation Parameters

It should be noted that based on the site investigation results, Class III shale/siltstone is expected to present at deeper levels within the southern portion compared to the northern of the site and as such extension of

the foundation piles within the southern portion of the site could be expected (if embedment into Class III is required in design). In addition, itis recommended to place all the foundations in material of similar strata. This will require foundations to comprise pile foundations extending to at least Class V siltstone. Considering the site subsurface conditions, bored concrete piles are expected to be suitable.

Design values presented in Table 10-1 assumes that:

> Pile foundations comprise centrally loaded piles suitably embedded into Class V Siltstone bedrock or the underlying Class III Siltstone bedrock.

> Piles are constructed using appropriate construction practice.

> Serviceability limit state design is undertaken for the foundation to consider the settlement of the various foundation types and structural tolerances.

The foundation detailed design should include assessments of both strength and serviceability limit states. General design parameters are presented in the following sections and should be used as guidance for the design.

Bored piles or shallow foundations required to support the structure could be designed using the parameters presented in Table 10-1 below. Reference to AS 2159-2009 *Piling Design and Installation* [8] a geotechnical reduction factor (ϕ_g) of 0.48 is recommended for the below geotechnical ultimate design value. The reduction factor has been estimated utilising the procedure outlines in AS 2159-2009 Table 4.3.2 (A) with Individual Risk Rating (IRR) nominated based on the site conditions, design procedure and assumed construction control monitoring procedures as outlined in Section 1.1.

Table 10-1 Geotechnical Design Parameters for Pile and Shallow Foundations

Description	Inferred Rock Class[1]/ Soil Consistency	Average UCS (MPa)[5]	Serviceability End Bearing Pressure (MPa)	Ultimate[6] End Bearing (MPa)	Ultimate[6] Shaft Adhesion (Compression) within layer (MPa)	Intact Rock Elastic Modulus (MPa)
Unit R Very stiff residual clays present at depth below 1.0m BGL for a minimum 1X1m pad foundation with 0.5m embedment	-	-	0.2	0.3	0.04	8
Unit T1 Very Low to Low strength SILTSTONE present to depths up to 6.0m BGL	Class V SILTSTONE	1.0	0.70[4]	3.0[3]	0.1[2]	50
Unit T2 Low to Medium strength SILTSTONE present to depths greater than 6.0m BGL	Class III SILTSTONE	4.5	2.0[4]	6.0[3]	0.35[2]	200

Notes:
1- The inferred rock classifications are based on P.J.N Pells et al [10].
2- The shaft adhesion value is based on clean socket roughness of R2 [10] or better which must comprise grooves of depth 1-4mm, width greater than 2mm at spacing 50mm to 200mm.
3- At ultimate bearing pressure large settlements greater than 5% of the minimum foundation dimensions are expected.
4- Serviceability bearing pressure is expected to cause settlement of <1% of footing dimension for foundations embedded in weathered rock.
5- Average UCS values are based on interpretation of $I_{s(50)}$ values and representative rock samples UCS values based on an assumed correlation factor of 15.
6- Ultimate loads shall be reduced by a Basic geotechnical strength reduction factor of 0.48 to obtain allowable pile loads.

Inspection of the foundation conditions and pile excavations shall be undertaken by experienced geotechnical engineer to confirm the founding conditions and above values. All foundation excavations should be kept free of fall-ins and water ponding.

The proposed piling methodology must consider equipment sufficient for drilling into the described subsurface conditions.

11 Retaining Structures

11.1 Design Criteria

This section outlines design criteria and parameters for the purpose of retaining structures design. Based on the preliminary information regarding the proposed site cut it is likely that retaining walls will be required to facilitate final design levels. Excavations of up to 1.0-2.0m excavations are likely to be required within the southern portion of the site.

The following design criteria should be adopted for the design of the retaining structures:

> AS 4678 (2002) – Earth Retaining Structures [8];

> AS 3798 (2007) – Guideline on Earthworks for Commercial and Residential Developments [7]; and

> An accepted industry practice for global stability factors of safety (FOS) for slopes of 1.3 for long-term conditions and 1.2 for short term construction conditions.

For a simplified or preliminary design, retaining structures such as cantilever or gravity walls may adopt a triangular earth-pressure distribution. During detailed design, the designer should select earth pressure coefficients based on the specific geotechnical and geometrical situation under consideration. The retaining walls design should comprise assessment of foundation bearing capacity, sliding, overturning and global stability checks.

11.2 Retaining Wall Design Parameters

The subsurface profile to be retained by the shoring structure is generally expected to comprise:

> Unit F to depths of up to 1.0m BGL; overlying

> Unit R to depths up to 4.0m BGL.

It should be noted that the above conditions are inferred from the discrete borehole locations and variation of the subsurface conditions should be considered in the design.

It is recommended to calculate the lateral earth pressure coefficient values based on the wall geometry, type and backfill slopes using the values provided in the following table. The earth coefficients presented in the following table have been calculated for level backfill/ground surface and vertical wall arrangements. The designer should reference to the requirements of AS 4678 (2002) – Earth Retaining Structures [8] for the selection of appropriate groundwater level for the design purpose. It should be noted that groundwater was not encountered during site investigation but groundwater levels can fluctuate with seasonal variations in climate.

Recommended design parameters for retaining walls are presented below in Table 11-1.

Table 11-1 Retaining Wall Design Parameters

Unit ID	Description	Soil/ Rock Density (kN/m^3)	Effective Friction Angle[1] ϕ' (°)	Effective Cohesion[1] C' (kPa)	Undrained Cohesion Cu (kPa)	Effective Elastic Modulus E' (MPa)	Active Earth Pressure Coefficient K_A	Passive Earth Pressure Coefficient K_P
F	Loose to medium dense Silty SAND / GRAVEL	18	29	0	0	7	0.35	2.88
R	Very Stiff Residual Silty CLAY	20	26	5	100	30	0.39	2.56

Notes to table:
(1) Coefficients are for use with effective stress calculations.

11.3 Construction Recommendations

> Retaining wall backfill should comprise granular free-draining material with appropriate separation geofabric placed between the wall and granular backfill;

> All foundations should be founded on similar strata to limit the effects of differential settlement;

> Subsurface drainage lines should be placed behind the permanent and temporary (depending on the type) retaining wall, to direct seepage to appropriate points of discharge. Subsurface lines should be installed with consideration of maintenance and flush-out points;

> Additional surcharge loading from adjoining structures should be taken into consideration when designing retaining walls; and

> Retaining wall foundations should be inspected by experienced geotechnical and engineer.

12 Pavements

12.1 Design Criteria

It is understood that the construction of the proposed Bioresources Facility will likely comprise the reconstruction of some of the adjacent car parking areas. The current extent of the pavement reconstruction is unknown, therefore the following section details preliminary pavement design based on expected traffic loadings and current subsurface conditions.

Pavement thickness design has been performed in accordance with mechanistic procedure indicated in Austroads AGPT02-12 Guide to Pavement Technology [11]. It is also understood that Newcastle City Council adopts AUS-SPEC Specification [12], and the pavement design requirements from the specification have been utilised herein. The specification will be referred to as NCC specifications in the following report sections.

12.2 Design Parameters and Pavement Thickness Composition

12.2.1 Design Subgrade

BH01 & BH02 were drilled within the existing car park pavement where subgrade material comprised Silty CLAY at depths of 0.30m BGL. Laboratory analysis indicated a CBR of 4.5% for the residual Silty CLAY subgrade. With reference to laboratory testing, tactile assessment and acknowledgement of potential for variability of the subgrade compositions across the site a CBR of 3% has been adopted for design purposes.

12.2.2 Design Traffic

In absence of detailed traffic analysis, pavement design has been undertaken using likely design traffic loading calculations undertaken by Cardno based on the number of car parking spaces available in the adjacent areas to the proposed Bioresources Facility. The following assumptions have been made in order to calculate appropriate design traffic loadings:

> Annual Average Daily Traffic (AADT) estimated by Cardno:
  - 45 Vehicles Per Day (VPD) for both carpark pavements;
> A percentage of heavy vehicles (HV) of 5% to account for vehicles accessing the proposed loading bay:
> A heavy vehicle growth rate of 3% per year over the design period;
> A design Life of 25 Years;
> Austroads [11] example Traffic Load Distribution (TLD) in the absence of detailed traffic data or vehicle class counts;
> Direction factor of 1.0 for one-way traffic and Lane Distribution Factor (LDF) of 1.0 for single lane traffic has been assumed.
> Where data varies from the information provided, review of pavement design may be required.

A traffic loading of 5.5×10^4 Design Equivalent Standard Axle (DESA) with a 25 year design life has been adopted for the purpose of design.

12.2.3 Pavement Composition and Thickness Design

Table 12-1 below indicates the recommended preliminary pavement thickness design for the likely car park reconstruction based on likely traffic loadings and design subgrade CBR. It should be noted that layer thicknesses detailed in Table 12-1 are minimum thicknesses regardless of construction tolerances.

Table 12-1 Unbound Granular Pavement Reconstruction

Car Park Reconstruction	Founded on Silty CLAY Subgrade
Wearing Course	AC10 (40mm)
Basecourse (mm)	150
Subbase (mm)	180
Total Thickness (mm)	370
Subgrade design CBR	3.0%
Design Life	25 years
Design Traffic	5.5×10^4 DESA

Notes to table:
(1) Refer to Section 12.3 for material specification and compaction requirements.
(2) Select subgrade material may be required in areas where elevated moisture conditions in subgrade materials are encountered particularly during wet weather.

12.3 Construction Notes

12.3.1 Subgrade Preparation

Subgrade preparation should be in general accordance with the relevant council construction specifications and the following procedures.

> Excavation, including removal of fill and existing pavement material to subgrade formation level, with the spoiling of any deleterious or over wet material.

> The existing pavement gravels may be suitability for re-use as a select material except those containing slag (refer to Cardno's PSI report for details?). Further investigation and additional laboratory testing may be required to confirm the suitability. Preliminary discussion on the suitability of slag pavement can be seen in Section 6.

> Static proof-rolling of the exposed subgrade using a heavy (minimum 10 tonne) roller under the direction of an experienced geotechnical consultant. This should identify the unsuitable and yielding areas.

> Where filling or subgrade replacement is required, the materials employed should be free of organics or other deleterious material and could compromise the existing salvaged pavement gravels. The material should also have a maximum particle size of 100mm or one third of the layer thickness, with a CBR > 10%.

> Excessive wetting and drying of the subgrade should be prevented. The subgrade should be covered by base course/select layer to prevent moisture ingress (i.e. due to wet weather).

> Where placement of the select material is required due to the potential subgrade elevated moisture conditions, placement of a nominal 200 mm thick select layer will be required to facilitate the construction. This requirement should be assessed following the excavation to the subgrade level.

> Compaction of the subgrade, subgrade filling and select material (if required) should be to a minimum 100% of SMDD in layers of not greater than 250 mm loose thickness. Moisture contents should be within 0 to -3% of SOMC.

It is recommended that trafficking of the subgrade be minimised or avoided (where possible) during construction to prevent the permanent deformation of the subgrade. The boxed road alignment should not be used as a haul road during construction.

12.3.2 Material Specifications and Compaction Requirements

Pavement materials and compaction requirements for new pavement construction should conform to the following requirements.

Table 12-2 Summary of Material Specification and Compaction Requirements

Pavement Course	Material Specification	Compaction Requirements
Basecourse High quality crushed rock	Material complying with RMS QA Specification 3051 Category D [13] and a CBR ≥ 80%, PI ≤ 8%	Min 98% Modified (AS1289 5.2.1)
Subbase Subbase quality crushed rock	Material complying with RMS QA Specification 3051 Category D [13] and a CBR ≥ 30%, PI ≤ 12%	Min 95% Modified (AS1289 5.2.1)
Select Existing pavement material or other imported granular	Minimum CBR 15%	Min 100% Standard (AS 1289 5.1.1) (or 75% Density Index for non-cohesive material)
Subgrade or replacement	Minimum CBR 3%	

All granular pavement material quality should be in general accordance with RMS QA Specification 3051 [13] for Traffic Category D and the relevant design period.

Minimum testing on all potential imported pavement materials should include four-day soaked CBR, Atterberg Limits, Particle Size Distribution analysis and Wet/Dry strength determination. Pre-treatment of materials prior to testing would be advisable for material subject to breakdown.

12.3.3 Alternative Construction Materials

Alternative materials used in the construction should comply with the specifications indicated in this report. It is suggested that Cardno be consulted prior to the use of alternate materials. Contractors should specify materials to be used in construction at the time of tendering, with all materials to be approved prior to incorporation in the works.

Relatively low permeability and durable pavement materials would be recommended for new flexible reconstruction given the subgrade conditions.

12.3.4 Subsoil Drainage

Owing to the potential for cracking along the interface where new pavements are joined to existing pavements, it is suggested that an intra-pavement drain should be provided at the interface between any sections of new and existing pavements. Intra-pavement subsoil drains should penetrate to the subgrade or to the base of any select material.

It is recommended the subgrade should be constructed with sufficient cross fall (in general 3%) to assist in reducing retention time for moisture entering the pavement. The subsoil drains will require flush-out points and regular maintenance to ensure their correct operation. Subsoil drains shall be connected into the existing / proposed stormwater drainage system.

Provision of adequate cross fall to direct runoff from the pavement to drainage lines should be achieved as part of the reconstruction.

12.3.5 Pavement Interface and Tie-In

Where new pavement construction abuts an existing pavement, care should be exercised to either create a clean vertical construction joint or provide adequate benching. The basecourse and subbase layers should be benched for a minimum of 0.3 m for the entire pavement width, in accordance with the NCC Pavement Extension Typical Detail.

Adequate compaction of the subgrade and pavements in this area is essential to maximise the performance of the pavement. It is noted that where variable pavements are abutted, the potential for localised failure is generally greater. Consideration should be given to sealing any cracks that may develop between existing and new pavements. Installation of intra-pavement drainage at subgrade level at the interface with the adjoining road sections is recommended. If construction of intra-pavement drainage is not possible due to the road geometry further consultation would be required.

12.3.6 Inspections

The subgrade will require inspection by an experienced geotechnical consultant after boxing out or filling to design subgrade level. The purpose of inspections is to confirm design parameters, assess the suitability of the subgrade to support the pavement, and delineate areas which may require subgrade replacement or remedial treatment (such as placement of select layer) prior to pavement construction.

13 Summary

Based upon the findings of the report the site is deemed to be geotechnically suitable for the intended use as a UoN building.

Building footings could be shallow or deep depending upon the loadings required.

Pavement materials and slag materials shall be disposed of as general solid waste. Subject to further testing at the time of removal.

Other excavated soils are likely be suitable for classification as ENM. Subject to further testing at the time of removal.

14 Limitations

Cardno has performed investigation and consulting services for this project in general accordance with current professional and industry standards. The extent of testing was limited to discrete test locations and variations in ground conditions can occur between test locations that cannot be inferred or predicted.

A geotechnical consultant or qualified engineer shall provide inspections during construction to confirm assumed conditions in this assessment. If subsurface conditions encountered during construction differ from those given in this report, further advice shall be sought without delay.

Cardno, or any other reputable consultant, cannot provide unqualified warranties nor does it assume any liability for the site conditions not observed or accessible during the investigations. Site conditions may also change subsequent to the investigations and assessment due to ongoing use.

This report and associated documentation was undertaken for the specific purpose described in the report and shall not be relied on for other purposes. This report was prepared solely for the use by University of Newcastle and any reliance assumed by other parties on this report shall be at such parties own risk.

References

[1] Douglas Partners, “Report on Geotechnical Investigation - Proposed Anatomy Building,” DP, September 2010.

[2] Australian Standard AS1170.4, “Earthquake actions in Australia,” Standards Australia, 2007.

[3] Newcastle Geology Map, “1:250,000 Geological Series Sheet SI 56-2 (First Edition),” NSW Department of Mines, 1966.

[4] NSW EPA, “Waste Classification Guidelines - Part 1: Classifying Waste,” NSW Environment Protection Authority, Sydney, November 2014.

[5] National Environment Protection (Assessment of Site Contamination) Measure 1999, “Schedule B1 Guidelines on Investigation Levels For Soil and Groundwater,” National Environment Protection Council (NEPC), 16 May 2013.

[6] Australian Standard AS2870-2011, “Residential Slabs and Footings,” Standards Australia, 2011.

[7] Australian Standard AS3798-2007, “Guidelines on Earthworks for Commercial and Residential Structures,” Standards Australia, 2007.

[8] Australian Standard AS2159-2009, “Piling - Design & Installation,” Standards Australia, 2009.

[9] Australian Standard AS5100-2007, “Bridge Design Set,” Standards Australia, 2017.

[10] P. J. Pells, G. Mostyn and B. F. Walker, “Foundations on Sandstone and Shale in the Sydney Region,” Australian Geomechanics, Dec 1998.

[11] Austroads AGPT02-12, “Guide to Pavement Technology Part 2: Pavement Structural Design,” Austroads Ltd, 2012.

[12] Newcastle Technical Manuals, “Subdivision,” City Of Newcastle, 2014.

[13] RMS QA Specification 3051 (Ed 6 Rev 2), “Granular Base and Subbase Materials for Surfaced Road Pavements,” Roads and Maritime Services, April 2011.

Bioresources Facility, University of Newcastle

APPENDIX A

SITE PLAN

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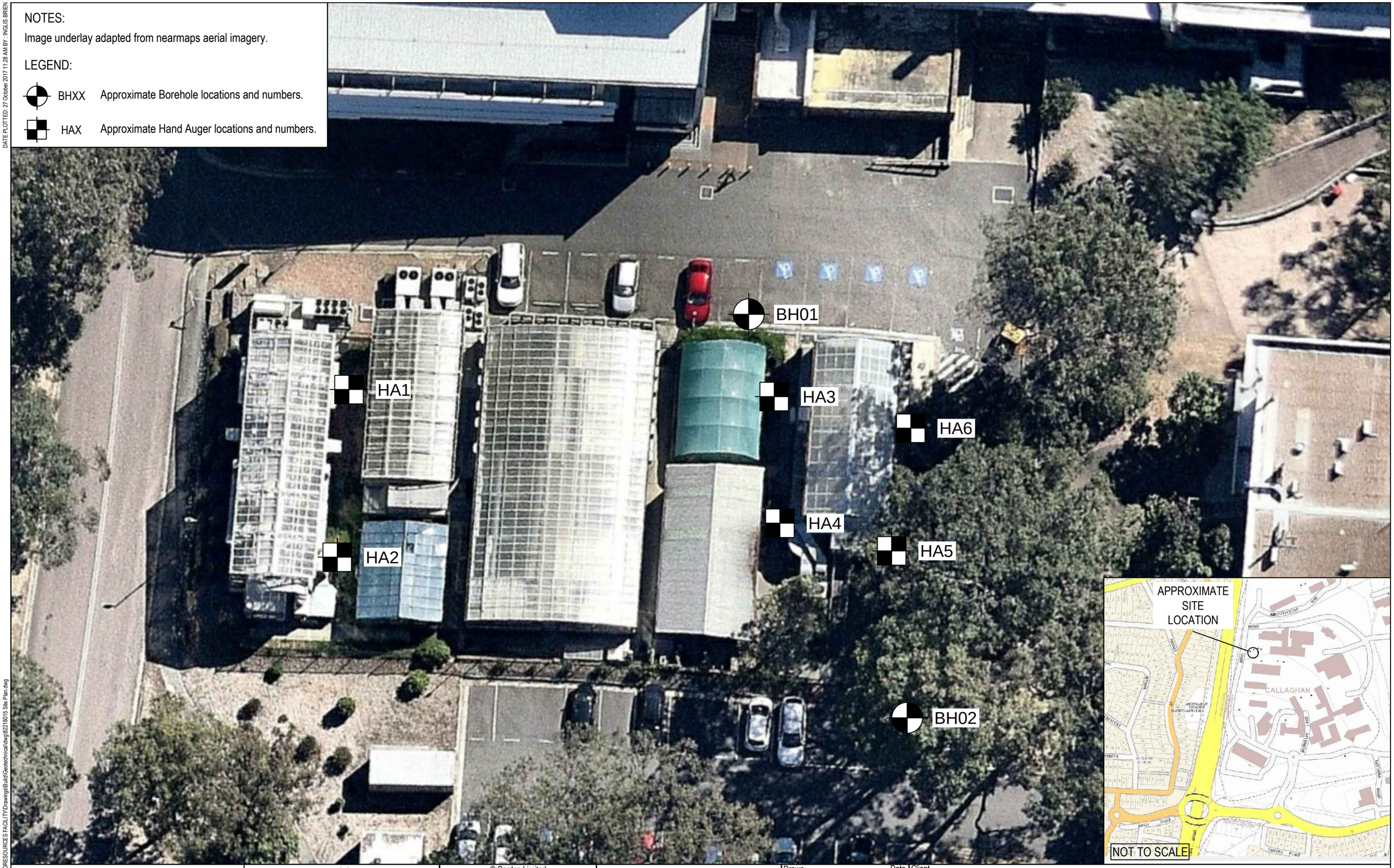
NOTES:

Image underlay adapted from nearmaps aerial imagery.

LEGEND:

BHXX Approximate Borehole locations and numbers.

HAX Approximate Hand Auger locations and numbers.



0 5 10m

SCALE 1:250 @A3

NORTH

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Drawn	JG	Date 18/10/17
Checked	IB	Date 25/10/2017
		Date
Verified		Date
Approved		

Client: University of Newcastle

Project: Geotechnical Investigation
Bioresources Facility
Ring Road, University of Newcastle, Callaghan

Title: Site Plan

Status: FOR INFORMATION ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

Project Number	Scale	Size
82218015	1:250	A3

Drawing Number: DW01

Revision: A

DATE PLOTTED: 27 October 2017 11:28 AM BY : INGLIS BRIEN

XREFs:

CAD File: N:\Projects\82\PRY\80\15_UON BIORESOURCES FACILITY\Drawings\Build\Geotechnical\dwg\82218015 Site Plan.dwg

Bioresources Facility, University of Newcastle

APPENDIX

B

ENGINEERING LOGS & EXPLANATORY NOTES

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BOREHOLE LOG SHEET

Client: University of Newcastle **Project:** UON Bioresources Facility **Location:** University of Newcastle, Callaghan			**Hole No: BH01**
Position: See drawing	**Job No: 82218015**	**Angle from Horizontal: 90°**	**Sheet: 1 of 3**
Rig Type: Scout		**Bit: Diamond Impreg/TC**	**Surface Elevation:**
Casing Diameter: HQ	**Core Diameter: 52 mm**		**Driller: MICK**
Date Started : 29/9/17	**Date Completed: 29/9/17**	**Logged By: JG**	**Contractor: Total Drilling**
			Date Logged: 29/9/17

Drilling				Sampling & Testing	Depth (m)	Material Description					
Method	Resistance	Casing	Groundwater	Sample or Field Test		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
Auger 'TC' Bit			Not Encountered				GW	0.04m ASPHALT 0.10m	M	VD	
				D 0.10 - 0.30 m			GP	FILL; Sandy GRAVEL; fine to coarse (slag fragments), sub-angular to angular, light brown	D - M	VD	
				B 0.30 - 0.50 m				0.25m FILL; GRAVEL; coarse (slag fragments), grey			RESIDUAL SOIL
								Silty CLAY; medium to high plasticity, pale grey mottled orange			
				U50 1.00 - 1.28 m	1						
									w > PL	F	
					2		CH				
				D 2.50 - 2.95 m SPT 2.50 - 2.95 m 5, 10, 15 N*=25				As above, becomes friable, siltstone rock structure becoming evident (Extremely weathered siltstone)			
					3				*w < PL*	VSt	3.00: Lenses of dark grey carboniferous colour present throughout depth
		HQ		D 4.00 - 4.20 m SPT 4.00 - 4.20 m 23, 7/50mm N*=R	4			4.20m			
								Continued as Cored Drill Hole			
					5						

See Standard Sheets for details of abbreviations & basis of descriptions

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CORE LOG SHEET

Client: University of Newcastle			**Hole No: BH01**
Project: UON Bioresources Facility			
Location: University of Newcastle, Callaghan	**Job No: 82218015**		**Sheet: 2 of 3**
Position: See drawing	**Angle from Horizontal: 90°**		**Surface Elevation:**
Rig Type: Scout	**Bit: Diamond Impreg/TC**		**Driller: MICK**
Casing Diameter: HQ	**Core Diameter: 52 mm**		**Contractor: Total Drilling**
Date Started : 29/9/17	**Date Completed: 29/9/17**	**Logged By: JG**	**Date Logged: 29/9/17**

Drilling						Material Description				Defect Description		
Method	Water	TCR	RQD	RL (m AHD)	Depth (m)	Graphic Log	SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components	Weathering	Estimated Strength $Is_{(50)}$ MPa ● - Axial ○ - Diametral VL 0.1 L 0.3 M 1 H 3 VH 10 EH	Average Natural Defect Spacing (mm) 20 40 100 300 1000	Visual	Additional Data DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other
					1							
					2							
					3							
					4							
							4.20m START CORING AT 4.20m					
NMLC	100% Water RETURN	100	30		5		Laminated SILTSTONE; grey with light brown staining	HW				4.29 m: BP, 0°, PR, S, SN 4.32 m: BP, 0°, PR, S, SN 4.39 m: BP, 0°, PR, S, SN
								MW				4.57 m: BP, 0°, PR, S, SN 4.64 m: BP, 0°, PR, S, SN 4.74 m: IS, 0°, Clay, 20 mm 4.82 m: IS, 0°, Clay, 20 mm
							As above, change in colour to dark grey					5.15 m: BP, 0°, PR, S, VNR 5.23 m: JT, 30°, PR, S, VNR 5.34 m: JT, 70°, PR, S, CN 5.40 m: IS, 0°, PR, S, Coal, 3 mm 5.44 m: IS, 5°, CU, S, Coal 5.52 m: IS, 20°, U, S, Clay 5.56 m: JT, 30°, U, Coal 5.60 m: BP, 5°, U, S, SN
		100	69				As above, change in colour to grey with light brown staining and dark grey carbonaceous bedding	MW				5.79 m: IS, 10°, IR, Coal, 2 mm 5.89 m: IS, 0°, PR, Coal, 25 mm

See Standard Sheets for details of abbreviations & basis of descriptions

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NOTES:

1) Visual strength classification
2) Discontinuities recorded from the horizontal

CORE LOG SHEET

Client: University of Newcastle			**Hole No: BH01**
Project: UON Bioresources Facility			
Location: University of Newcastle, Callaghan	**Job No: 82218015**		**Sheet: 3 of 3**
Position: See drawing	**Angle from Horizontal: 90°**		**Surface Elevation:**
Rig Type: Scout	**Bit: Diamond Impreg/TC**		**Driller: MICK**
Casing Diameter: HQ	**Core Diameter: 52 mm**		**Contractor: Total Drilling**
Date Started : 29/9/17	**Date Completed: 29/9/17**	**Logged By: JG**	**Date Logged: 29/9/17**

Drilling						Material Description				Defect Description		
Method	Water	TCR	RQD	RL (m AHD)	Depth (m)	Graphic Log	SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components	Weathering	Estimated Strength $Is_{(50)}$ MPa ● - Axial ○ - Diametral VL 0.1 L 0.3 M 1 H 3 VH 10 EH	Average Natural Defect Spacing (mm) 20 40 100 300 1000	Visual	Additional Data DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other
NMLC	100% Water RETURN	100	69		7		Laminated SILTSTONE; grey with light brown staining *(continued)*	SW				6.20 m: JT, 20°, IR, SN 6.29 m: IS, 0°, CU, carboniferous, 2 mm 6.31 m: IS, 0°, U, carboniferous, 5 mm 6.44 m: JT, 10°, U, S, VNR 6.54 m: JT, 5°, PR, S, SN 6.57 m: JT, 60°, U, S, SN 6.74 m: IS, 0°, PR, carboniferous clay, 5 mm 6.81 m: IS, 10°, PR, carboniferous clay 6.86 m: BP, 0°, U, S, SN 6.93 m: BP, 0°, U, S, SN, 20 mm set of 2 7.00 m: JT, 80°, PR, S, IS 0 mm long
								F				7.32 m: JT, 10°, PR, S, SN 7.43 m: BPIS, 5°, PR, S, SN, carboniferous
					8		As above, grading to fine-grained sandstone					7.63 m: BPIS, 10°, PR, S, carboniferous 7.76 m: JT, 20°, U, S 8.08 m: JT, 10°, U, S, CN
		100	100		9							9.09 m: JT, 85°, U, S, 150 mm long 9.36 m: BP, 0°, CU, S, CN 9.48 m: JT, 10°, CU, S, CN 9.77 m: BP, 0°, PR, S, CN
					10		10.18m					9.98 m: IS, 0°, U, S, 3 mm carboniferous clay 10.07 m: JT, 20°, U, RF, VNR, carboniferous clay
					11		TERMINATED AT 10.18 m Target depth					

See Standard Sheets for details of abbreviations & basis of descriptions

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NOTES:

1) Visual strength classification
2) Discontinuities recorded from the horizontal

BOREHOLE LOG SHEET

Client: University of Newcastle **Project:** UON Bioresources Facility **Location:** University of Newcastle, Callaghan			**Hole No: BH02**
	Job No: 82218015		**Sheet: 1 of 3**
Position: See drawing	**Angle from Horizontal: 90°**		**Surface Elevation:**
Rig Type: Scout	**Bit: TC/Diamond Impreg**		**Driller: MICK**
Casing Diameter: HQ	**Core Diameter: 52 mm**		**Contractor: Total Drilling**
Date Started : 29/9/17	**Date Completed: 29/9/17**	**Logged By: JG**	**Date Logged: 29/9/17**

Drilling			Groundwater	Sampling & Testing	Depth (m)	Material Description					
Method	Resistance	Casing		Sample or Field Test		Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
Auger 'TC' Bit			Not Encountered					0.04m ASPHALT			
				B 0.20 - 0.40 m			GW	FILL; Sandy GRAVEL; light brown, fine to coarse, rounded to sub-angular [river gravel present]	D - M	VD	
								0.40m Silty CLAY; medium to high plasticity, red mottled grey	*w < PL*		RESIDUAL SOIL
				B 0.60 - 0.85 m					*w = PL*		
				D 1.00 - 1.45 m SPT 1.00 - 1.45 m 4, 8, 10 N*=18	1						
				U50 1.50 - 1.78 m			CH			VSt	
					2				*w > PL*		
				D 2.50 - 2.95 m SPT 2.50 - 2.95 m 5, 10, 15 N*=25							
		HQ			3			3.30m			
								Continued as Cored Drill Hole			
					4						
					5						

See Standard Sheets for details of abbreviations & basis of descriptions

Cardno
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CORE LOG SHEET

Client: University of Newcastle			**Hole No: BH02**
Project: UON Bioresources Facility			
Location: University of Newcastle, Callaghan	**Job No: 82218015**		**Sheet: 2 of 3**
Position: See drawing	**Angle from Horizontal: 90°**		**Surface Elevation:**
Rig Type: Scout	**Bit: TC/Diamond Impreg**		**Driller: MICK**
Casing Diameter: HQ	**Core Diameter: 52 mm**		**Contractor: Total Drilling**
Date Started : 29/9/17	**Date Completed: 29/9/17**	**Logged By: JG**	**Date Logged: 29/9/17**

Drilling						Material Description				Defect Description		
Method	Water	TCR	RQD	RL (m AHD)	Depth (m)	Graphic Log	SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components	Weathering	Estimated Strength $Is_{(50)}$ MPa ● - Axial ○ - Diametral VL 0.1 L 0.3 M 1 H 3 VH 10 EH	Average Natural Defect Spacing (mm) 20 40 100 300 1000	Visual	Additional Data DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other
					1							
					2							
					3							
							3.30m START CORING AT 3.30m					
NMLC	100% Water RETURN	100	67		4		Laminated SILTSTONE; dark grey	HW				3.47 m: BP, 0°, U, RF, FILLED, extremely weathered rock infilling 3.70 m: SZ, 0°, 40 mm, pale grey, clay
							As above, change in colour to grey-dark grey mottled red-brown, rock structure becoming more evident					4.21 m: JT, 75°, U, RF, SN 4.31 m: SZ, 0°, 30 mm, pale grey
					5							4.69 m: IS, 5°, PR, clay, 10 mm 4.75 m: BP, 10°, PR, S, SN 4.77 m: IS, 0°, pale grey, soft clay, 20 mm 4.81 m: BP, 0°, PR, S, SN 4.94 m: 70°, U, S, CN 5.14 m: 70°, U, S, SN
		100	87				5.90m Laminated SILTSTONE; dark grey	MW				5.62 m: IS, 30°, CU, S, clay, pale-grey, 10 mm 5.71 m: JT, 40°, CU, S, SN 5.76 m: JT, 40°, CU, S, SN 5.91 m: BP, 0°, PR, S 5.95 m: JT, 10°, PR, S, VNR, iron veneer

See Standard Sheets for details of abbreviations & basis of descriptions

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NOTES:

1) Visual strength classification
2) Discontinuities recorded from the horizontal

CORE LOG SHEET

Client: University of Newcastle
Project: UON Bioresources Facility
Location: University of Newcastle, Callaghan

Hole No: BH02

Job No: 82218015 **Sheet:** 3 of 3

Position: See drawing **Angle from Horizontal:** 90° **Surface Elevation:**
Rig Type: Scout **Bit:** TC/Diamond Impreg **Driller:** MICK
Casing Diameter: HQ **Core Diameter:** 52 mm **Contractor:** Total Drilling
Date Started : 29/9/17 **Date Completed:** 29/9/17 **Logged By:** JG **Date Logged:** 29/9/17

Drilling						Material Description				Defect Description		
Method	Water	TCR	RQD	RL (m AHD)	Depth (m)	Graphic Log	SOIL TYPE, plasticity or particle characteristic, colour, secondary & minor components ROCK NAME, grain size and type, colour, fabric and texture, inclusions & minor components	Weathering	Estimated Strength $Is_{(50)}$ MPa ● - Axial ○ - Diametral VL 0.1 L 0.3 M 1 H 3 VH 10 EH	Average Natural Defect Spacing (mm) 20 40 100 300 1000	Visual	Additional Data DEFECT TYPE, orientation, shape, roughness, infilling or coating, thickness, other
NMLC	100% Water RETURN	100	87		7		Laminated SILTSTONE; dark grey *(continued)*	MW				6.04 m: JT, 20°, PR, RF, SN, iron 6.19 m: BP, 10°, U, S, CN 6.41 m: BP, 0°, U, S, SN 6.60 m: BP, 0°, U, S, SN 6.63 m: IS, 0°, 5 mm, soft clay, pale grey
							6.75m Laminated SILTSTONE; grey mottled orange	DW				
							7.09m TERMINATED AT 7.09 m Target depth					
					8							
					9							
					10							
					11							

See Standard Sheets for details of abbreviations & basis of descriptions

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NOTES:

1) Visual strength classification
2) Discontinuities recorded from the horizontal

TESTBORE LOG

CLIENT : University of Newcastle
PROJECT : Contamination Investigation
LOCATION : Callaghan

HOLE NO : HA1
PROJECT REF : 82218015
SHEET : 1 OF 1

EQUIPMENT TYPE : Hand Auger | METHOD : Hand Auger
DATE EXCAVATED : 29/9/17 | LOGGED BY : JB | CHECKED BY :
LOCATION : See Drawing for location

GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, plasticity or particle characteristic, colour Rock Type, grain size, colour Secondary and minor components	MOISTURE / WEATHERING	CONSISTENCY / REL DENSITY / ROCK STRENGTH	DYNAMIC PENETROMETER	HAND PENETRO-METER (kPa) 100 200 300 400	STRUCTURE & Other Observations
Not Encountered		0.0			FILL; GRAVEL, medium to coarse, sub-rounded to angular					FILL, gravel on surface
	0.05m				0.05m					
	ES-HA1				Silty CLAY, medium to high plasticity, brown					RESIDUAL
	0.15m					MC = PL	St			
					As above, colour change to orange to pale brown				X	HP In-situ = 120 kPa
					0.30m					
					Silty CLAY, medium to high plasticity, grey mottled orange					RESIDUAL
									X	HP In-situ = 170 kPa
	0.40m									
	ES-HA1				As above, trace of root fibres	MC = PL	St			
	0.50m	0.5			0.50m					
					Testbore HA1 terminated at 0.50 m					
					End at natural profile					
		1.0								

MOISTURE & GROUNDWATER
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

ROCK STRENGTH
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

ROCK WEATHERING
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO (NSW/ACT) PTY LTD

TESTBORE LOG

CLIENT : University of Newcastle
PROJECT : Contamination Investigation
LOCATION : Callaghan

HOLE NO : HA2
PROJECT REF : 82218015
SHEET : 1 OF 1

EQUIPMENT TYPE : Hand Auger | METHOD : Hand Auger

DATE EXCAVATED : 29/9/17 | LOGGED BY : JB | CHECKED BY :

LOCATION : See Drawing for location

GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, plasticity or particle characteristic, colour Rock Type, grain size, colour Secondary and minor components	MOISTURE / WEATHERING	CONSISTENCY / REL DENSITY / ROCK STRENGTH	DYNAMIC PENETROMETER	HAND PENETRO-METER (kPa)	STRUCTURE & Other Observations
Not Encountered		0.0			FILL; Silty SAND, fine to coarse grained, brown, with gravel					FILL; scattered gravel on surface
	0.05m ES-HA2-DUP/TRIP				@0.05m trace of steel fragments					
	0.15m					D - M				
	0.40m				0.40m					
	ES-HA2				Silty CLAY, low to medium plasticity, dark brown, with sand	MC = PL	F		X	RESIDUAL HP In-situ = 70 kPa
	0.50m	0.5			0.50m Silty CLAY, medium to high plasticity, grey to brown mottled orange	MC = PL	St		X	RESIDUAL HP In-situ = 150 kPa
	0.60m ES-HA2									
	0.70m	1.0			0.70m Testbore HA2 terminated at 0.70 m End at natural profile					

HAND PENETRO-METER (kPa) scale: 100, 200, 300, 400

MOISTURE & GROUNDWATER
- D - Dry
- M - Moist
- W - Wet
- OMC - Optimum MC
- PL - Plastic Limit
- ▶— - Water seepage/inflow
- ▼ - Water level

SAMPLES & FIELD TESTS
- U - Undisturbed Sample
- D - Disturbed Sample
- ES - Environmental sample
- B - Bulk Disturbed Sample
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer

CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

ROCK STRENGTH
- EL - Extremely low
- VL - Very low
- L - Low
- M - Medium
- H - High
- VH - Very high
- EH - Extremely high

ROCK WEATHERING
- RS - Residual soil
- XW - Extremely weathered
- DW - Distinctly weathered
- SW - Slightly weathered
- FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO (NSW/ACT) PTY LTD

TESTBORE LOG

CLIENT : University of Newcastle
PROJECT : Contamination Investigation
LOCATION : Callaghan

HOLE NO : HA3
PROJECT REF : 82218015
SHEET : 1 OF 1

EQUIPMENT TYPE : Hand Auger | METHOD : Hand Auger

DATE EXCAVATED : 29/9/17 | LOGGED BY : JB | CHECKED BY :

LOCATION : See Drawing for location

GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, plasticity or particle characteristic, colour Rock Type, grain size, colour Secondary and minor components	MOISTURE / WEATHERING	CONSISTENCY / REL DENSITY / ROCK STRENGTH	DYNAMIC PENETROMETER	HAND PENETRO-METER (kPa) 100 200 300 400	STRUCTURE & Other Observations
Not Encountered	0.05m ES-HA3 0.15m	0.0			FILL; Silty SAND, fine to coarse grained, grey to brown, with gravel and trace of root fibres	D - M				FILL/TOPSOIL
					0.15m FILL; SAND, fine to medium grained, pale yellow					FILL; service trench backfill
	0.50m ES-HA3 0.60m	0.5				D - M				
	0.70m ES-HA3 0.80m				0.70m Silty CLAY, low to medium plasticity, grey mottled red	MC = PL	St		×	RESIDUAL HP In-situ = 170 kPa
					0.80m Testbore HA3 terminated at 0.80 m End at natural profile					
		1.0								

MOISTURE & GROUNDWATER
D - Dry
M - Moist
W - Wet
OMC - Optimum MC
PL - Plastic Limit
▶— - Water seepage/inflow
▼ - Water level

SAMPLES & FIELD TESTS
U - Undisturbed Sample
D - Disturbed Sample
ES - Environmental sample
B - Bulk Disturbed Sample
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer

CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

ROCK STRENGTH
EL - Extremely low
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

ROCK WEATHERING
RS - Residual soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO (NSW/ACT) PTY LTD

TESTBORE LOG

CLIENT : University of Newcastle
PROJECT : Contamination Investigation
LOCATION : Callaghan

HOLE NO : HA4
PROJECT REF : 82218015
SHEET : 1 OF 1

EQUIPMENT TYPE : Hand Auger | METHOD : Hand Auger

DATE EXCAVATED : 29/9/17 | LOGGED BY : JB | CHECKED BY :

LOCATION : See Drawing for location

GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, plasticity or particle characteristic, colour Rock Type, grain size, colour Secondary and minor components	MOISTURE / WEATHERING	CONSISTENCY / REL DENSITY / ROCK STRENGTH	DYNAMIC PENETROMETER	HAND PENETRO-METER (kPa) 100 200 300 400	STRUCTURE & Other Observations
Not Encountered	0.05m ES-HA4 0.15m	0.0			FILL; Silty SAND, fine to coarse grained, grey to brown, with gravel and trace of slag	D - M				FILL; scattered grass on surface
					0.30m Testbore HA4 terminated at 0.30 m Possible services					
		0.5								
		1.0								

MOISTURE & GROUNDWATER
- D - Dry
- M - Moist
- W - Wet
- OMC - Optimum MC
- PL - Plastic Limit
- ▶— - Water seepage/inflow
- ▼ - Water level

SAMPLES & FIELD TESTS
- U - Undisturbed Sample
- D - Disturbed Sample
- ES - Environmental sample
- B - Bulk Disturbed Sample
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer

CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

ROCK STRENGTH
- EL - Extremely low
- VL - Very low
- L - Low
- M - Medium
- H - High
- VH - Very high
- EH - Extremely high

ROCK WEATHERING
- RS - Residual soil
- XW - Extremely weathered
- DW - Distinctly weathered
- SW - Slightly weathered
- FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO (NSW/ACT) PTY LTD

TESTBORE LOG

CLIENT : University of Newcastle
PROJECT : Contamination Investigation
LOCATION : Callaghan

HOLE NO : HA5
PROJECT REF : 82218015
SHEET : 1 OF 1

EQUIPMENT TYPE : Hand Auger | METHOD : Hand Auger

DATE EXCAVATED : 29/9/17 | LOGGED BY : JB | CHECKED BY :

LOCATION : See Drawing for location

GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, plasticity or particle characteristic, colour Rock Type, grain size, colour Secondary and minor components	MOISTURE / WEATHERING	CONSISTENCY / REL DENSITY / ROCK STRENGTH	DYNAMIC PENETROMETER	HAND PENETRO-METER (kPa) 100 200 300 400	STRUCTURE & Other Observations
Not Encountered	0.05m ES-HA5 0.15m 0.20m	0.0			FILL; Silty SAND, fine to coarse grained, grey to brown, with gravel and trace of slag	D - M				FILL
	ES-HA5 0.30m				0.20m FILL; GRAVEL, fine to coarse, sub-rounded to sub-angular 0.30m					FILL; potential drainage trench.
		0.5			Testbore HA5 terminated at 0.30 m Possible services					
		1.0								

MOISTURE & GROUNDWATER
- D - Dry
- M - Moist
- W - Wet
- OMC - Optimum MC
- PL - Plastic Limit
- ▶— - Water seepage/inflow
- ▼ - Water level

SAMPLES & FIELD TESTS
- U - Undisturbed Sample
- D - Disturbed Sample
- ES - Environmental sample
- B - Bulk Disturbed Sample
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer

CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

ROCK STRENGTH
- EL - Extremely low
- VL - Very low
- L - Low
- M - Medium
- H - High
- VH - Very high
- EH - Extremely high

ROCK WEATHERING
- RS - Residual soil
- XW - Extremely weathered
- DW - Distinctly weathered
- SW - Slightly weathered
- FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO (NSW/ACT) PTY LTD

TESTBORE LOG

CLIENT : University of Newcastle
PROJECT : Contamination Investigation
LOCATION : Callaghan

HOLE NO : HA6
PROJECT REF : 82218015
SHEET : 1 OF 1

EQUIPMENT TYPE : Hand Auger | METHOD : Hand Auger

DATE EXCAVATED : 29/9/17 | LOGGED BY : JB | CHECKED BY :

LOCATION : See Drawing for location

GROUND WATER LEVELS	SAMPLES & FIELD TESTS	DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, plasticity or particle characteristic, colour Rock Type, grain size, colour Secondary and minor components	MOISTURE / WEATHERING	CONSISTENCY / REL DENSITY / ROCK STRENGTH	DYNAMIC PENETROMETER	HAND PENETRO-METER (kPa) 100 200 300 400	STRUCTURE & Other Observations
Not Encountered	0.05m ES-HA6	0.0			FILL; Silty SAND, fine to coarse grained, grey to brown, with gravel and root fibres	D - M				FILL/TOPSOIL
	0.15m				0.20m					
					Silty CLAY, medium plasticity, grey to brown	MC < PL				RESIDUAL
	0.40m ES-HA6									
	0.50m	0.5			0.50m Testbore HA6 terminated at 0.50 m End at natural profile					
		1.0								

MOISTURE & GROUNDWATER
- D - Dry
- M - Moist
- W - Wet
- OMC - Optimum MC
- PL - Plastic Limit
- ▶— - Water seepage/inflow
- ▼ - Water level

SAMPLES & FIELD TESTS
- U - Undisturbed Sample
- D - Disturbed Sample
- ES - Environmental sample
- B - Bulk Disturbed Sample
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer

CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

ROCK STRENGTH
- EL - Extremely low
- VL - Very low
- L - Low
- M - Medium
- H - High
- VH - Very high
- EH - Extremely high

ROCK WEATHERING
- RS - Residual soil
- XW - Extremely weathered
- DW - Distinctly weathered
- SW - Slightly weathered
- FR - Fresh rock

See Explanatory Notes for details of abbreviations & basis of descriptions.

CARDNO (NSW/ACT) PTY LTD

Explanatory Notes

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS1726-1993 Geotechnical Site Investigations. Material descriptions are deduced from field observation or engineering examination, and may be appended or confirmed by in situ or laboratory testing. The information is dependent on the scope of investigation, the extent of sampling and testing, and the inherent variability of the conditions encountered.

Subsurface investigation may be conducted by one or a combination of the following methods.

Method	
Test Pitting: excavation/trench	
BH	Backhoe bucket
EX	Excavator bucket
X	Existing excavation
Natural Exposure: existing natural rock or soil exposure	
Manual drilling: hand operated tools	
HA	Hand Auger
Continuous sample drilling	
PT	Push tube
Hammer drilling	
AH	Air hammer
AT	Air track
Spiral flight auger drilling	
AS	Large diameter short spiral auger
AD/V	Continuous spiral flight auger: V-Bit
AD/T	Continuous spiral flight auger: TC-Bit
Hollow flight auger drilling	
HFA	Continuous hollow flight auger
Rotary non-core drilling	
WS	Washbore (mud drilling)
RR	Rock roller
Rotary core drilling	
HQ	63mm diamond-tipped core barrel
NMLC	52mm diamond-tipped core barrel
NQ	47mm diamond-tipped core barrel
Concrete coring	
DT	Diatube

Sampling is conducted to facilitate further assessment of selected materials encountered.

Sampling method	
Disturbed sampling	
B	Bulk disturbed sample
D	Disturbed sample
ES	Environmental soil sample
Undisturbed sampling	
SPT	Standard Penetration Test sample
U	Thin wall tube ‘undisturbed’ sample
Water samples	
EW	Environmental water sample

Field testing may be conducted as a means of assessment of the in situ conditions of materials.

Field testing	
SPT	Standard Penetration Test (blows/150mm)
HP/PP	Hand/Pocket Penetrometer
Dynamic Penetrometers (generally blows/150mm)	
DCP	Dynamic Cone Penetrometer
PSP	Perth Sand Penetrometer
MC	Moisture Content
VS	Vane Shear
PBT	Plate Bearing Test
PID	Photo Ionization Detector

If encountered, refusal (R) or virtual refusal (VR) of SPT or dynamic penetrometers may be noted.

The quality of the rock can be assessed be the degree of fracturing and the following.

Rock quality description	
TCR	Total Core Recovery (%) (length of core recovered divided by the length of core run)
RQD	Rock Quality Designation (%) (sum of axial lengths of core greater than 100mm long divided by the length of core run)

Notes on groundwater conditions encountered may include.

Groundwater	
Not Encountered	Excavation is dry in the short term
Not Observed	Water level observation not possible
Seepage	Water seeping into hole
Inflow	Water flowing/flooding into hole

Perched groundwater may result in a misleading indication of the depth to the true water table. Groundwater levels are also likely to fluctuate with variations in climatic and site conditions.

Notes on the stability of excavations may include.

Excavation conditions	
Stable	No obvious/gross short term instability noted
Spalling	Material falling into excavation (minor/major)
Unstable	Collapse of the majority, or one or more face of the excavation

Explanatory Notes: General Soil Description

The methods of description and classification of soils used in this report are based on Australian Standard AS1726-1993 Geotechnical Site Investigations. In practice, a material is described as a soil if it can be remoulded by hand in its field condition or in water. The dominant component is shown in upper case, with secondary components in lower case. In general descriptions cover: soil type, plasticity or particle size/shape, colour, strength or density, moisture and inclusions.

In general, soil types are classified according to the dominant particle on the basis of the following particle sizes.

Soil Classification		Particle Size
CLAY		< 0.002mm
SILT		0.002mm 0.075mm
SAND	fine	0.075mm to 0.2mm
	medium	0.2mm to 0.6mm
	coarse	0.6mm to 2.36mm
GRAVEL	fine	2.36mm to 6mm
	medium	6mm to 20mm
	coarse	20mm to 63mm
COBBLES		63mm to 200mm
BOULDERS		> 200mm

Soil types are qualified by the presence of minor components on the basis of field examination or the particle size distribution.

Description	Percentage of minor component
Trace	< 5% in coarse grained soils
	< 15% in fine grained soils
With	5% to 12% in coarse grained soils
	15% to 30% in fine grained soils

The strength of cohesive soils is classified by engineering assessment or field/laboratory testing as follows.

Strength	Symbol	Undrained shear strength
Very Soft	VS	< 12kPa
Soft	S	12kPa to 25kPa
Firm	F	25kPa to 50kPa
Stiff	St	50kPa to 100kPa
Very Stiff	VSt	100kPa to 200kPa
Hard	H	> 200kPa

Cohesionless soils are classified on the basis of relative density as follows.

Relative Density	Symbol	Density Index
Very Loose	VL	< 15%
Loose	L	15% to 35%
Medium Dense	MD	35% to 65%
Dense	D	65% to 85%
Very Dense	VD	> 85%

The moisture condition of soil is described by appearance and feel and may be described in relation to the Plastic Limit (PL) or Optimum Moisture Content (OMC).

Moisture condition and description	
Dry	Cohesive soils: hard, friable, dry of plastic limit. Granular soils: cohesionless and free-running
Moist	Cool feel and darkened colour: Cohesive soils can be moulded. Granular soils tend to cohere
Wet	Cool feel and darkened colour: Cohesive soils usually weakened and free water forms when handling. Granular soils tend to cohere

The plasticity of cohesive soils is defined as follows.

Plasticity	Liquid Limit
Low plasticity	≤ 35%
Medium plasticity	> 35% ≤ 50%
High plasticity	> 50%

The structure of the soil may be described as follows.

Zoning	Description
Layer	Continuous across exposure or sample
Lens	Discontinuous layer (lenticular shape)
Pocket	Irregular inclusion of different material

The structure of soil layers may include: defects such as softened zones, fissures, cracks, joints and root-holes; and coarse grained soils may be described as strongly or weakly cemented.

The soil origin may also be noted if possible to deduce.

Soil origin and description	
Fill	Man-made deposits or disturbed material
Topsoil	Material affected by roots and root fibres
Colluvial	Transported down slopes by gravity
Aeolian	Transported and deposited by wind
Alluvial	Deposited by rivers
Lacustrine	Deposited by lakes
Marine	Deposits in beaches, bays and estuaries
Residual	Developed on weathered rock

The origin of the soil generally cannot be deduced on the appearance of the material only and may be determined based on further geological evidence or other field observation.

Explanatory Notes: General Rock Description

The methods of description and classification of rocks used in this report are based on Australian Standard AS1726-1993 Geotechnical Site Investigations. In practice, if a material cannot be remoulded by hand in its field condition or in water, it is described as a rock. In general, descriptions cover: rock type, grain size, structure, colour, degree of weathering, strength, minor components or inclusions, and where applicable, the defect types, shape, roughness and coating/infill.

Sedimentary rock types are generally described according to the predominant grain size as follows.

Rock Type	Description
CONGLOMERATE	Rounded gravel sized fragments (>2mm) cemented in a finer matrix
SANDSTONE	Sand size particles defined by the following grain sizes: fine 0.06mm to 0.2mm medium 0.2mm to 0.6mm coarse 0.6mm to 2mm
SILTSTONE	Predominately silt sized particles
SHALE	Fine particles (silt or clay) and fissile
CLAYSTONE	Predominately clay sized particles

The classification of rock weathering is described based on definitions in AS1726 and summarised as follows.

Term and symbol		Definition
Residual Soil	RS	Soil developed on rock with the mass structure and substance of the parent rock no longer evident
Extremely weathered	XW	Weathered to such an extent that the rock has 'soil-like' properties
Distinctly weathered	DW	The strength is usually changed and may be highly discoloured. Porosity may be increased by leaching, or decreased due to deposition in pores
Slightly weathered	SW	Slightly discoloured; little or no change of strength from fresh rock
Fresh Rock	FR	The rock shows no sign of decomposition or staining

The rock material strength can be defined based on the point load index as follows.

Term and symbol		Point Load Index I_s50
Extremely low	EL	< 0.03MPa
Very Low	VL	0.03MPa to 0.1MPa
Low	L	0.1MPa to 0.3MPa
Medium	M	0.3MPa to 1MPa
High	H	1MPa to 3MPa
Very High	VH	3MPa to 10MPa
Extremely High	EH	> 10MPa

It is important to note that the rock material strength as above is distinct from the rock mass strength which can be significantly weaker due to the effect of defects.

A preliminary assessment of rock strength may be made using the field guide detailed in AS1726, and this is conducted in the absence of point load testing.

The defect spacing and bedding thickness, measured normal to defects of the same set or bedding, is described as follows.

Definition	Defect Spacing
Thinly laminated	< 6mm
Laminated	6mm to 20mm
Very thinly bedded	20mm to 60mm
Thinly bedded	60mm to 0.2m
Medium bedded	0.2m to 0.6m
Thickly bedded	0.6m to 2m
Very thickly bedded	> 2m

Terms for describing rock and defects are as follows.

Terms			
Joint	JT	Sheared zone	SZ
Bed Parting	BP	Sheared surface	SS
Contact	CO	Seam	SM
Dyke	DK	Crushed Seam	CS
Decomposed Zone	DZ	Infilled Seam	IS
Fracture	FC	Foliation	FL
Fracture Zone	FZ	Vein	VN

The shape and roughness of defects in the rock mass are described using the following terms.

Planarity		Roughness	
Planar	PR	Very Rough	VR
Curved	CU	Rough	RF
Undulating	U	Smooth	S
Irregular	IR	Polished	POL
Stepped	ST	Slickensides	SL

The coating or infill associated with defects in the rock mass are described as follows.

Definition	Description
Clean	No visible coating or infilling
Stain	No visible coating or infilling; surfaces discoloured by mineral staining
Veneer	Visible coating or infilling of soil or mineral substance (<1mm). If discontinuous over the plane; patchy veneer
Coating	Visible coating or infilling of soil or mineral substance (>1mm)

Graphic Symbols Index

Clays


CLAY


Silty CLAY


Sandy CLAY


Gravelly CLAY

Silts


SILT


Clayey SILT


Sandy SILT


Gravelly SILT

Sands


SAND


Clayey SAND


Silty SAND


Gravelly SAND

Gravels


GRAVEL


Clayey GRAVEL


Silty GRAVEL


Sandy GRAVEL

Sedimentary Rock


CONGLOMERATE


BRECCIA


SANDSTONE


SILTSTONE


SHALE


MUDSTONE, CLAYSTONE


COAL


LIMESTONE

Metamorphic Rock


SLATE, PHYLLITE, SHIST


GNEISS


QUARTZITE, MARBLE

Igneous Rock


GRANITE


RHYOLITE


BASALT, DOLERITE


IGNIMBRITE


TUFF, VOLCANIC BRECCIA

Other Soils


TOPSOIL


ORGANIC SOILS


COBBLES, BOULDERS

Fill Strata


FILL


ASPHALT


CONCRETE


ROADBASE


BALLAST

Piezometer Symbols

Screen Section

Casing: sand backfill

Casing: gravel backfill

Casing: spoil backfill

Bentonite Seal

Cement Seal

Spoil Backfill

Cement Backfill

Bioresources Facility, University of Newcastle

APPENDIX C

LABORATORY RESULTS

Cardno
Shaping the Future

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Unit 1, 10 Denney Street
Broadmeadow NSW 2292

Laboratory: **Newcastle Laboratory**
Phone: 02 4965 4555 **Fax:** 02 4946 4666

Email: Newcastle@constructionsciences.net

SHRINK SWELL INDEX

Client:	Cardno (NSW/ACT) Pty Ltd	Report Number:	16822/R/11388-1
Client Address:	1/10 Denney Street, Broadmeadow	Project Number:	16822/P/77
Project:	UON Callaghan Campus	Lot Number:	
Location:	1/10 Denney Street Broadmeadow	Internal Test Request:	16822/T/8954
Component:		Client Reference/s:	82218024
Area Description:		Report Date / Page:	18/10/2017 Page 1 of 2

Test Procedures:	AS1289.7.1.1, AS1289.2.1.1	Pit No.		BH01
Sample Number	16822/S/42264	Sample Type		U50
Sampling Method	Tested As Received	Sample Depth	m	1.0-1.28
Date Sampled	29/09/2017			
Sampled By	Client Sampled	Material Source	-	
Date Tested	11/10/2017	Material Type	-	

Soil Description:	Silty CLAY; pale grey mottled orange		
Cracking / Crumbling:	no crumbling		
Estimated Inert Inclusions (%):	0.00	Swell Pre-Soak Moisture Content (%)	25.2
Shrinkage Moisture Content (%):	24.8	Swell Post-Soak Moisture Content (%)	28.8

Shrinkage Strain (%)	4.2	Shrink / Swell Index	2.9
Swell Strain (%)	1.9		

Remarks

NATA

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Approved Signatory: Joseph Stallard
Form ID: W21Rep Rev 1

Construction Sciences

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Phone: 02 4965 4555 **Fax:** 02 4946 4666

Email: Newcastle@constructionsciences.net

SHRINK SWELL INDEX

Client:	Cardno (NSW/ACT) Pty Ltd	Report Number:	16822/R/11388-1
Client Address:	1/10 Denney Street, Broadmeadow	Project Number:	16822/P/77
Project:	UON Callaghan Campus	Lot Number:	
Location:	1/10 Denney Street Broadmeadow	Internal Test Request:	16822/T/8954
Component:		Client Reference/s:	82218024
Area Description:		Report Date / Page:	18/10/2017 Page 2 of 2

Test Procedures:	AS1289.7.1.1, AS1289.2.1.1	Pit No.		BH02
Sample Number	16822/S/42266	Sample Type		U50
Sampling Method	Tested As Received	Sample Depth	m	1.5-1.78
Date Sampled	29/09/2017			
Sampled By	Client Sampled	Material Source	-	
Date Tested	11/10/2017	Material Type	-	

Soil Description:	Silty CLAY; pale grey mottled orange		
Cracking / Crumbling:	no crumbling		
Estimated Inert Inclusions (%):	0.00	Swell Pre-Soak Moisture Content (%)	16.1
Shrinkage Moisture Content (%):	18.7	Swell Post-Soak Moisture Content (%)	22.3

Shrinkage Strain (%)	2.1	Shrink / Swell Index	1.7
Swell Strain (%)	1.8		

Remarks

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Broadmeadow NSW 2292

Laboratory: Newcastle Laboratory
Phone: 02 4965 4555 **Fax:** 02 4946 4666

Email: Newcastle@constructionsciences.net

ATTERBERG LIMITS REPORT

Client:	Cardno (NSW/ACT) Pty Ltd	Report Number:	16822/R/11518-1
Client Address:	1/10 Denney Street, Broadmeadow	Project Number:	16822/P/77
Project:	UON Callaghan Campus	Lot Number:	
Location:	1/10 Denney Street Broadmeadow	Internal Test Request:	16822/T/8954
Component:		Client Reference/s:	82218015
Area Description:		Report Date / Page:	23/10/2017 Page 1 of 3

Test Procedures:	AS1289.3.1.2, AS 1289.3.3.1, AS1289.3.2.1, AS1289.2.1.1		
Sample Number	16822/S/42265	Sample Location	
Sampling Method	Tested As Received	Pit No.	BH02
Date Sampled	29/09/2017	Sample Type	B
Sampled By	Client Sampled	Sample Depth m	0.6-0.85
Date Tested	20/10/2017		
Att. Drying Method	Oven Dried	Material Source	-
Atterberg Preparation	Dry Sieved	Material Type	-
Material Description	Silty CLAY; red mottled grey		

Atterberg Limits Results

Atterberg Limit	Specification Minimum	Test Result	Specification Maximum
Liquid Limit (%)		**47**	
Plastic Limit (%)		**16**	
Plasticity Index (%)		**31**	
Linear Shrinkage (%)			
Linear Shrinkage Defects:			

Remarks

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Phone: 02 4965 4555 **Fax:** 02 4946 4666

Email: Newcastle@constructionsciences.net

ATTERBERG LIMITS REPORT

Client:	Cardno (NSW/ACT) Pty Ltd	Report Number:	16822/R/11518-1
Client Address:	1/10 Denney Street, Broadmeadow	Project Number:	16822/P/77
Project:	UON Callaghan Campus	Lot Number:	
Location:	1/10 Denney Street Broadmeadow	Internal Test Request:	16822/T/8954
Component:		Client Reference/s:	82218015
Area Description:		Report Date / Page:	23/10/2017 Page 2 of 3

Test Procedures:	AS1289.3.1.2, AS 1289.3.3.1, AS1289.3.2.1, AS1289.2.1.1			
Sample Number	16822/S/42267	Sample Location		
Sampling Method	Tested As Received	Pit No.		BH02
Date Sampled	29/09/2017	Sample Type		Core
Sampled By	Client Sampled	Sample Depth	m	3.4-3.7
Date Tested	20/10/2017			
Att. Drying Method	Oven Dried	Material Source	-	
Atterberg Preparation	Dry Sieved	Material Type	-	
Material Description	Silty CLAY; pale grey mottled red & light brown			

Atterberg Limits Results

Atterberg Limit	Specification Minimum	Test Result	Specification Maximum
Liquid Limit (%)		**66**	
Plastic Limit (%)		**19**	
Plasticity Index (%)		**47**	
Linear Shrinkage (%)			
Linear Shrinkage Defects:			

Remarks

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Email: Newcastle@constructionsciences.net

ATTERBERG LIMITS REPORT

Client:	Cardno (NSW/ACT) Pty Ltd	Report Number:	16822/R/11518-1
Client Address:	1/10 Denney Street, Broadmeadow	Project Number:	16822/P/77
Project:	UON Callaghan Campus	Lot Number:	
Location:	1/10 Denney Street Broadmeadow	Internal Test Request:	16822/T/8954
Component:		Client Reference/s:	82218015
Area Description:		Report Date / Page:	23/10/2017 Page 3 of 3

Test Procedures:	AS1289.3.1.2, AS 1289.3.3.1, AS1289.3.2.1, AS1289.2.1.1			
Sample Number	16822/S/42268	Sample Location		
Sampling Method	Tested As Received	Pit No.		BH02
Date Sampled	29/09/2017	Sample Type		Core
Sampled By	Client Sampled	Sample Depth	m	4.3-4.6
Date Tested	20/10/2017			
Att. Drying Method	Oven Dried	Material Source	-	
Atterberg Preparation	Dry Sieved	Material Type	-	
Material Description	Silty CLAY; grey-dark grey bedding mottled red			

Atterberg Limits Results

Atterberg Limit	Specification Minimum	Test Result	Specification Maximum
Liquid Limit (%)		**52**	
Plastic Limit (%)		**24**	
Plasticity Index (%)		**28**	
Linear Shrinkage (%)			
Linear Shrinkage Defects:			

Remarks

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Address:
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Broadmeadow NSW 2292

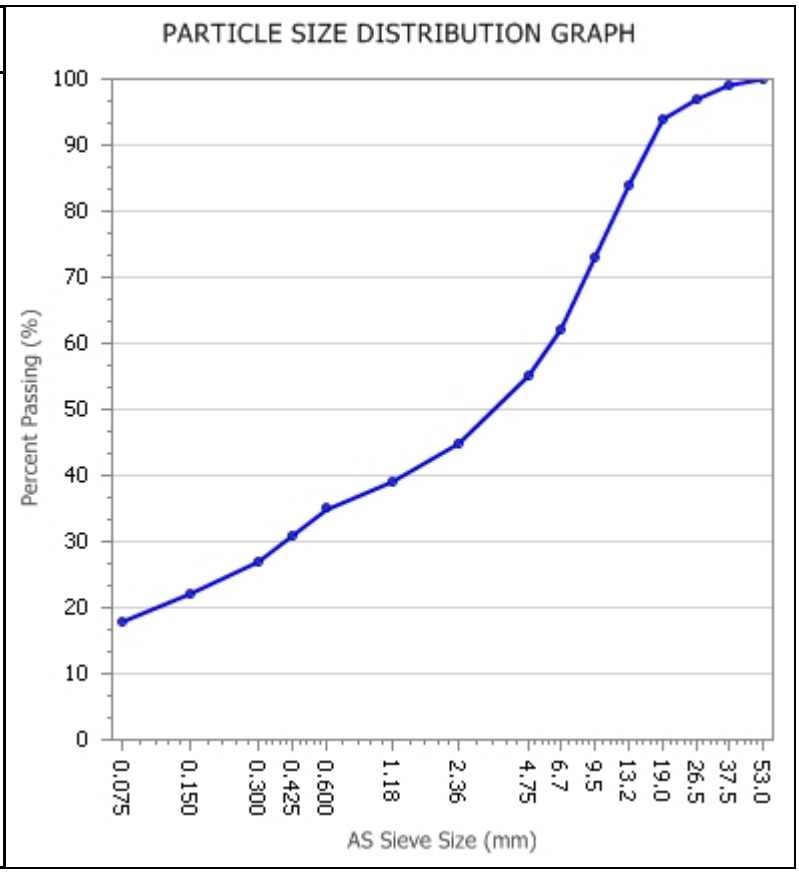
Laboratory: Newcastle Laboratory
Phone: 02 4965 4555 **Fax:** 02 4946 4666
Email: Newcastle@constructionsciences.net

PARTICLE SIZE DISTRIBUTION REPORT

Client:	Cardno (NSW/ACT) Pty Ltd	Report Number:	16822/R/11545-1
Client Address:	1/10 Denney Street, Broadmeadow	Project Number:	16822/P/77
Project:	UON Callaghan Campus	Lot Number:	
Location:	1/10 Denney Street Broadmeadow	Internal Test Request:	16822/T/9092
Component:		Client Reference/s:	82218015
Area Description:		Report Date / Page:	24/10/2017 Page 1 of 1

Test Procedures:	AS1289.3.6.1			
Sample Number	16822/S/42970	Sample Location		
Sampling Method	Tested As Received	Pit No.		BH02
Date Sampled	29/09/2017	Sample Type		B
Sampled By	Client Sampled	Sample Depth	m	0.2-0.4
Date Tested	20/10/2017			
Material Source	-	Material Type	-	

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
53.0		**100**	
37.5		**99**	
26.5		**97**	
19.0		**94**	
13.2		**84**	
9.5		**73**	
6.7		**62**	
4.75		**55**	
2.36		**45**	
1.18		**39**	
0.600		**35**	
0.425		**31**	
0.300		**27**	
0.150		**22**	
0.075		**18**	



Remarks

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Accreditation Number: 1986
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Approved Signatory: Joseph Stallard
Form ID: W9Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Unit 1, 10 Denney Street
Broadmeadow NSW 2292

Laboratory: Newcastle Laboratory
Phone: 02 4965 4555 **Fax:** 02 4946 4666
Email: Newcastle@constructionsciences.net

CALIFORNIA BEARING RATIO REPORT

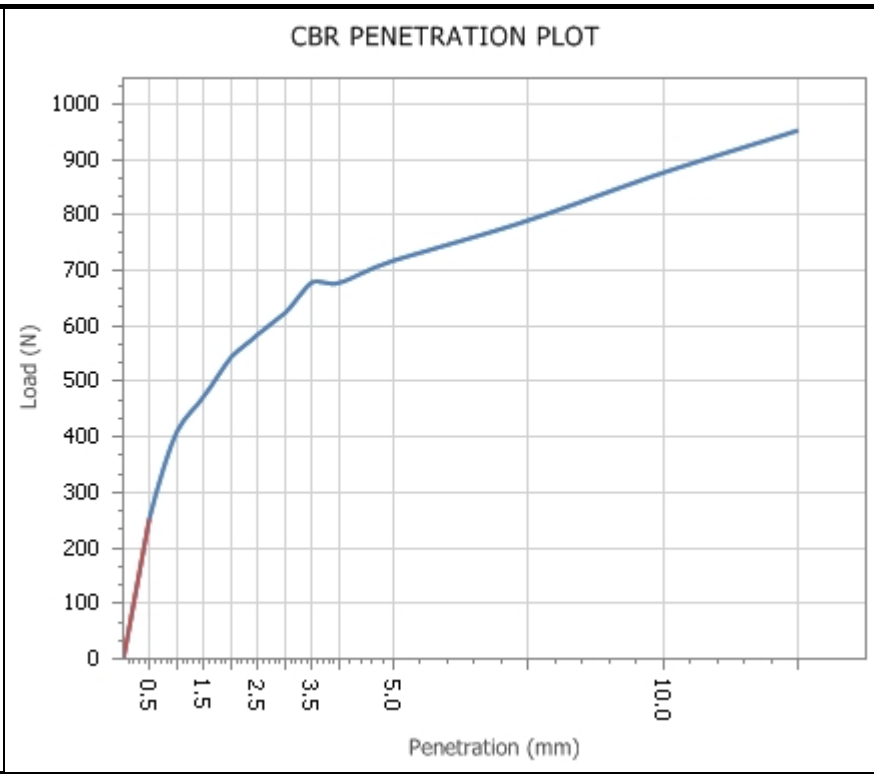
Client:	Cardno (NSW/ACT) Pty Ltd	Report Number:	16822/R/11570-1
Client Address:	1/10 Denney Street, Broadmeadow	Project Number:	16822/P/77
Project:	UON Callaghan Campus	Lot Number:	
Location:	1/10 Denney Street Broadmeadow	Internal Test Request:	16822/T/9092
Component:		Client Reference/s:	82218015
Area Description:		Report Date / Page:	26/10/2017 Page 1 of 1

Test Procedures	AS1289.6.1.1, AS1289.5.1.1, AS1289.2.1.1

Sample Number	16822/S/42969	Sample Location		
Sampling Method	Tested As Received	Pit No.		BH01
Date Sampled	29/09/2017	Sample Type		B
Sampled By	Client Sampled	Sample Depth	m	0.3-0.5
Date Tested	24/10/2017			
Material Source	-	Material Limit Start		-
Material Type	-	Material Limit End		-
Client Reference	-	Compactive Effort		Standard

Material Description	Silty CLAY, pale grey mottled orange

Maximum Dry Density (t/m³):	1.71
Optimum Moisture Content (%):	19.0
Field Moisture Content (%):	21.4
Sample Percent Oversize (%)	0.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	100
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	1.72
Placement Dry Density Ratio (%):	100.5
Placement Moisture Content (%):	18.7
Placement Moisture Ratio (%):	98.0
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	1.70
Total Curing Time (hrs)	n/a
Liquid Limit Method	Estimation
Moisture (top 30mm) After Soak (%)	24.7
Moisture (remainder) After Soak (%)	21.5
CBR Swell (%):	1.5
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**4.5**



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Accreditation Number: 1986
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Approved Signatory: Joseph Stallard
Form ID: W2ASRep Rev2

CHAIN OF CUSTODY RECORD

LAB Name	Envirolab	***Att:***	
Address			
Client	Cardno	***Contact***	
		Phone	4965 4555
		Fax	
Contact	Jesse Graczyk	***E-mail***	jesse.graczyk@cardno.com.au (invoice to geotech@cardno.com.au)
Sampled by	Jesse Graczyk		
Project Ref:	822180215	***Date Results Required***	Standard

ENVIROLAB GROUP

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200

Job No: 177411

Date Received: 11/10
Time Received: 10:00
Received by: DW
Temp: Cool/Ambient
Cooling: Ice/Icepack 14.1
Security: Intact/Broken/None

Laboratory LIMS ID	Sample ID on zip lock bags (where different to Client Sample ID)	Client Sample ID	Date Sampled	Matrix: Soil	Matrix: Water	Containers/Preservation: Soil Jar (G) Nat. Orange	0.5-1.0 litre (G) Nat. Yellow	0.1-1.0 litre (P) Nat. Green	50mL VOA Vial (G) H_2SO_4 Maroon	0.1-1.0 litre (P) H_2SO_4 Maroon	0.2-1.0 litre (G) H_2SO_4 Maroon	0.1-0.2 (P) Filtered?? Y=Yes, N=No (HNO3) Red	0.2l (P) NaOH Blue	Other - ZIP LOCK	Analysis Required: Soil Agressivity pH, EC chlorides/ sulfates			**Material type**
1	BH01 2.5-2.95m		29/09/17	✓										✓	✓			Silty Clay; pgrey mot org (XW material)
2	BH01 4.0-4.2m		29/09/17	✓										✓	✓			Silty Clay; pgrey mot org (XW material)
3	BH02 1.0-1.45m		29/09/17	✓										✓	✓			Silty Clay; pale grey mott orange
4	BH02 2.5-2.95m		29/09/17	✓										✓	✓			Silty Clay; pgrey mot org (XW material)

Released by: Jesse Graczyk Signature Date/Time

Received by: Signature Date/Time

Custody Seals Intact? / Samples Received Chilled?

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

SAMPLE RECEIPT ADVICE

Client Details

Client	Cardno (NSW/ACT) Pty Ltd
Attention	Jesse Graczyk

Sample Login Details

Your reference	822180215
Envirolab Reference	177411
Date Sample Received	11/10/2017
Date Instructions Received	11/10/2017
Date Results Expected to be Reported	18/10/2017

Sample Condition

Samples received in appropriate condition for analysis	YES
No. of Samples Provided	4 Soil
Turnaround Time Requested	Standard
Temperature on Receipt (°C)	14.1
Cooling Method	Ice
Sampling Date Provided	YES

Comments

Nil

Please direct any queries to:

Aileen Hie	Jacinta Hurst
Phone: 02 9910 6200	**Phone: 02 9910 6200**
Fax: 02 9910 6201	**Fax: 02 9910 6201**
Email: ahie@envirolab.com.au	**Email: jhurst@envirolab.com.au**

Analysis Underway, details on the following page:

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

Sample ID	Soil Aggressivity
BH01-2.5-2.95	✓
BH01-4.0-4.2	✓
BH02-1.0-1.45	✓
BH02-2.5-2.95	✓

The '✓' indicates the testing you have requested. **THIS IS NOT A REPORT OF THE RESULTS.**

Additional Info

Sample storage - Waters are routinely disposed of approximately 1 month and soils approximately 2 months from receipt.
Requests for longer term sample storage must be received in writing.

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
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customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 177411

Client Details

Client	Cardno (NSW/ACT) Pty Ltd
Attention	Jesse Graczyk
Address	PO Box 19, St Leonards, NSW, 1590

Sample Details

Your Reference	**822180215**
Number of Samples	4 Soil
Date samples received	11/10/2017
Date completed instructions received	11/10/2017

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	18/10/2017
Date of Issue	17/10/2017

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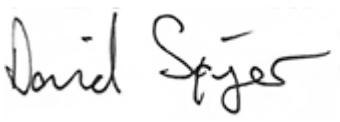
Results Approved By
Nick Sarlamis, Inorganics Supervisor

Authorised By



David Springer, General Manager

Soil Aggressivity					
Our Reference		177411-1	177411-2	177411-3	177411-4
Your Reference	UNITS	BH01	BH01	BH02	BH02
Depth		2.5-2.95	4.0-4.2	1.0-1.45	2.5-2.95
Date Sampled		29/09/2017	29/09/2017	29/09/2017	29/09/2017
Type of sample		Soil	Soil	Soil	Soil
pH 1:5 soil:water	pH Units	6.2	7.2	4.7	4.8
Electrical Conductivity 1:5 soil:water	µS/cm	420	400	540	850
Resistivity by calculation	ohm m	24	25	19	12
Chloride, Cl 1:5 soil:water	mg/kg	180	190	360	630
Sulphate, SO4 1:5 soil:water	mg/kg	820	380	480	740

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.

QUALITY CONTROL: Soil Aggressivity					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	103	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	96	[NT]
Resistivity by calculation	ohm m	0.1	Inorg-002	<0.1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	95	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	105	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

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

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

CHAIN OF CUSTODY RECORD

Cardno
Shaping the Future

LAB Name	SGS
Address	16/33 Maddox St Alexandria NSW 2015

Client	Cardno Pty Ltd PO Box 74 Broadmeadow NSW 2292

Contact Numbers	
Phone	0249 494300
Fax	0249 654666

Contact	Malcolm Adrien
Sampled by	Malcolm Adrien
Project Ref:	82218015

E-mail	malcolm.adrien@cardno.com.au	ian.piper@cardno.com.au

(invoice to geotech@cardno.com.au)

Date Results Required ~~Standard TAT~~ as per clients request (Phone call) 1 day TAT - EMB 23/10/17

Laboratory LIMS ID	Client Sample ID	Date Sampled	Matrix: Soil	Matrix: Water	Containers/Preservation: Soil Jar (G) Nat. Orange	0.5-1.0 litre (G) Nat. Yellow	0.1-1.0 litre (P) Nat. Green	50mL VOA Vial (G) H_2SO_4 Maroon	0.1-1.0 litre (P) H_2SO_4 Maroon	0.2-1.0 litre (G) H_2SO_4 Maroon	0.1-0.2 (P) Filtered?? Y=Yes, N=No (HNO_3) Red	0.2l (P) NaOH Blue	Other	Analysis Required: CL10					
1	BH001.1 ~~-0.3~~ 0.1-0.3 DS	29/09/2017	☒		☒									4					

SGS EHS Alexandria Laboratory

SE171696 COC

Received: 23 – Oct – 2017

Released by: Dimce Stojanovski Signature Date/Time

Received by: Suba Signature 23/10/17 @ 11:30 Date/Time

Custody Seals Intact? / Samples Received Chilled?

SAMPLE RECEIPT ADVICE

SE171696A

CLIENT DETAILS

Contact	Inglis Brien
Client	CARDNO (NSW/ACT) PTY LTD
Address	Unit 1 10 Denney Street Broadmeadow NSW 2292
Telephone	61 2 4940 5527
Facsimile	61 2 4965 4666
Email	inglis.brien@cardno.com.au
Project	**82218015 Additional**
Order Number	**82218015**
Samples	1

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
Samples Received	Tue 24/10/2017
Report Due	Wed 25/10/2017
SGS Reference	**SE171696A**

SUBMISSION DETAILS

This is to confirm that 1 sample was received on Tuesday 24/10/2017. Results are expected to be ready by COB Wednesday 25/10/2017.
Please quote SGS reference SE171696A when making enquiries. Refer below for details relating to sample integrity upon receipt.

Samples clearly labelled	Yes	Complete documentation received	Yes
Sample container provider	SGS	Sample cooling method	Ice Bricks
Samples received in correct containers	Yes	Sample counts by matrix	1 Soil
Date documentation received	24/10/17@10:21am	Type of documentation received	Email
Samples received in good order	Yes	Samples received without headspace	Yes
Sample temperature upon receipt	9.3°C	Sufficient sample for analysis	Yes
Turnaround time requested	Next Day		

Unless otherwise instructed, water and bulk samples will be held for one month from date of report, and soil samples will be held for two months.

COMMENTS

SAMPLE RECEIPT ADVICE

SE171696A

CLIENT DETAILS

Client CARDNO (NSW/ACT) PTY LTD

Project 82218015 Additional

SUMMARY OF ANALYSIS

No.	Sample ID	Mercury in TCLP Extract	Metals in TCLP Extract by ICPOES	PAH (Polynuclear Aromatic Hydrocarbons) in TCLP	TCLP (Toxicity Characteristic Leaching
001	BH001 0.1-0.3	1	7	22	6

The above table represents SGS' interpretation of the client-supplied Chain Of Custody document.
The numbers shown in the table indicate the number of results requested in each package.
Please indicate as soon as possible should your request differ from these details .
Testing as per this table shall commence immediately unless the client intervenes with a correction .

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Malcolm Adrien
Client	CARDNO (NSW/ACT) PTY LTD
Address	Unit 1 10 Denney Street Broadmeadow NSW 2292
Telephone	61 2 4949 4300
Facsimile	61 2 4965 4666
Email	malcolm.adrien@cardno.com.au
Project	**82218015**
Order Number	**82218015**
Samples	1

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE171696 R0**
Date Received	23/10/2017
Date Reported	24/10/2017

COMMENTS

Accredited for compliance with ISO/IEC 17025- Testing. NATA accredited laboratory 2562(4354).

SIGNATORIES

Akheeqar Beniameen
Chemist

Bennet Lo
Senior Organic Chemist/Metals Chemist

Dong Liang
Metals/Inorganics Team Leader

Ly Kim Ha
Organic Section Head

VOC's in Soil [AN433] Tested: 23/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696.001
Benzene	mg/kg	0.1	<0.1
Toluene	mg/kg	0.1	<0.1
Ethylbenzene	mg/kg	0.1	<0.1
m/p-xylene	mg/kg	0.2	<0.2
o-xylene	mg/kg	0.1	<0.1
Total Xylenes	mg/kg	0.3	<0.3
Total BTEX	mg/kg	0.6	<0.6
Naphthalene	mg/kg	0.1	<0.1

Volatile Petroleum Hydrocarbons in Soil [AN433] Tested: 23/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696.001
TRH C6-C9	mg/kg	20	<20
Benzene (F0)	mg/kg	0.1	<0.1
TRH C6-C10	mg/kg	25	<25
TRH C6-C10 minus BTEX (F1)	mg/kg	25	<25

TRH (Total Recoverable Hydrocarbons) in Soil [AN403] Tested: 23/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696.001
TRH C10-C14	mg/kg	20	<20
TRH C15-C28	mg/kg	45	<45
TRH C29-C36	mg/kg	45	<45
TRH C37-C40	mg/kg	100	<100
TRH >C10-C16 (F2)	mg/kg	25	<25
TRH >C10-C16 (F2) - Naphthalene	mg/kg	25	<25
TRH >C16-C34 (F3)	mg/kg	90	<90
TRH >C34-C40 (F4)	mg/kg	120	<120
TRH C10-C36 Total	mg/kg	110	<110
TRH C10-C40 Total	mg/kg	210	<210

PAH (Polynuclear Aromatic Hydrocarbons) in Soil [AN420] Tested: 23/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696.001
Naphthalene	mg/kg	0.1	<0.1
2-methylnaphthalene	mg/kg	0.1	<0.1
1-methylnaphthalene	mg/kg	0.1	<0.1
Acenaphthylene	mg/kg	0.1	<0.1
Acenaphthene	mg/kg	0.1	<0.1
Fluorene	mg/kg	0.1	<0.1
Phenanthrene	mg/kg	0.1	<0.1
Anthracene	mg/kg	0.1	<0.1
Fluoranthene	mg/kg	0.1	<0.1
Pyrene	mg/kg	0.1	<0.1
Benzo(a)anthracene	mg/kg	0.1	<0.1
Chrysene	mg/kg	0.1	<0.1
Benzo(b&j)fluoranthene	mg/kg	0.1	<0.1
Benzo(k)fluoranthene	mg/kg	0.1	<0.1
Benzo(a)pyrene	mg/kg	0.1	<0.1
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	<0.1
Dibenzo(ah)anthracene	mg/kg	0.1	<0.1
Benzo(ghi)perylene	mg/kg	0.1	<0.1
Carcinogenic PAHs, BaP TEQ <LOR=0	TEQ	0.2	<0.2
Carcinogenic PAHs, BaP TEQ <LOR=LOR	TEQ (mg/kg)	0.3	<0.3
Carcinogenic PAHs, BaP TEQ <LOR=LOR/2	TEQ (mg/kg)	0.2	<0.2
Total PAH (18)	mg/kg	0.8	<0.8
Total PAH (NEPM/WHO 16)	mg/kg	0.8	<0.8

Total Recoverable Elements in Soil/Waste Solids/Materials by ICPOES [AN040/AN320] Tested: 24/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696.001
Arsenic, As	mg/kg	3	<3
Cadmium, Cd	mg/kg	0.3	<0.3
Chromium, Cr	mg/kg	0.3	**2.7**
Copper, Cu	mg/kg	0.5	**0.5**
Lead, Pb	mg/kg	1	<1
Nickel, Ni	mg/kg	0.5	<0.5
Zinc, Zn	mg/kg	0.5	**1.7**

Mercury in Soil [AN312] Tested: 24/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696.001
Mercury	mg/kg	0.05	<0.05

Moisture Content [AN002] Tested: 23/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696.001
% Moisture	%w/w	0.5	**9.0**

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN040/AN320	A portion of sample is digested with nitric acid to decompose organic matter and hydrochloric acid to complete the digestion of metals. The digest is then analysed by ICP OES with metals results reported on the dried sample basis. Based on USEPA method 200.8 and 6010C.
AN040	A portion of sample is digested with Nitric acid to decompose organic matter and Hydrochloric acid to complete the digestion of metals and then filtered for analysis by ASS or ICP as per USEPA Method 200.8.
AN312	Mercury by Cold Vapour AAS in Soils: After digestion with nitric acid, hydrogen peroxide and hydrochloric acid , mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser . Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500
AN403	Total Recoverable Hydrocarbons: Determination of Hydrocarbons by gas chromatography after a solvent extraction. Detection is by flame ionisation detector (FID) that produces an electronic signal in proportion to the combustible matter passing through it. Total Recoverable Hydrocarbons (TRH) are routinely reported as four alkane groupings based on the carbon chain length of the compounds: C6-C9, C10-C14, C15-C28 and C29-C36 and in recognition of the NEPM 1999 (2013), >C10-C16 (F2), >C16-C34 (F3) and >C34-C40 (F4). F2 is reported directly and also corrected by subtracting Naphthalene (from VOC method AN433) where available.
AN403	Additionally, the volatile C6-C9 fraction may be determined by a purge and trap technique and GC/MS because of the potential for volatiles loss. Total Petroleum Hydrocarbons (TPH) follows the same method of analysis after silica gel cleanup of the solvent extract. Aliphatic/Aromatic Speciation follows the same method of analysis after fractionation of the solvent extract over silica with differential polarity of the eluent solvents .
AN403	The GC/FID method is not well suited to the analysis of refined high boiling point materials (ie lubricating oils or greases) but is particularly suited for measuring diesel, kerosene and petrol if care to control volatility is taken. This method will detect naturally occurring hydrocarbons, lipids, animal fats, phenols and PAHs if they are present at sufficient levels, dependent on the use of specific cleanup/fractionation techniques. Reference USEPA 3510B, 8015B.
AN420	(SVOCs) including OC, OP, PCB, Herbicides, PAH, Phthalates and Speciated Phenols (etc) in soils, sediments and waters are determined by GCMS/ECD technique following appropriate solvent extraction process (Based on USEPA 3500C and 8270D).
AN420	Carcinogenic PAHs may be expressed as Benzo(a)pyrene equivalents by applying the BaP toxicity equivalence factor (NEPM 1999, June 2013, B7). These can be reported as the individual PAHs and as a sum of carcinogenic PAHs. The sum is reported three ways, the first assuming all <LOR results are zero, the second assuming all < LOR results are half the LOR and the third assuming all <LOR results are the LOR.
AN433	VOCs and C6-C9 Hydrocarbons by GC-MS P&T: VOC`s are volatile organic compounds. The sample is presented to a gas chromatograph via a purge and trap (P&T) concentrator and autosampler and is detected with a Mass Spectrometer (MSD). Solid samples are initially extracted with methanol whilst liquid samples are processed directly. References: USEPA 5030B, 8020A, 8260.

FOOTNOTES

*	NATA accreditation does not cover the performance of this service.	-	Not analysed.	UOM	Unit of Measure.
		NVL	Not validated.	LOR	Limit of Reporting.
**	Indicative data, theoretical holding time exceeded.	IS	Insufficient sample for analysis.	↑↓	Raised/lowered Limit of Reporting.
		LNR	Sample listed, but not received.		

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

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ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Inglis Brien
Client	CARDNO (NSW/ACT) PTY LTD
Address	Unit 1 10 Denney Street Broadmeadow NSW 2292
Telephone	61 2 4940 5527
Facsimile	61 2 4965 4666
Email	inglis.brien@cardno.com.au
Project	**82218015 Additional**
Order Number	**82218015**
Samples	1

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE171696A R0**
Date Received	24/10/2017
Date Reported	25/10/2017

COMMENTS

Accredited for compliance with ISO/IEC 17025- Testing. NATA accredited laboratory 2562(4354).

SIGNATORIES

Dong Liang
Metals/Inorganics Team Leader

Huong Crawford
Production Manager

Ly Kim Ha
Organic Section Head

TCLP (Toxicity Characteristic Leaching Procedure) for Organics/SVOC [AN006] Tested: 24/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696A.001
pH 1:20	pH Units	-	**10**
pH 1:20 plus HCL	pH Units	-	**1.7**
Extraction Solution Used	No unit	-	**1**
Mass of Sample Used*	g	-	**25**
Volume of ExtractionSolution Used*	mL	-	**500**
pH TCLP after 18 hours	pH Units	-	**5.7**

PAH (Polynuclear Aromatic Hydrocarbons) in TCLP Extract [AN420] Tested: 24/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696A.001
Naphthalene	µg/L	0.1	<0.1
2-methylnaphthalene	µg/L	0.1	<0.1
1-methylnaphthalene	µg/L	0.1	<0.1
Acenaphthylene	µg/L	0.1	<0.1
Acenaphthene	µg/L	0.1	<0.1
Fluorene	µg/L	0.1	<0.1
Phenanthrene	µg/L	0.1	<0.1
Anthracene	µg/L	0.1	<0.1
Fluoranthene	µg/L	0.1	<0.1
Pyrene	µg/L	0.1	<0.1
Benzo(a)anthracene	µg/L	0.1	<0.1
Chrysene	µg/L	0.1	<0.1
Benzo(b&j)fluoranthene	µg/L	0.1	<0.1
Benzo(k)fluoranthene	µg/L	0.1	<0.1
Benzo(a)pyrene	µg/L	0.1	<0.1
Indeno(1,2,3-cd)pyrene	µg/L	0.1	<0.1
Dibenzo(ah)anthracene	µg/L	0.1	<0.1
Benzo(ghi)perylene	µg/L	0.1	<0.1
Total PAH (18)	µg/L	1	<1

Metals in TCLP Extract by ICPOES [AN320] Tested: 24/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696A.001
Arsenic, As	mg/L	0.02	<0.02
Cadmium, Cd	mg/L	0.001	<0.001
Chromium, Cr	mg/L	0.005	<0.005
Copper, Cu	mg/L	0.005	<0.005
Lead, Pb	mg/L	0.02	<0.02
Nickel, Ni	mg/L	0.005	<0.005
Zinc, Zn	mg/L	0.01	<0.01

Mercury in TCLP Extract [AN311(Perth) /AN312] Tested: 24/10/2017

PARAMETER	UOM	LOR	BH001 0.1-0.3 SOIL - 29/9/2017 SE171696A.001
Mercury	mg/L	0.0001	<0.0001

METHOD	METHODOLOGY SUMMARY
AN006	Contaminants of interest in a waste material are leached out of the waste with a selected leaching solution under controlled conditions. The ratio of sample to extraction fluid is 100g to 2L (1 to 20 by mass). The concentration of each contaminant of interest is determined in the leachate by appropriate methods after separation from the sample by filtering. Base on USEPA 1311.
AN006	Extraction Fluid #1: This fluid is made by combining 128.6mL of dilute sodium hydroxide solution and 11.5mL glacial acetic acid with water and diluting to a volume of 2 litres. The pH of this fluid should be 4.93 ± 0.05.
AN006	Extraction Fluid #2: This fluid is made by diluting 5.7mL glacial acetic acid with water to a volume of 1 litre. The pH of this fluid should be 2.88 ± 0.05.
AN020	Unpreserved water sample is filtered through a 0.45µm membrane filter and acidified with nitric acid similar to APHA3030B.
AN311(Perth) /AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components .
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements . Reference APHA 3120 B.
AN420	(SVOCs) including OC, OP, PCB, Herbicides, PAH, Phthalates and Speciated Phenols (etc) in soils, sediments and waters are determined by GCMS/ECD technique following appropriate solvent extraction process (Based on USEPA 3500C and 8270D).

FOOTNOTES

*	NATA accreditation does not cover the performance of this service.	-	Not analysed.	UOM	Unit of Measure.
		NVL	Not validated.	LOR	Limit of Reporting.
**	Indicative data, theoretical holding time exceeded.	IS	Insufficient sample for analysis.	↑↓	Raised/lowered Limit of Reporting.
		LNR	Sample listed, but not received.		

Samples analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calculated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here : http://www.sgs.com.au/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

Bioresources Facility, University of Newcastle

APPENDIX D

POINT LOAD TESTING RESULTS

Cardno
Shaping the Future

POINT LOAD STRENGTH TEST RESULTS

CLIENT: University of Newcastle
PROJECT: Bioresources Facility
LOCATION: University of Newcastle, Callaghan

DATE: 13/10/2017
PROJECT No: 82218015
CLIENT REF:

Bore	Depth (m)	Sample length (mm)	Sample diameter (mm)	Minimum cross-sectional area of plane (mm)	Separation at failure (mm)	Orientation (A = axial, D = diametrical, I = irregular, AS = Anisotropic rock)	Load at failure (kN)	Point load strength, I_s	Point load index, $I_{s(50)}$	Rock type & structure	Moisture content & storage history	Failure mechanism (M = massive, B = bedded, J = jointed)	Strength
BH01	4.43	41.0	52.0	2132	36.0	A	0.12	0.04	0.04			M	Very Low
	4.61	70.0	52.0	0	49.0	D	0.28	0.1	0.1			B	Low
	4.61	39.0	52.0	2028	36.0	A	0.06	0.02	0.02			J	Extremely Low
	4.89	100.0	52.0	0	49.0	D	0.28	0.1	0.1			M	Low
	4.89	39.0	52.0	2028	33.0	A	0.53	0.2	0.2			Invalid	Low
	5.09	65.0	52.0	0	48.0	D	1.03	0.4	0.4			M	Medium
	5.11	40.0	52.0	2080	35.0	A	0.64	0.2	0.2			M	Low
	5.67	110.0	52.0	0	48.0	D	0.58	0.2	0.2			M	Low
	5.67	46.0	52.0	2392	38.0	A	0.64	0.2	0.2			M	Low
	6.12	85.0	52.0	0	50.0	D	0.40	0.2	0.2			M	Low
	6.12	43.0	52.0	2236	38.0	A	0.93	0.3	0.3			M	Medium
	6.71	85.0	52.0	0	50.0	D	0.11	0.04	0.04			M	Very Low
	6.71	32.0	52.0	1664	27.0	A	0.44	0.2	0.2			Invalid	Low
	7.27	95.0	52.0	0	48.0	D	0.68	0.3	0.3			M	Low
	7.27	35.0	52.0	1820	31.0	A	0.90	0.4	0.4			M	Medium
	7.67	80.0	52.0	0	48.0	D	0.68	0.3	0.3			M	Low
	7.67	44.0	52.0	2288	37.0	A	1.16	0.4	0.4			M	Medium
	8.05	80.0	52.0	0	48.0	D	1.09	0.5	0.5			M	Medium
	8.05	39.0	52.0	2028	34.0	A	2.10	0.8	0.8			M	Medium
				0									

Test Methods: AS4133.4.1-1993 Cl 3.2 - Diametrical test; AS4133.4.1-1993 Cl 3.2 - Block and irregular lump test; AS4133.4.1-1993 Cl 3.3 - Axial test; AS4133.4.1-1993 Cl 3.5 - Anisometrical rock test

Cardno NSW/ACT Pty Ltd	**Calculated by: AA**	**Date: 13/10/2017**
Office: Broadmeadow	**Checked by: IB**	**Date: 25/10/2017**

POINT LOAD STRENGTH TEST RESULTS

CLIENT: University of Newcastle
PROJECT: Bioresources Facility
LOCATION: University of Newcastle, Callaghan

DATE: 13/10/2017
PROJECT No: 82218015
CLIENT REF:

Bore	Depth (m)	Sample length (mm)	Sample diameter (mm)	Minimum cross-sectional area of plane (mm)	Separation at failure (mm)	Orientation (A = axial, D = diametrical, I = irregular, AS = Anisotropic rock)	Load at failure (kN)	Point load strength, I_s	Point load index, $I_{s(50)}$	Rock type & structure	Moisture content & storage history	Failure mechanism (M = massive, B = bedded, J = jointed)	Strength
BH01	8.48	60.0	52.0	0	49.0	D	0.42	0.2	0.2			M	Low
	8.51	39.0	52.0	2028	32.0	A	1.58	0.6	0.6			M	Medium
	8.82	65.0	52.0	0	49.0	D	0.54	0.2	0.2			M	Low
	8.82	36.0	52.0	1872	30.0	A	0.90	0.4	0.4			M	Medium
	9.34	60.0	52.0	0	49.0	D	0.48	0.2	0.2			M	Low
	9.34	35.0	52.0	1820	31.0	A	0.89	0.4	0.4			M	Medium
	9.73	90.0	52.0	0	48.0	D	1.92	0.8	0.8			M	Medium
	9.73	43.0	52.0	2236	38.0	A	1.57	0.6	0.6			M	Medium
	10.01	70.0	52.0	0	48.0	D	1.07	0.5	0.5			M	Medium

Test Methods: AS4133.4.1-1993 Cl 3.2 - Diametrical test
AS4133.4.1-1993 Cl 3.3 - Axial test
AS4133.4.1-1993 Cl 3.2 - Block and irregular lump test
AS4133.4.1-1993 Cl 3.5 - Anisometrical rock test

Cardno NSW/ACT Pty Ltd	**Calculated by: AA**	**Date: 13/10/2017**
Office: Broadmeadow	**Checked by: IB**	**Date: 25/10/2017**

POINT LOAD STRENGTH TEST RESULTS

CLIENT: University of Newcastle
PROJECT: Bioresources Facility
LOCATION: University of Newcastle, Callaghan

DATE: 13/10/2017
PROJECT No: 82218015
CLIENT REF:

Bore	Depth (m)	Sample length (mm)	Sample diameter (mm)	Minimum cross-sectional area of plane (mm)	Separation at failure (mm)	Orientation A = axial D = diametrical I = irregular AS = Anisotropic rock	Load at failure (kN)	Point load strength, I_s	Point load index, $I_{s(50)}$	Rock type & structure	Moisture content & storage history	Failure mechanism M = massive B = bedded J = jointed	Strength
BH02	6.30	44.0	52.0	2288	38.0	A	0.08	0.03	0.03				Extremely Low
	6.35	55.0	52.0	0	44.0	D	0.06	0.03	0.03				Extremely Low
		30.0	52.0	1560	25.0	A	0.01	0.01	0.00			J	Extremely Low
	6.90	130.0	52.0	0	47.0	D	0.53	0.2	0.2				Low
		43.0	52.0	2236	38.0	A	0.28	0.10	0.1			Invalid	Low
		32.0	52.0	1664	26.0	A	0.35	0.2	0.2				Low
	7.04	42.0	52.0	2184	36.0	A	1.20	0.4	0.4				Medium

Test Methods: AS4133.4.1-1993 Cl 3.2 - Diametrical test
AS4133.4.1-1993 Cl 3.3 - Axial test
AS4133.4.1-1993 Cl 3.2 - Block and irregular lump test
AS4133.4.1-1993 Cl 3.5 - Anisometrical rock test

Cardno NSW/ACT Pty Ltd	**Calculated by: AA**	**Date: 13/10/2017**
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