Douglas Partners
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Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Administration Building
High Street Maitland

Prepared for
Maitland City Council

Project 49797.01
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Douglas Partners
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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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Report on Geotechnical Investigation
Proposed Administration Building
High Street Maitland

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed administration building at High Street Maitland. The investigation was commissioned by Aaron Cook of Maitland City Council and was undertaken in accordance with Douglas Partners' Pty Ltd (DP) proposal NCL 180163 dated 17 April 2018.

The proposed development at the site is understood to include a four level commercial structure together with additional car parking areas. It is further understood that a basement is not proposed as part of the construction. DP has previously conducted preliminary geotechnical and contamination investigations for Maitland City Council in 2011. The results from that investigation has been included (where appropriate) in this report.

A geotechnical investigation was required to assist with the design and construction of the proposed development, specifically:

- Subsurface conditions including depth to groundwater;
- Geotechnical parameters for piling design of the building;
- Estimated foundation settlements under design loading;
- Earthquake site factor in accordance with AS1170.4-2007;
- Flexible pavement thickness design for internal asphalt and concrete pavements; and
- Site preparation measures.

An assessment on contamination (DSI) was also required to provide a preliminary assessment of the contamination status of the site and suitability of the site for the proposed development. Comments on these aspects as well as acid sulphate soils have been included in a separate contamination report 49797.01.R.002.Rev0.

The investigation included the drilling of two boreholes, three cone penetration tests (CPTs), the excavation of eight test pits and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site consists of 13 small allotments in the vicinity of 263 High Street, Maitland, as well as the existing Pryor Lane, as indicated in Figure 1 below.

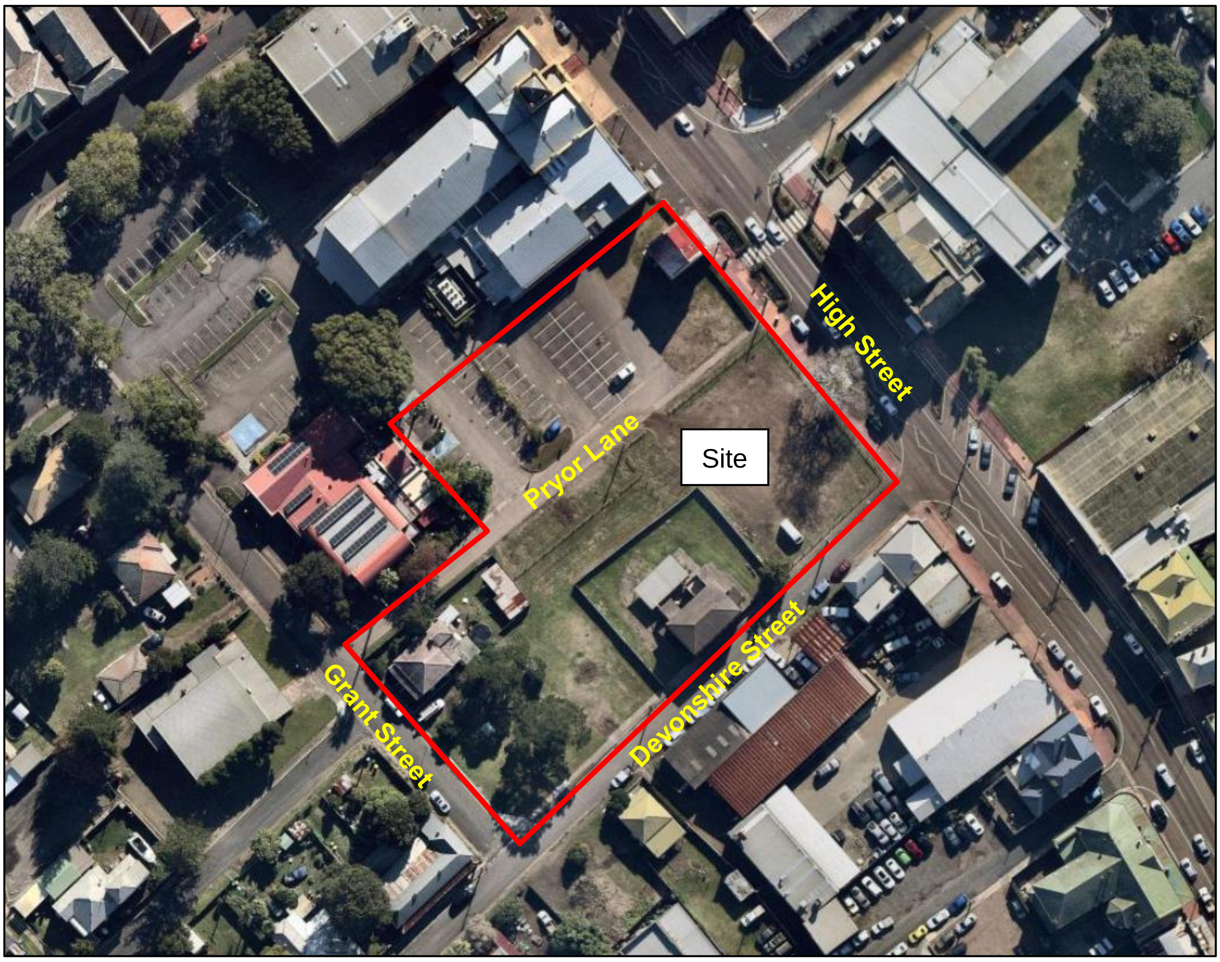


Figure 1: Proposed Site (aerial image taken from Nearmap.com.au)

The site is bounded to the north-east by High Street, to the south-east by Devonshire Street, to the south-west by Grant Street, and to the north-west by an existing administration building and town hall. The site area is approximately 7000 m^2.

Site features include the following:

- Unsealed parking area in the north-eastern corner of site;
- Vacant grassed area in the north-western and southern portions of the site;
- Existing residential developments in the south-eastern and western portions of the site;
- Driveways in the footpath adjacent to the north-eastern boundary likely to be associated with a former petrol station;
- Sealed asphalt carpark in the north-eastern portion of the site adjoining Pryor Lane; and
- A two storey heritage building located in the northern corner of the site.

Parts of the site are shown in the following Figures 2 to 4.

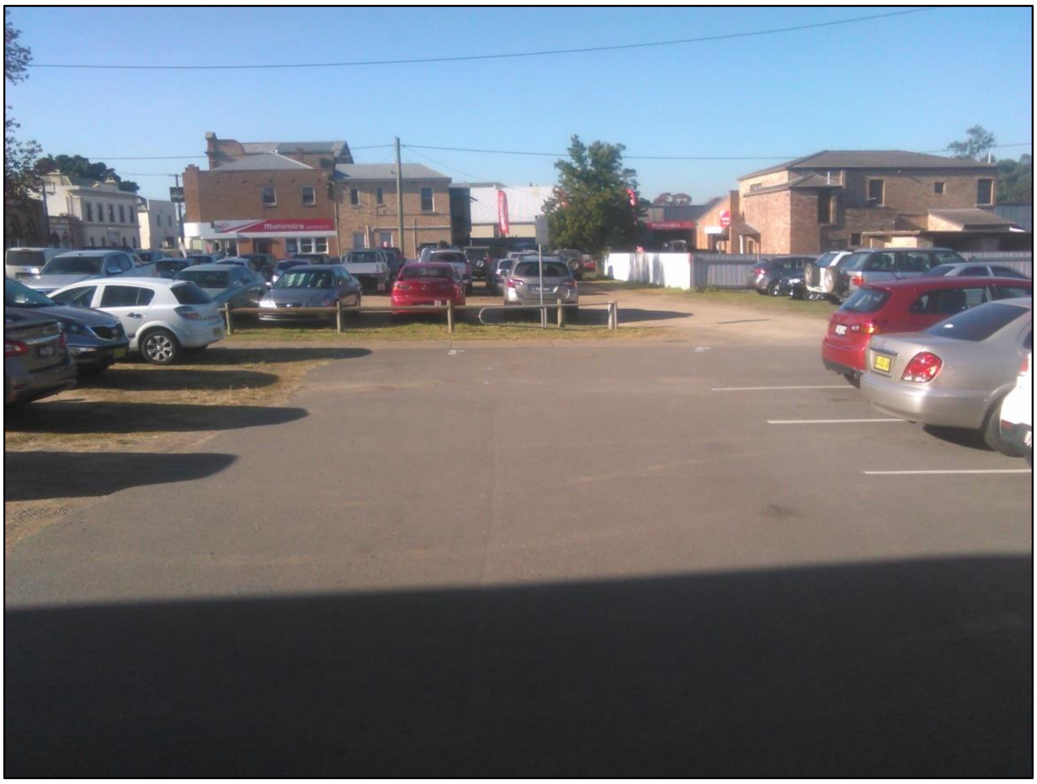


Figure 2: Facing south-east from near Bore 202 towards Prior Lane

Figure 3: Facing south-east towards Bore 403

Figure 4: Facing north-west from near High Street

The surface of the site is relatively flat. The surrounding area slopes gently towards the south-west.

Reference to the 1:100 000 Newcastle Coal Geology sheet indicates that the site is underlain by Quaternary Alluvium deposits generally comprising gravel, sand, silt and clay.

Reference to the Maitland Acid Sulphate Soil Risk Map prepared by the Department of Land & Water Conservation indicates that there is no known occurrence of acid sulphate soil materials at the site. It is noted, however, that there is a high probability of acid sulphate soils at depths greater than 3 m immediately south of the site.

The regional groundwater flow regime is probably towards the Hunter River or former river alignments, about 500 m north or north-east of the site, which is considered to be the nearest sensitive receptor. The depth to the water table is likely to be greater than 2 m, based on site observations and the nearby investigations.

3. Background

DP has previously conducted preliminary geotechnical and contamination testing at the site as part of previous investigations for Maitland City Council in 2011 (DP report reference 49797).

The area investigated included five of the 13 allotments included in the current site, located within the area to the south-east of Pryor Lane. It is noted that the two houses visible in the area were omitted from the investigation. The investigation included five cone penetration tests (CPTs) carried out to refusal and eight test bores/pits which were sampled for contamination purposes.

The pertinent findings indicated:

- The site is underlain by filling to depths of up to 2.8 m, which generally comprised clayey silty sand with trace to some building rubble consisting of bricks, tiles, concrete, glass, and ceramic;
- The subsurface conditions beneath the filling consisted of an alluvial sequence typically comprising stiff to hard silts and clay with variable proportions of silt and sand to depths of between 5 m and 7 m overlying interbedded silty sand and clay to the depth of investigation of 12.33 m to 14.46 m where CPTs refused in a sand / gravel layer;
- Groundwater was encountered at depths of 6.0 m to 7.5 m. It is noted that groundwater is variable, and is impacted by seasonal and climatic condition, as well as soil permeability;
- Whilst a site history review was not carried out, Council indicated (and provided a proposed development plan) that part of the site may have previously been used as a service station. A Ground Penetrating Radar (GPR) survey was carried out which did not indicate the presence of any underground structures;
- Contamination testing identified elevated lead and toluene concentrations within the filling at one test location (which was within the former service station site). Whilst the contamination assessment was carried out with reference to outdated guidelines, majority of the results were noted to be within the current Health Investigation Level (HIL D) for commercial/industrial land use;
- Groundwater was not subject to sampling and testing for contamination purposes; and
- An acid sulphate soil assessment was not carried out.

Council has indicated that previous land-use within the site include a plaster works, other small shops, a church of “fibro” construction and other unknown potentially contaminating activities.

4. Field Work Methods

The field work was undertaken on 19 May 2018 and 29 May 2018 to 1 June 2018 and comprised the following:

- Three CPTs (201 to 203) were undertaken using a purpose-built truck-mounted CPT rig. A 35 mm diameter instrumented cone and friction sleeve assembly was hydraulically thrust into the soil at a rate of about 1 cm/sec. Cone tip resistance, sleeve friction, pore water pressure and inclination from vertical were recorded by a computer data acquisition system for subsequent plotting and analysis. The CPTs were undertaken to refusal. Refusal on gravel was encountered in CPTs 201 and 203 at 19.13 m and 13.45 m respectively. Refusal on probable bedrock was encountered at CPT 202 at 23.95 m depth;
- Excavation of nine test pits (Pits 301 to 309) using a 3.5T excavator fitted with a 450 mm wide toothed bucket. Test pits were undertaken to depths of between 2.0 m to 3.2 m;
- Two bores (401 and 403) were drilled using a Hydrapower Scout V to depths of 28.4 m and 29.5 m respectively. The bores were drilled without sampling and testing to the nearby CPT refusal depths, with standard penetration testing then undertaken below this depth to the top of bedrock. The bores were then drilled using diamond bit coring techniques to retrieve at least 3 m of sound (i.e. low to medium strength) bedrock; and

- Dynamic penetrometer testing was undertaken up to 1.2 m depth at each test pit location.

The approximate locations of the boreholes, pits and CPTs are indicated on Drawing 1, Appendix D. Bore locations were set out by the DP engineer from site surface features. The results of the subsurface investigation indicated similar conditions to the previous investigation completed in 2011, as summarised in Section 3.

The boreholes, pits and CPTs were logged by an experienced engineer from DP with samples collected for geotechnical and contamination testing.

5. Field Work Results

The subsurface conditions are presented in detail in the borehole / test pit logs in Appendix B. The results of the CPTs are also presented in Appendix B which show an inferred strata description, based on published correlations between cone resistance, friction ratio and soil type. These should be read in conjunction with the general notes in Appendix A, which explain definitions of the classification methods and descriptive terms used.

A summary of the ground conditions is presented below:

- Unit 1: Filling was encountered to depths of up to 2.8 m at the test locations;
- An alluvial profile was encountered beneath the filling which comprised:
    - Unit 2.1: Clay (initially firm increasing to stiff or very stiff) interbedded with sandy layers to depths ranging from 9 m to 14 m; overlying;
    - Unit 2.2: Sand and gravel (locally loose but typically medium dense to dense) interbedded with stiff clay layers to about 21 m. CPT refusal occurred at all tests in this layer except CPT 202; overlying;
    - Unit 2.3: Clay (very stiff to hard) with some sandy layers; overlying; and
    - Unit 3: Siltstone which was initially extremely low strength but increased to medium strength (Bores 401 and 403 only).

Groundwater was observed following CPTs at between 2.1 m depth and 5.7 m depth. The measurement of groundwater level by dipping the CPT hole provides a relatively crude indication of groundwater levels. The groundwater at 2.1 m could potentially represent perched water above the clay rather than the regional groundwater which was observed below 5 m depth. It should be noted that groundwater levels are affected by factors such as climatic conditions and soil permeability and will therefore vary with time.

A plot of the cone resistance against depth for all CPTs completed at the site is presented in Figure 5 below to provide an indication of the main subsoil units that were encountered at the site.

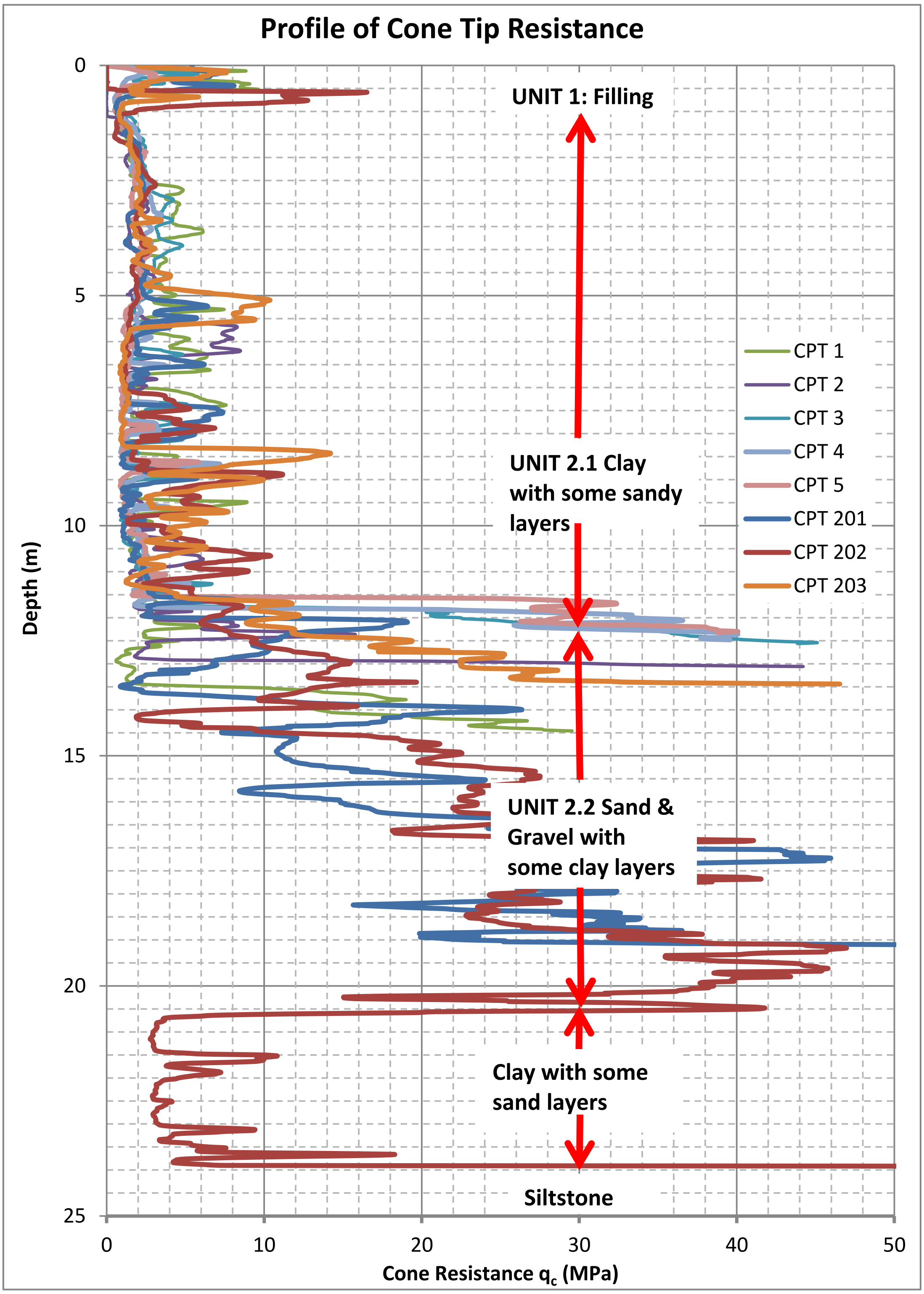


Figure 5: Cone Resistance (qc – MPa) v Depth (m)

6. Laboratory Testing

Laboratory testing was undertaken by Douglas Partners laboratory, a National Association of Testing Authorities, Australia (NATA) registered laboratory.

Laboratory testing undertaken on selected materials sampled from the test pits comprised the following:

- Two Standard compaction / 4-day soaked California bearing ratio (CBR) test on the subgrade material;
- Two shrink swell tests.

The detailed results of laboratory testing are included in Appendix C. Summaries of the laboratory tests are given in Table 1.

Table 1: Summary of CBR and Shrink Swell Results

Bore	Depth (m)	Description	FMC (%)	SOMC (%)	SMDD (t/m^3)	CBR (%)	Swell (%)	MC after Soaking (%)	MC Top 30mm (%)	Iss (%)
301	1.3 – 1.7	Silty Clay	30.4	-	-	-	-	-	-	3.3
302	0.7 – 0.9	Filling – Sandy Silt	25.1	23.0	1.57	6	1.0	26.3	27.6	-
304	0.7 – 1.0	Silty Clay	17.6	20.5	1.63	7	1.0	22.6	23.1	-
306	0.6 – 0.7	Silty Clay	27.2	-	-	-	-	-	-	0.8
501	0.75 – 1.1	Silty Clay	31.3	-	-	-	-	-	-	2.7

Notes to Table 1:
FMC - Field Moisture Content
SOMC - Standard Optimum Moisture Content
MC – Moisture Content
SMDD - Standard Maximum Dry Density
CBR - California Bearing Ratio (4 day soaked)
🟦 – Nearby test for damaged building DP report 49797.01.R.001.Rev0

Three samples were also submitted to Envirolab for analysis of pH, electrical conductivity (EC), soluble sulphate (SO_4) and soluble chloride (Cl), to assess soil aggressiveness. Detailed laboratory report sheets are provided in Appendix C, and are summarised in Table 7 within Section 8.6 of this report.

7. Proposed Development

The site for the building is located on High Street, Maitland, adjacent to the existing administration building and Town Hall. It is understood that the proposed site and development includes the following:

- The site consists of 13 small allotments as well as the existing Pryor Lane, as indicated in Figure 6 below;
- The proposed building is to be some 6000 m^2, four stories high with no basement, covering the northern portion of the site fronting High Street;
- An at-grade car park is to be built on the remainder (southern portion) of the site;
- Column loads are expected to be in the order of 5500 kN; and
- Council have indicated that the entire site is zoned as B4 Mixed Use.

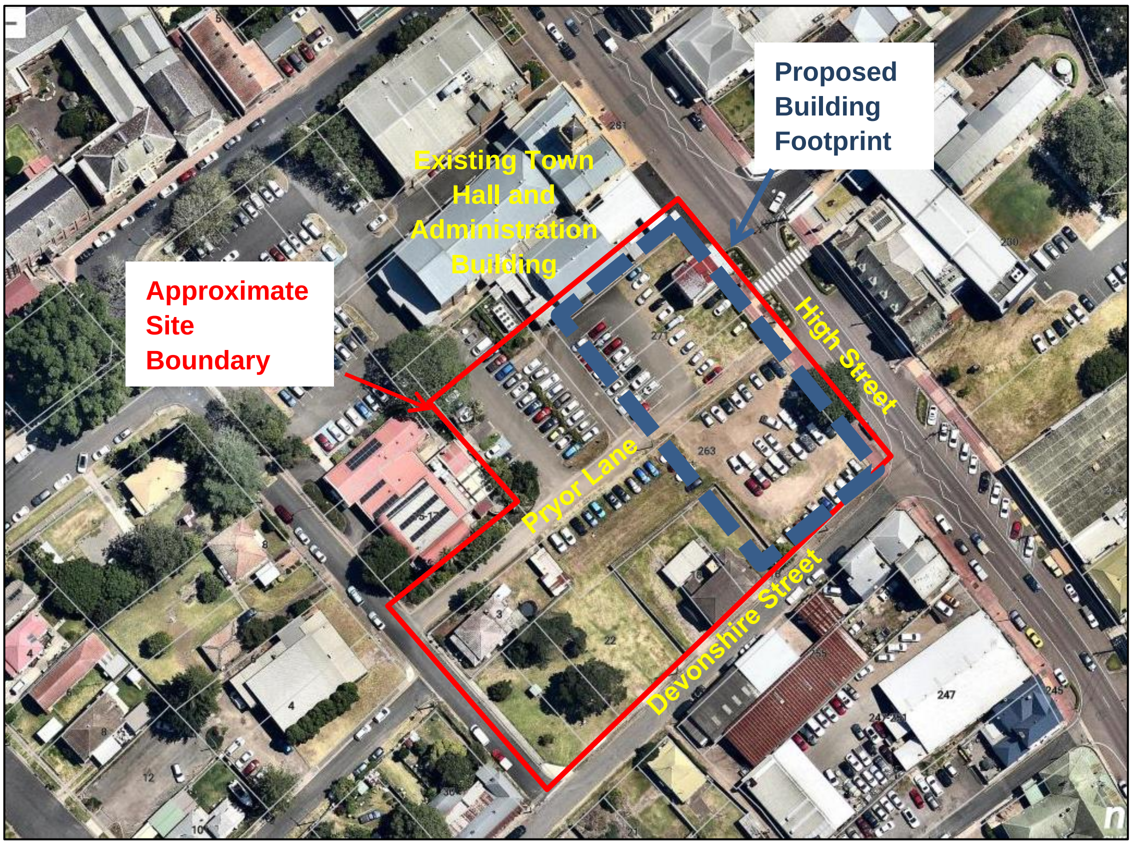


Figure 6: Proposed Site (aerial image taken from Nearmap.com.au)

8. Comments

8.1 Site Classification

Site classification to AS 2870 is not strictly applicable to this project because the proposed building is not residential. However, the principles of footing design and site maintenance presented therein should be taken into account for structures such as that proposed for the site.

A significant part of the site contains filling which is considered to be uncontrolled.

Accordingly, the classification for the site is Class P in accordance with AS2870 – 2011 (Ref 1).

The results of the laboratory shrink-swell testing taken from the silty clay returned Iss values of between 0.8% and 3.3% per ΔpF indicating that the site is moderately to highly susceptible to volume change with changes in moisture content. Therefore, it is recommended that possible reactive movements within the filling and natural soil be taken into account under proposed floor slabs. Based on the results of shrink-swell testing, the characteristic surface movement for normal seasonal fluctuations in soil moisture content has been estimated to be up to 45 mm to 55 mm.

The above classification should be revised following earthworks (cutting or filling) as required by AS 2870-2011. The classification would depend on the depth and type of material used as well as the level of compaction and level of quality control.

8.2 Pavement Design

8.2.1 General

There is variation in the depth and consistency of the filling subgrade across the site as indicated by the logs and DCP results. Fill materials generally consisted of a mixture of sands, silts and clays with some deleterious materials such as brick, concrete, ceramic, glass and fibro sheet fragments (potential asbestos containing materials – ACM). The thickness of the filling ranges from 0.4 m to 2.8 m. Firm to stiff silty clay generally immediately underlies the filling. Elevated moisture was encountered in the filling tested in Pit 302 from 0.7 m to 0.9 m. Further, the firm to stiff silty clays are also expected to have elevated moisture contents in parts of the site.

Based on the results of the testing, investigation and experience with similar materials, a design subgrade CBR of 3.5% has been adopted based on provision of a 300 mm layer of select subgrade over the existing filling, firm to stiff silty clays and any soft/ l oose materials. The provision of a select layer is expected to allow adequate compaction of the overlying pavement materials but due to the variability of filling and elevated soil-moisture in the natural clays, additional subgrade improvement should be anticipated.

If possible, civil design of the pavements should minimise the amount of excavation that is proposed i.e. building above current surface levels to minimise exposure of the underlying weaker materials.

Estimated traffic loadings for site pavements were not available at the time of this report, therefore the loadings for the car park have been assumed to comprise primarily car type traffic (150 cars per day) with 1% heavy vehicles for servicing. If heavier traffic is envisaged, or if more detailed traffic information becomes available, these values should be revised.

8.2.1 Flexible Pavement

Based on the procedures presented in Ref 2, the recommended flexible pavement thickness design for the traffic loadings above is presented in Table 2 below.

Table 2: Pavement Thickness Design

Pavement Layer	CBR 3.5%*, ESA = 4 x 10^3
Wearing Course	40 AC#
Basecourse	100
Subbase	140
Total	280 plus select*

Notes to Table 2:

A primer seal should be placed over the basecourse

* 300 mm layer of select subgrade over the existing filling, firm to stiff silty clays and any soft/loose materials.

The pavement thickness designs provided in this report are dependent on the provision of adequate surface and subsurface drainage measures and include (but not limited to) installation of subsoil drains within the subgrade on either side of the road pavement. Such drainage measures should be designed to enable regular maintenance.

Recommended pavement material quality and compaction requirements are presented in Table 3 below.

Table 3: Material Quality and Compaction Requirements – Flexible Pavement

Pavement Layer	Material Quality	Compaction
Basecourse	CBR > 80%, PI ≤ 6%, Grading in accordance with MCC requirements for a basecourse gravel	Compact to at least 98% dry density ratio Modified (AS 1289.5.2.1)
Subbase	CBR > 30%, PI≤ 12%, Grading in accordance with MCC requirements for a subbase gravel	Compact to at least 95% dry density ratio Modified (AS 1289.5.2.1)
Select Subgrade	CBR > 15%	Compact to at least 100% dry density ratio Standard (AS 1289.5.2.1)
Subgrade	CBR ≥ 3.5%	Refer to Section 8.3

8.2.2 Rigid Pavement

For rigid pavements with a concrete base, the subbase should comprise compacted base quality gravel with a minimum thickness of 125 mm. The subbase for a lightly trafficked rigid pavement is required to provide a uniform support for the concrete base, and allow load spreading between the panels.

A select subgrade layer of 300 mm thickness may be required to assist compaction over the existing filling, firm to stiff silty clays and any soft / loose materials.

The rigid pavement thickness design for the car park is presented in Table 4 and has been based on the procedures presented in Ref 2. The pavement thickness design presented in this report refers to minimum layer thicknesses, no allowance has been made for construction tolerances and the like.

Table 4: Rigid Pavement Thickness

Layer	Thickness (mm)
Basecourse (32 MPa concrete)	145*
Granular Subbase	125
Select Subgrade (where required)	0 to 300
Total	270 plus select

Notes to Table 4:

* The concrete thickness refers to a pavement with shoulders, that is, concrete of at least 0.6 m width, cast integrally with the pavement, that is not subject to wheel loading. If a shoulder cannot be provided for the pavement, the concrete thickness should be increased to at least 170 mm.

Joints in the concrete should be dowelled.

The pavement thickness is for concrete pavements at grade and is not appropriate for suspended slabs, which should be designed on structural principles.

Material quality and compaction requirements for rigid pavements are shown in Table 5 below.

Table 5: Material Quality and Compaction Requirements – Rigid Pavement

Pavement Layer	Material Quality	Compaction Requirements
Basecourse*	32 MPa compressive strength at 28 days. Dowelled at joints*	-
Subbase	CBR > 30%, PI≤ 12%, Grading in accordance with MCC requirements for a subbase gravel	Compact to at least 95% dry density ratio Modified (AS 1289.5.2.1)
Select Subgrade	CBR > 15%	Compact to at least 100% dry density ratio Standard (AS 1289.5.2.1)
Subgrade	CBR ≥ 3.5%	Refer to Section 8.3

Notes to Table 5:

*Reinforcement design should be undertaken by a structural engineer.

8.3 Site Preparation

The success of the earthworks and site preparation will depend on the experience of the contractor, on the equipment, techniques and materials used, and on the prevailing weather conditions.

Based on the results of the investigation and the proposed development, the following site preparation measures are recommended for the pavement areas:

- Remove topsoil / organic layer from the surface;
- Test roll the surface using a heavy (10 tonne static weight) smooth drum non vibrating roller. It is recommended that a vibratory roller should not be used on this site to reduce the risk of water pumping which may soften the subgrade;

- Any soft soils encountered during poof rolling should be excavated to a depth of no greater than 0.5 m initially and replaced with approved granular materials and compacted in layers to achieve a dry density ratio of at least 98% Standard or 75% density index (depending on the material used). A geotechnical engineer should inspect the surface during the test roll and the need for excavation and replacement;
- Where raising the site, approved material should be placed in layers not exceeding 0.3 m loose thickness and compacted to a dry density ratio of at least 98% Standard with a moisture range of between -3% (dry) and -1% (wet) of standard optimum moisture content. This moisture specification should be reviewed during the initial field trials at the commencement of earthworks;
- In pavement areas, the upper 1 m of the profile should be compacted to a density ratio of least 100% Standard with a moisture range of between -3% (dry) and -1% (dry) of standard optimum moisture content (OMC);
- Temporary fill batter slopes (where proposed), above groundwater, should be battered no steeper than:
    - 1.5H:1V in the short term for cuts up to 3 m height and above the groundwater level; or
    - Provided that existing services and buildings are beyond the line extending from the toe of the batter up at 2H:1V.

Geotechnical inspections and testing should be undertaken during construction in accordance with AS 3798-2007(Ref 3).

8.4 Footing Options and Estimated Capacities

The surface filling and variable alluvial soils are considered unsuitable founding strata for the high column loads proposed, because of the potential for large settlements and therefore piled footings are recommended for this project.

It is considered that suitable pile types for this site would include bored piles, grout injected (CFA) piles and screw cast concrete piles (eg Atlas). The preferred pile is considered to be CFA piles. Driven piles such as precast concrete or treated timber would also be technically feasible; however installation may cause vibration damage, particularly where sensitive heritage buildings are located in the near vicinity of the site.

In the case of bored piles, consideration should be given to the use of temporary or permanent casing to overcome groundwater inflow, together with clay and sand collapsing into the pile excavation during drilling. Bored piles founding in the gravel and sand layer, however, is not recommended due to possible decompression or “base-boiling” of this layer during the installation process.

The design geotechnical strength of a pile ($R_{d,g}$) is the ultimate geotechnical strength ($R_{d,ug}$) multiplied by the geotechnical strength reduction factor (ϕ_g), such that:

$$R_{d,g} = \phi_g . R_{d,ug}$$

The calculated value $R_{d,g}$ must equal or exceed the structural design action effect E_d.

Selection of the geotechnical strength reduction factor (ϕ_g) is based on a series of individual risk ratings (IRR) which are weighted and lead to an average risk rating (ARR). The individual risk ratings and final value of ϕ_g depend on the following factors:

- Site: the type, quantity and quality of testing;
- Design: design methods and parameter selection;
- Installation: construction control and monitoring;
- Pile testing regime: testing benefit factor based on percentage of piles tested and the type of testing; and
- Redundancy – whether other piles can take up load if a given pile settles or fails.

Based on current testing, a basic geotechnical strength reduction factor of 0.52 has been adopted (assuming low redundancy).

The following presents comments on the three main target layers for the support of piles:

Unit 2.1 Clay

Piles founding in the Unit 2.1 stiff or stronger clay at depths of 6 m to 10 m were successfully installed for the upgrade of the Art gallery which is located on the north-eastern side of High Street (within 50 m of the boundary of the site). Temporary casing was required for some of these piles due to collapsing conditions where piles were founded at or below the groundwater. It should be noted that the clay layer is not suitable for the support of heavily loaded piles. For example, based on a geotechnical reduction factor ϕ_g of 0.52, the design geotechnical compressive strength of a single 0.6 m diameter CFA pile installed at a depth of 8 m to 10 m is in the range of about 300 kN to 400 kN.

Unit 2.2 Sand and Gravel

The Unit 2.2 sand and gravel layer has successfully been used for the support of more heavily loaded piles in the Maitland CBD area in areas where the layer was sufficiently thick and consistent across the site. The results of the current investigation (Bores 401 and 403 and CPT 202) indicate that this layer could be used to support piles although additional CPTs or bores would be required once the pile layout has been confirmed. Based on the results of CPT 202, the optimal target depth for piles installed in this layer is at about 17 m to 18 m. At these depths, specialist piling contractors are expected to be required for the project. As a guide, based on a geotechnical reduction factor Φg of 0.52, the design geotechnical compressive strength of a single 0.6 m diameter CFA pile installed at a depth of 17 m to 18 m was estimated to be about 1800 kN. The geotechnical compressive strength of a single 0.75 m diameter CFA pile installed at a depth of 17 m to 18 m was estimated to be about 2300 kN.

Unit 3 Siltstone

> Piles socketed into the medium strength Unit 3 siltstone could be used to support heavily loaded piles. The medium strength siltstone was encountered at depths of 24.6 m (Bore 401) and 26 m (Bore 403) and therefore specialist piling contractors are expected to be required to achieve these depths. The capacity of the piles will depend on the length of socket and the installation method. As a guide, a 0.75 m diameter pile socketed at least 2 to 3 m into the medium strength siltstone could support a compressive serviceability load of up to about 3000 kN.

The above estimated capacities relate to geotechnical strength only, the structural adequacy of the piles should also be checked. It should also be noted that estimated capacity is for properly installed piles. The actual capacity of a pile is very much dependant on the installation technique and therefore actual capacities may vary from those predicted. Of particular importance is the correct rate of rotation versus penetration through the sand / gravel soil. Over-rotation for grout-injected piles can lead to de-compression of such soil leading to reduced pile capacity / increased settlement.

Table 6 shows the main geotechnical strata / units and the recommended design parameters for each geological unit. No values are provided for Unit 1 as any contribution from this layer should be ignored.

Table 6: Preliminary Design Parameters for Piles

Unit	Stratum	Depth Range (m)	Ultimate Values		Serviceability Values	
			End Bearing (kPa)	Shaft Adhesion (kPa)	End Bearing (kPa)	Shaft Adhesion (kPa)
2.1	CLAY stiff	2 - 13	900[5]	20	360	8
2.2	SAND & GRAVEL: dense	13 - 20	4500	70	1800	28
2.3	CLAY: hard	20 - 26	1500	25	600	10
3.0	SILTSTONE – medium strength	26 - 29	10,000	350	3500	150

Notes to Table 6

1. Ultimate Values occur at large settlements (> 5% of minimum footing diameter) - Ref 5.
2. Shaft adhesion values based on a shaft roughness of R2 or better.
3. Serviceability / Max Allowable end bearing to cause settlement of < 1% of minimum footing dimension or pile diameter.
4. AS 2159 – 2009 requires that the contribution of the shaft from ground surface to 1.5 times pile diameter or 1 m (whichever is greater) shall be ignored.
5. Based on piles founding below 8 m depth.

Tension (uplift) capacities should be based on 75% of the shaft adhesion values shown in Table 6.

Estimated foundation settlements under design loading would be in the order of 1% of the pile diameter.

A piled raft could potentially combine the benefits of the Unit 2.1 clay layer of Unit 2.2 sand layer and substantially reduced pile lengths to say 12 m to 13 m to form a suitable foundation system. It would entail the use of a considerably thicker and stiffer raft slab to distribute the loads over strategically located piles. The layout and depth of piles, as well as slab thickness and stiffness, can be adjusted to minimise differential settlements between columns.

The design of piled rafts requires integrated geotechnical and structural analysis. It is best undertaken using finite element software (e.g. Plaxis). It is recommended that a piled raft analysis be carried out to assess the feasibility of this foundation option and enable a cost-benefit assessment.

8.5 Seismic Parameters

The current earthquake code (AS 1170.4-2007, Ref 4), has a rating system for soil profiles based on soil strength and average shear-wave velocities. The design of earthworks and structures should take into account potential seismic loading.

Based on the review of the existing data the ‘site sub-soil class’, as defined in Section 4.1 of Ref 4, has been assessed for the site in its *present* condition as Class C_e “Shallow soil site”.

The Hazard Factor Z is 0.10, corresponding to the bedrock acceleration coefficient for the Maitland area. This value has a 1 in 500 year annual probability of exceedance (or a 10% chance of exceedance in 50 years - a typical design life). The presence of deep alluvial soils will typically amplify the bedrock motion, resulting in larger accelerations at the ground surface: the earthquake code allows for amplification through the ‘site sub-soil class’ described above. A site specific seismic response investigation and analysis would be advisable for important or sensitive structures.

8.6 Aggressiveness

The results of soil aggressiveness testing on selected samples from selected test pits were compared to classifications for exposure in soil provided in AS 2159 - 2009 (Ref 5) The results are summarised in Table 7 below.

Table 7: Results of Soil Aggressiveness Tests

Test Location		Laboratory Testing				Interpretation of Results		
Bore	Depth (m)	pH	EC (µS/cm)	Cl (mg/kg)	SO_4 (mg/kg)	Soil Type (A or B)	Classification for Concrete	Classification for Steel
301	0.5	7.7	160	10	57	B	Non-aggressive	Non-aggressive
306	3.0	8.0	91	<10	24	B	Non-aggressive	Non-aggressive
307	1.7	8.0	88	<10	23	B	Non-aggressive	Non-aggressive

Notes to Table 7:

EC: Electrical Conductivity SO_4: Sulphates Cl: Chlorides

Soil Type A: High permeability soils (e.g. sands and gravels) which are in groundwater

Soil Type B: Low permeability soils (e.g. silts and clays) or all soils above groundwater

9. References

1. Australian Standard AS2870-2011, 'Residential Slabs and Footings', April 2011, Standards Australia.
2. “Guide to Pavement Technology, Part 2: Pavement Structural Design”, AUSTROADS AGPT02-12 February 2012.
3. Australian Standard AS 3798–2007, “Guidelines on Earthworks for Commercial and Residential Developments”, Standards Australia.
4. Australian Standard AS1170.4-2007, “Structural Design Actions, Part 4: Earthquake Actions in Australia”, Standards Australia.
5. Australian Standard AS 2159–2009, “Piling – design and installation”, Standards Australia.

10. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at High Street Maitland in accordance with DP’s proposal NCL180163 dated 17 April 2018 and acceptance received from Aaron Cook of Maitland City Council dated 7 May 2018. The work was carried out under DP’s Conditions of Engagement. This report is provided for the exclusive use of Maitland City Council for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and / or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and / or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

An assessment of surface or sub-surface materials for contaminants within the site is included in a separate report by DP titled 'Report on Detailed Site Investigation (Contamination)', 49797.01.R.002.Rev0.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the (geotechnical / environmental / groundwater) components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report
Sampling Methods
Soil Descriptions
Symbols and Abbreviations
Rock Descriptions
CSIRO BTF18

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726-1993, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	Lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

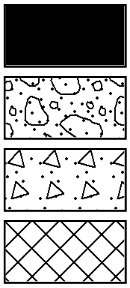
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

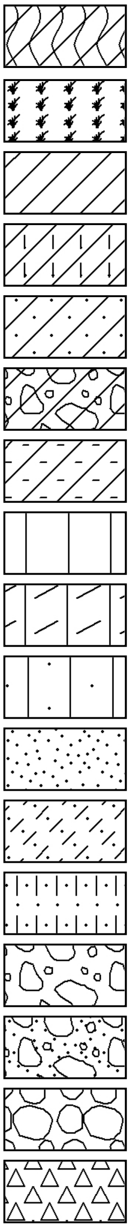
Graphic Symbols for Soil and Rock

General



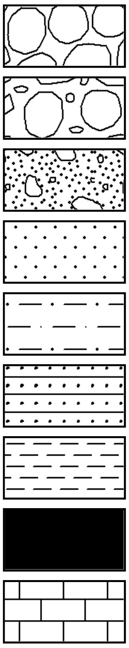
- Asphalt
- Road base
- Concrete
- Filling

Soils



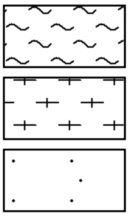
- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks



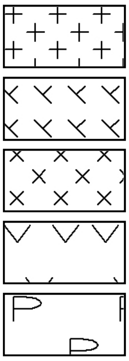
- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks



- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks



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

Rock Descriptions

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Core lengths mostly > 1000 mm

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

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

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Foundation Maintenance and Footing Performance: A Homeowner's Guide

CSIRO
PUBLISHING
BTF 18-2011
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay

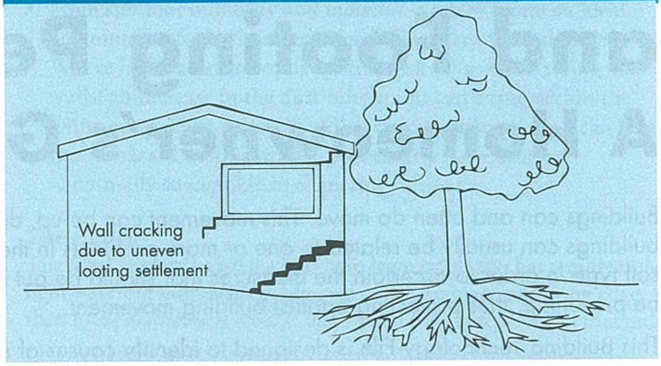
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Trees can cause shrinkage and damage



Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter

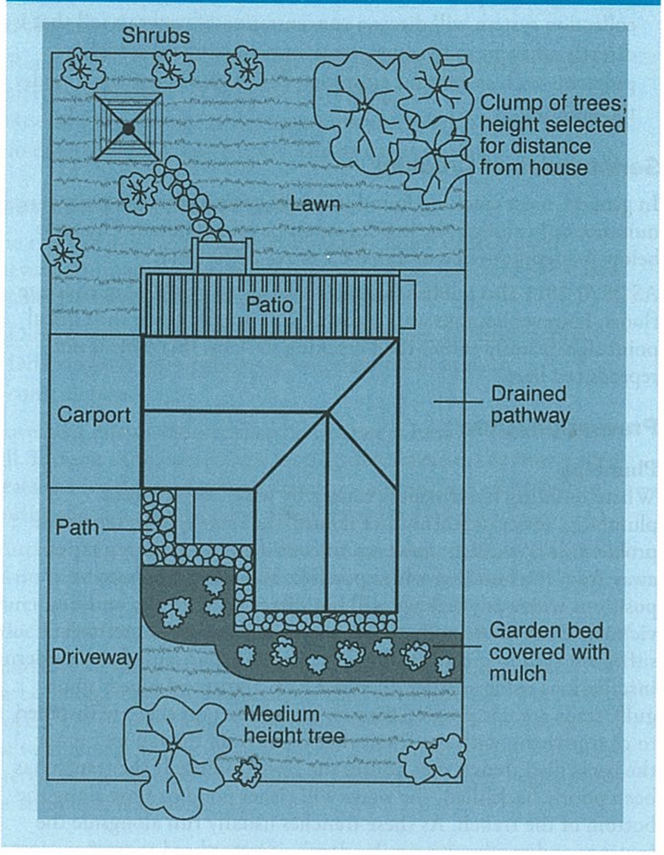
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4

Gardens for a reactive site



extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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Appendix B

Cone Penetration Tests (CPT-201 to CPT-203)
Test Pit Logs (Pits 301 to 309)
Borehole Logs (Bores 401 and 403)
Previous Investigation Cone Penetration Tests (1 to 5)
Previous Investigation Test Pit Logs (107 and 108)
Previous Investigation Borehole Logs (101 to 106)

PIEZOCONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PROPOSED ADMINISTRATION BUILDING

LOCATION: HIGH STREET, MAITLAND

REDUCED LEVEL: 7.3

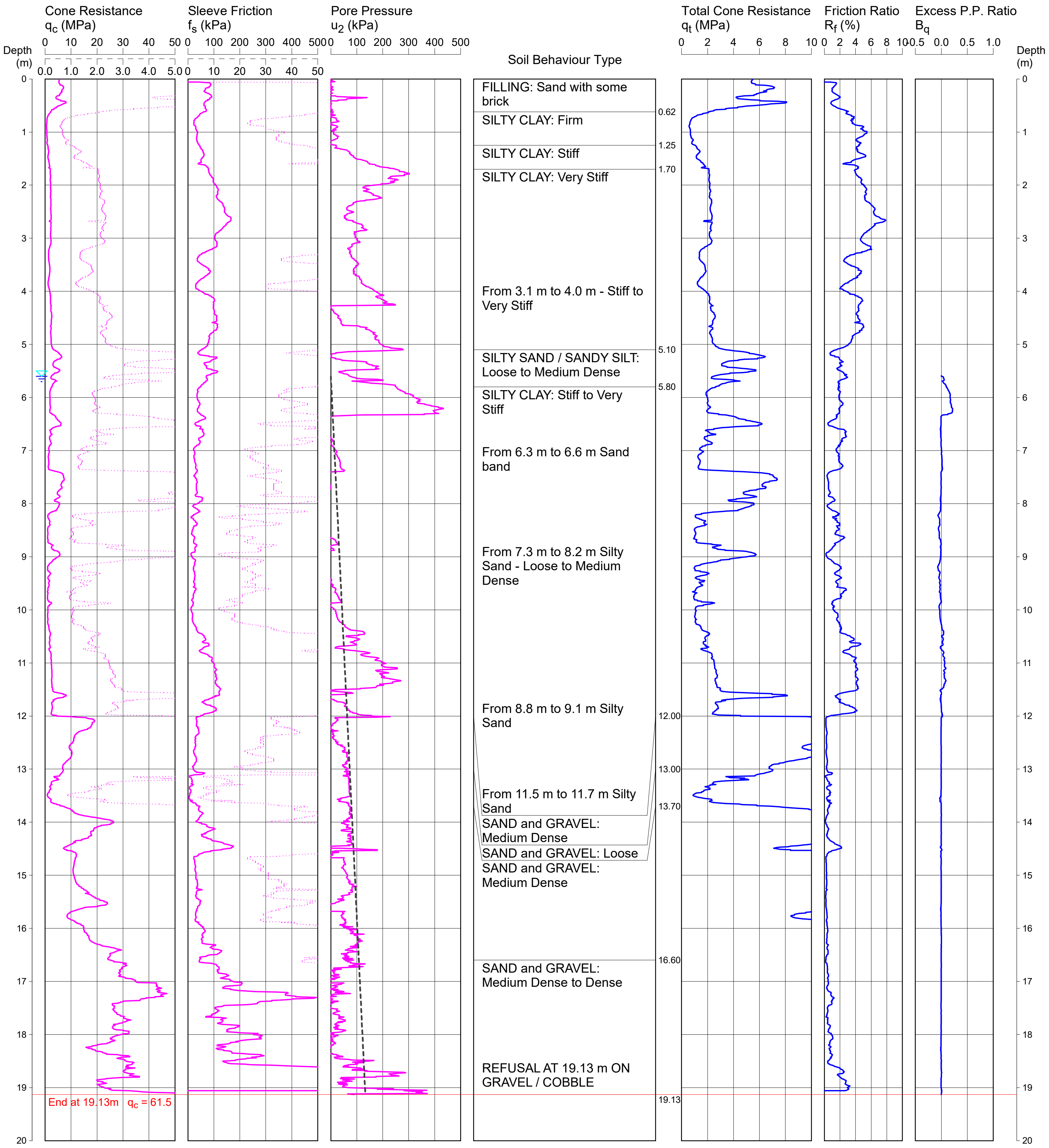
COORDINATES:

CPT-201

Page 1 of 1

DATE 19/05/2018

PROJECT No: 49797.01



FILLING: Sand with some brick

SILTY CLAY: Firm

SILTY CLAY: Stiff

SILTY CLAY: Very Stiff

From 3.1 m to 4.0 m - Stiff to Very Stiff

SILTY SAND / SANDY SILT: Loose to Medium Dense

SILTY CLAY: Stiff to Very Stiff

From 6.3 m to 6.6 m Sand band

From 7.3 m to 8.2 m Silty Sand - Loose to Medium Dense

From 8.8 m to 9.1 m Silty Sand

From 11.5 m to 11.7 m Silty Sand

SAND and GRAVEL: Medium Dense

SAND and GRAVEL: Loose

SAND and GRAVEL: Medium Dense

SAND and GRAVEL: Medium Dense to Dense

REFUSAL AT 19.13 m ON GRAVEL / COBBLE

REMARKS: DEPTH TO WATER AT COMPLETION OF TEST : 5.6 m

Water depth after test: 5.60m depth (measured)

File: P:\49797.01 - MAITLAND, 263 High Street\4.0 Field Work\4.2 Testing\49797.01-CPT-201.CP5
Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.9.2

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PIEZOCONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PROPOSED ADMINISTRATION BUILDING

LOCATION: HIGH STREET, MAITLAND

REDUCED LEVEL: 8.2

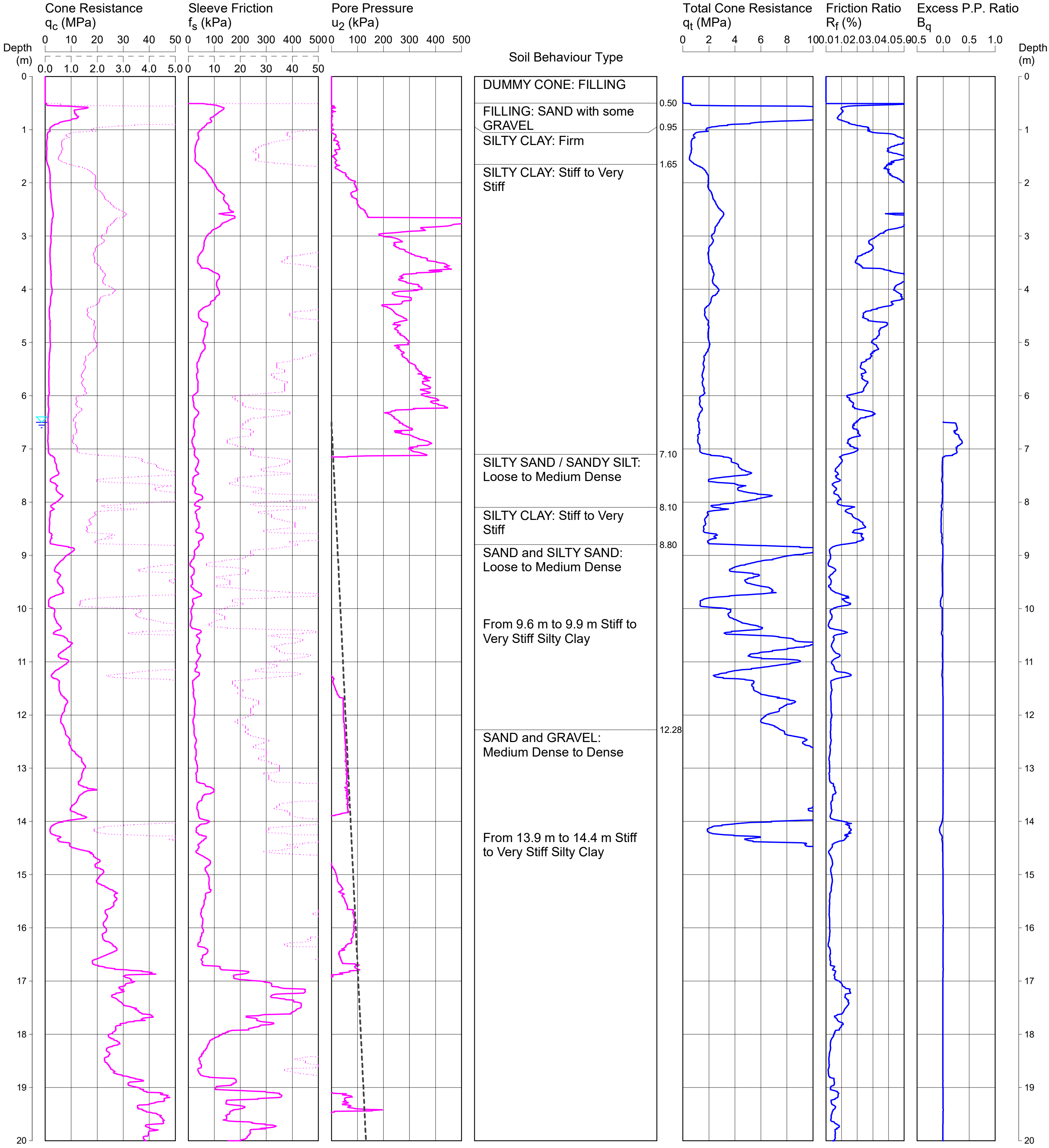
COORDINATES:

CPT-202

Page 1 of 2

DATE 19/05/2018

PROJECT No: 49797.01



Depth (m)	Soil Behaviour Type
0.50	DUMMY CONE: FILLING
0.95	FILLING: SAND with some GRAVEL
1.65	SILTY CLAY: Firm
7.10	SILTY CLAY: Stiff to Very Stiff
8.10	SILTY SAND / SANDY SILT: Loose to Medium Dense
8.80	SILTY CLAY: Stiff to Very Stiff
12.28	SAND and SILTY SAND: Loose to Medium Dense From 9.6 m to 9.9 m Stiff to Very Stiff Silty Clay
	SAND and GRAVEL: Medium Dense to Dense From 13.9 m to 14.4 m Stiff to Very Stiff Silty Clay

REMARKS: WATER LEVEL MEASURED AT 2.1 m AT COMPLETION OF TEST. ASSUMED WATER LEVEL AT 6.5 m to MATCH THE MEASURED POREWATER PRESSURE

Water depth after test: 6.50m depth (assumed)

File: P:\49797.01 - MAITLAND, 263 High Street\4.0 Field Work\4.2 Testing\49797.01-CPT-202.CP5
Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.9.2

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PIEZOCONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PROPOSED ADMINISTRATION BUILDING

LOCATION: HIGH STREET, MAITLAND

REDUCED LEVEL: 8.2

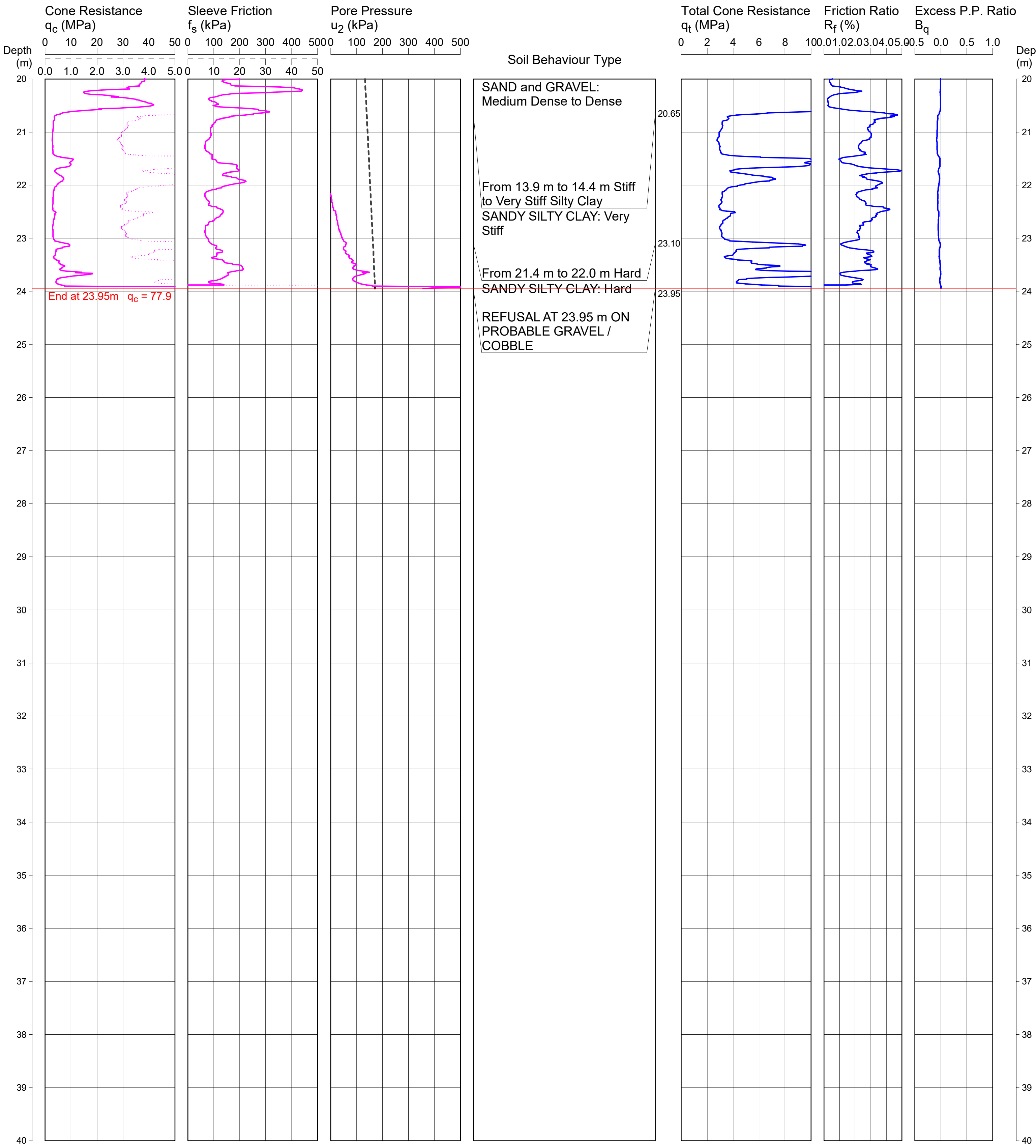
COORDINATES:

CPT-202

Page 2 of 2

DATE 19/05/2018

PROJECT No: 49797.01



REMARKS: WATER LEVEL MEASURED AT 2.1 m AT COMPLETION OF TEST. ASSUMED WATER LEVEL AT 6.5 m to MATCH THE MEASURED POREWATER PRESSURE

Water depth after test: 6.50m depth (assumed)

File: P:\49797.01 - MAITLAND, 263 High Street\4.0 Field Work\4.2 Testing\49797.01-CPT-202.CP5

Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.9.2

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PIEZOCONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PROPOSED ADMINISTRTION BUILDING

LOCATION: HIGH STREET, MAITLAND

REDUCED LEVEL: 8.5

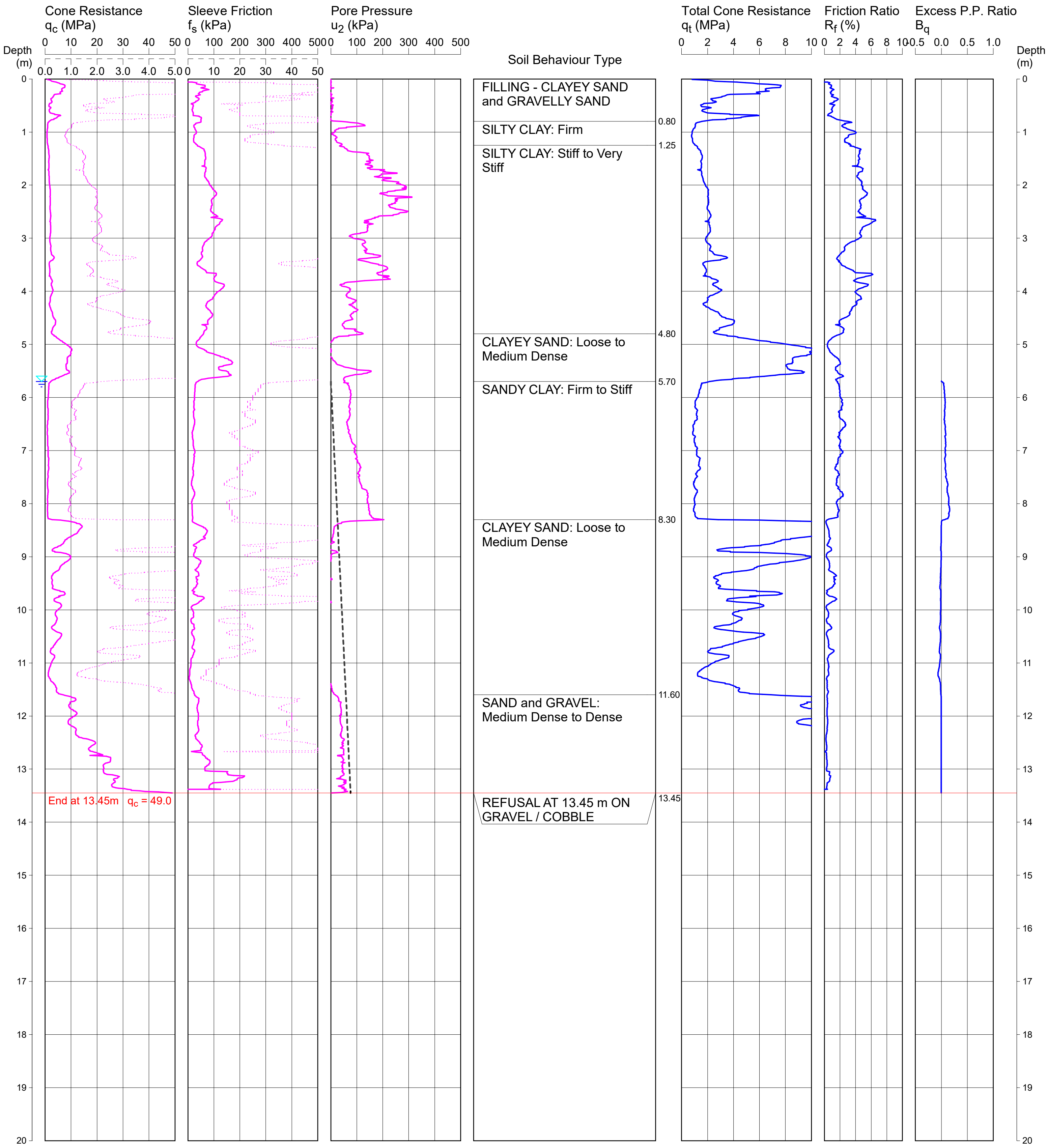
COORDINATES:

CPT-203

Page 1 of 1

DATE 19/05/2018

PROJECT No: 49797.01



REMARKS: DEPTH TO WATER AT COMPLETION OF TEST : 5.7 m

Water depth after test: 5.70m depth (measured)

File: P:\49797.01 - MAITLAND, 263 High Street\4.0 Field Work\4.2 Testing\49797.01-CPT-203.CP5
Cone ID: IGS **Type:** 5 Piezocone

ConePlot Version 5.9.2
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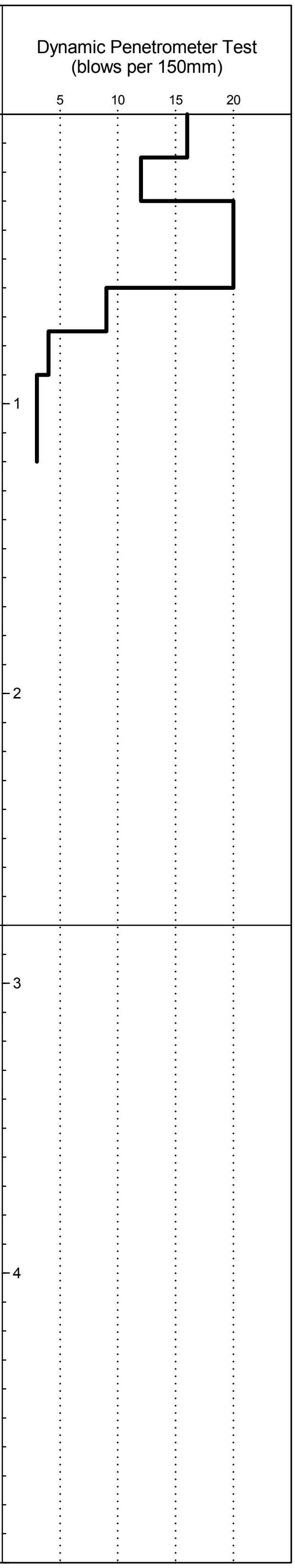
TEST PIT LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: High Street, Maitland

SURFACE LEVEL: --
EASTING: 365171
NORTHING: 6376885

PIT No: 301
PROJECT No: 49797.01
DATE: 19/5/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING - Generally comprising pale brown gravelly silty sand filling with subrounded gravel approximately 50mm diameter, moist		D	0.0 0.2	E		
	0.4	FILLING - Generally comprising dark brown silty sand filling with some to abundant, brick, ceramic and some coal, ash and subrounded gravel with trace silty clay, trace fibro and metal, moist		D	0.5	E		
	1.2	SILTY CLAY - Dark brown silty clay, M>Wp			1.3			
				U D	1.5	E		
					1.7		pp = 150	
				D	2.0	E		
				D	2.7	E	pp = 100-200	
	2.8	Pit discontinued at 2.8m, limit of investigation						



RIG: 3.5 Tonne Excavator with 450mm tooth bucket
LOGGED: Sebastian
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

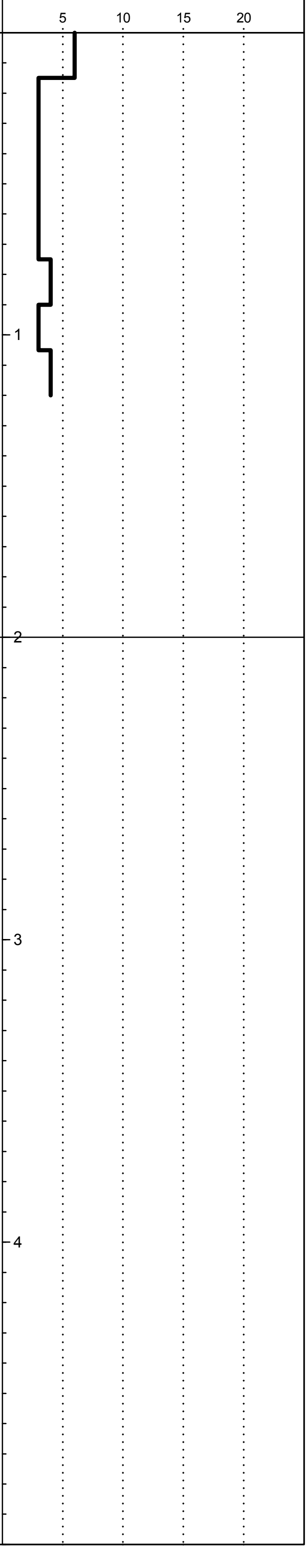
CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: High Street, Maitland

SURFACE LEVEL: --
EASTING: 365141
NORTHING: 6376847

PIT No: 303
PROJECT No: 49797.01
DATE: 19/5/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING - Generally comprising dark brown silty sandy clay filling with some glass and brick, moist		D	0.1	E, A		
				D	0.5	E, A		
	0.6	SILTY CLAY / CLAYEY SILT - Brown,silty clay / clayey silt with some sand, M≫Wp, moist						
				D	0.7 1.0	E, A		
1								
				D	1.5	E, A		
2	2.0	Pit discontinued at 2.0m, limit of investigation						
3								
4								

Dynamic Penetrometer Test
(blows per 150mm)



RIG: 3.5 Tonne Excavator with 450mm tooth bucket **LOGGED:** Sebastian **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

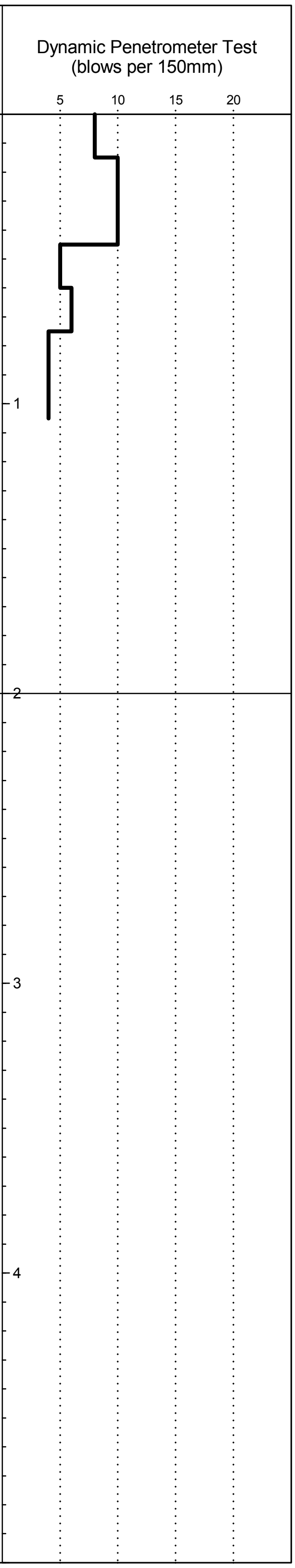
TEST PIT LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: High Street, Maitland

SURFACE LEVEL: --
EASTING: 365185
NORTHING: 6376808

PIT No: 304
PROJECT No: 49797.01
DATE: 19/5/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water
		FILLING - Generally comprising dark brown clayey sandy silt with abundant brick, ceramic pipe and concrete and gravel		D	0.1	E, A		
				D	0.5	E, A		
	0.6	SILTY CLAY / CLAYEY SILT - Brown silty clay / clayey silt with some sand, M≫Wp, moist						
				B	0.7 1.0	E, A		
				D	1.5	E, A		
	2.0	Pit discontinued at 2.0m, limit of investigation						



RIG: 3.5 Tonne Excavator with 450mm tooth bucket
LOGGED: Sebastian
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: High Street, Maitland

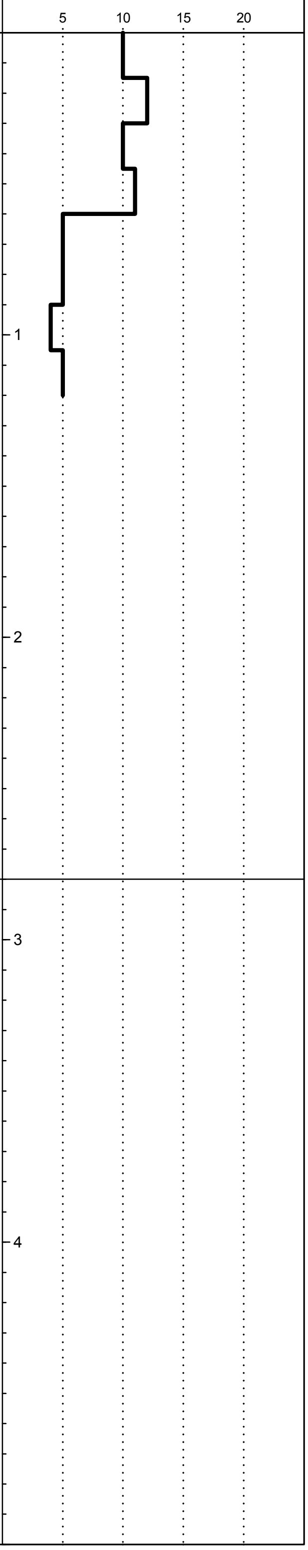
SURFACE LEVEL: --
EASTING: 365170
NORTHING: 6376842

PIT No: 305
PROJECT No: 49797.01
DATE: 19/5/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log
	0.0	FILLING - Generally comprising brown silty sand clay filling with some gravel, bricks, coal, ash and ceramics, moist	☒
	0.9	SILTY CLAY - Dark brown silty clay, M>Wp	▨
	2.8	Pit discontinued at 2.8m, limit of investigation	

Sampling & In Situ Testing				Water
Type	Depth	Sample	Results & Comments	
D	0.0 0.2			
U_{50}	0.3			
D	0.6 0.7			
D	1.0			
D	2.0			
D	2.5			

Dynamic Penetrometer Test (blows per 150mm)



RIG: 3.5 Tonne Excavator with 450mm tooth bucket **LOGGED:** Sebastian **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	⊳	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

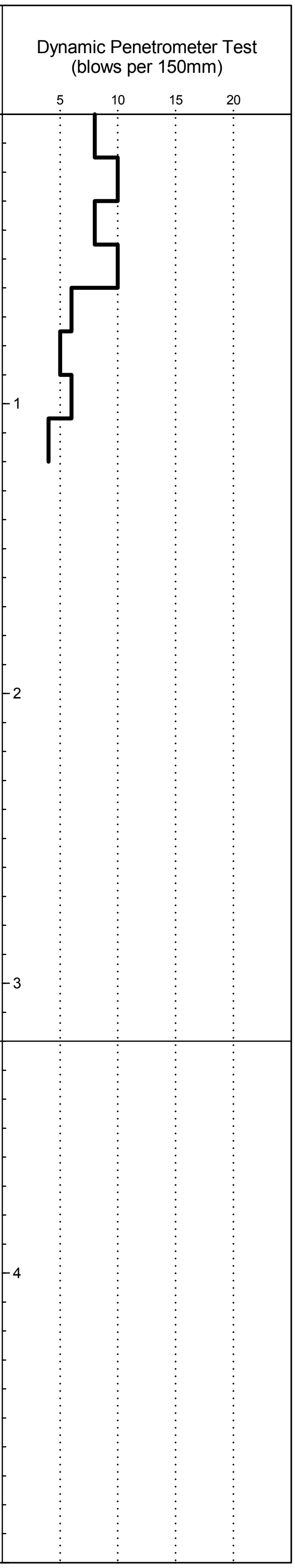
TEST PIT LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: High Street, Maitland

SURFACE LEVEL: --
EASTING: 365180
NORTHING: 6376841

PIT No: 306
PROJECT No: 49797.01
DATE: 19/5/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water
		FILLING - Generally comprising brown silty sandy clay filling with some gravel, brick, ash, coal and ceramics, M>Wp		D	0.0 0.2	E, A		
				U_{50}	0.3 0.7			
				D	0.5	E, A		
	0.6	SILTY CLAY - Dark brown silty clay, M>Wp						
	1			D	1.0	E, A	pp = 100	
	2			D	2.0	E, A	pp = 300	
	3			D	3.0	E, A		
	3.2	Pit discontinued at 3.2m, limit of investigation						
	4							



RIG: 3.5 Tonne Excavator with 450mm tooth bucket

LOGGED: Sebastian

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

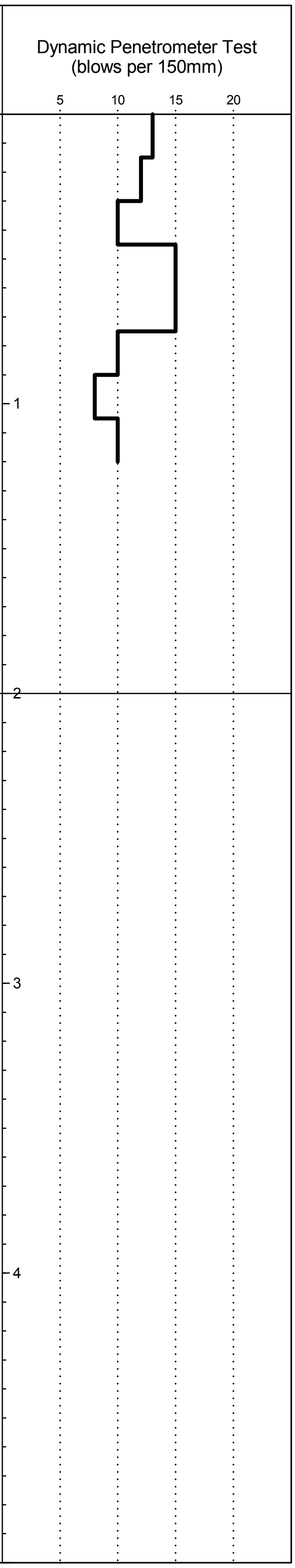
TEST PIT LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: High Street, Maitland

SURFACE LEVEL: --
EASTING: 365185
NORTHING: 6376855

PIT No: 307
PROJECT No: 49797.01
DATE: 19/5/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Type	Depth	Sample	Results & Comments	Water
		FILLING - Generally comprising pale brown sandy silty clay filling with trace ceramics and gravel, M>Wp	☒	D	0.0 0.2	E, A		
	0.4	FILLING - Generally comprising brown silty sandy clay filling with trace ceramics, brick, some subrounded gravel From 0.45m to 0.6m, concrete boulders	☒	D	0.5	E, A		
	1		☒	D	1.0	E, A		
			☒	D	1.7	E, A		
		From 1.8m, increased resistance (possible natural)	☒					
	2 2.0	Pit discontinued at 2.0m, virtual refusal						
	3							
	4							



RIG: 3.5 Tonne Excavator with 450mm tooth bucket **LOGGED:** Sebastian **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Concrete slab adjacent to pit from 0.4m

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

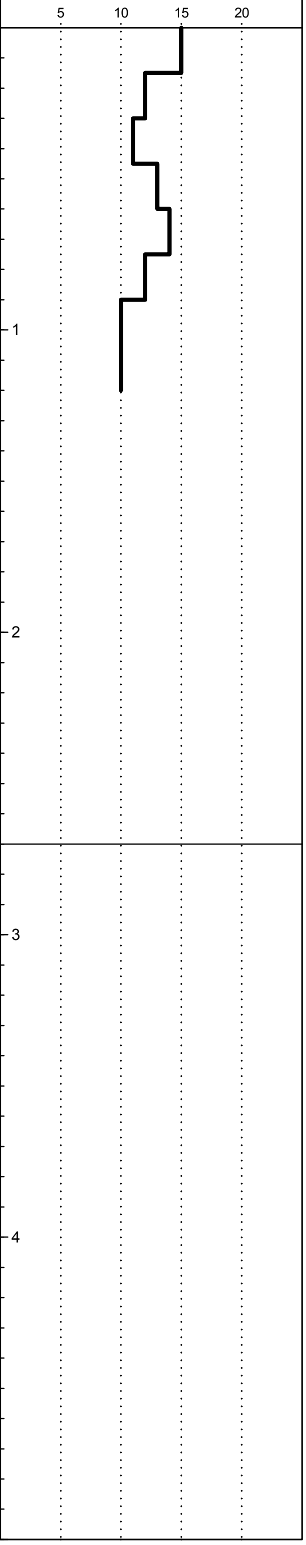
CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: High Street, Maitland

SURFACE LEVEL: --
EASTING: 365172
NORTHING: 6376868

PIT No: 308
PROJECT No: 49797.01
DATE: 19/5/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water
		FILLING - Generally comprising brown silty sandy clay filling, M>Wp	☒	D	0.0 0.2	E, A		
	0.3	FILLING - Generally comprising dark brown silty sandy clay filling, M≫Wp From 0.4m to 1.0m, some pale brown and grey ash and fibro, abundant brick and some ceramics and timber	☒	D	0.5	E, A		
				D	1.0	E, A		
	1.6	SILTY CLAY - Dark brown silty clay, M>Wp	▨	D	2.0	E, A		
	2.7	Pit discontinued at 2.7m, limit of investigation						

Dynamic Penetrometer Test (blows per 150mm)



RIG: 3.5 Tonne Excavator with 450mm tooth bucket
LOGGED: Sebastian
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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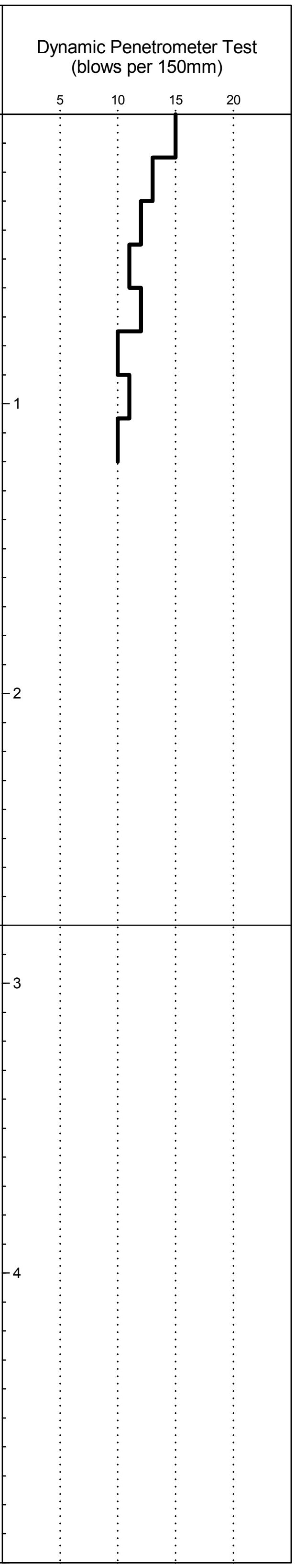
TEST PIT LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: High Street, Maitland

SURFACE LEVEL: --
EASTING: 365161
NORTHING: 6376852

PIT No: 309
PROJECT No: 49797.01
DATE: 19/5/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water
		FILLING - Generally comprising brown silty sandy clay filling, M>Wp		D	0.0 0.2	E, A		
	0.3	FILLING - Generally comprising dark brown silty sand with some gravel, clay and abundant bricks, ash and trace ceramics and timber, glass		D	0.5	E, A		
		From 0.8m, no bricks		D	1.0	E, A		
	1.4	SILTY CLAY - Dark brown silty clay, M>Wp		D	1.5	E, A	pp = 100-200	
				D	2.0	E, A	pp = 100-200	
				D	2.7	E, A		
	2.8	Pit discontinued at 2.8m, limit of investigation						



RIG: 3.5 Tonne Excavator with 450mm tooth bucket **LOGGED:** Sebastian **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: Adjacent to unknown scanned pipe

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 401
PROJECT No: 49797.01
DATE: 30/5-1/6/18
SHEET 1 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low, Very Low, Low, Medium, High, Very High, Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
		FILLING - Generally comprising grey-brown clayey sand filling, some fine coal, moist										
	0.8	SILTY CLAY - Grey brown silty clay, some silty sand bands, M>Wp										
	1											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	9											

RIG: TD106 **DRILLER:** Total Drilling (Keirnan) **LOGGED:** Parkinson **CASING:** HQ to 6m

TYPE OF BORING: Wash bore to 13m, rock roller to 24.5m, NMLC core to 28.4m

WATER OBSERVATIONS: No free groundwater observed observations obscured by drilling fluids

REMARKS: Strengths and strata pre 19m inferred from CPT 201

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 401
PROJECT No: 49797.01
DATE: 30/5-1/6/18
SHEET 2 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low Very Low Low Medium High Very High Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SILTY CLAY - Grey brown silty clay, some silty sand bands, M>Wp *(continued)*										
	11											
	12 12.0	SAND AND GRAVEL - Brown fine to coarse grained sand and gravel, gravel fine to coarse sized and subrounded with some possible cobbles										
	13											
	14											
	15											
	16											
	17											
	18											
	19											

RIG: TD106 **DRILLER:** Total Drilling (Keirnan) **LOGGED:** Parkinson **CASING:** HQ to 6m

TYPE OF BORING: Wash bore to 13m, rock roller to 24.5m, NMLC core to 28.4m

WATER OBSERVATIONS: No free groundwater observed observations obscured by drilling fluids

REMARKS: Strengths and strata pre 19m inferred from CPT 201

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

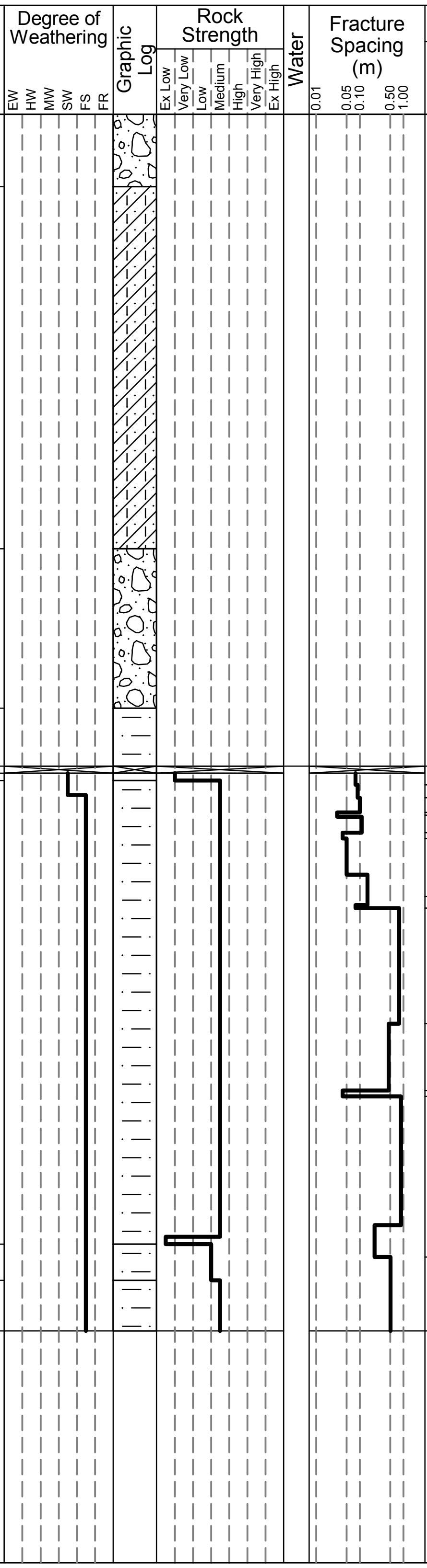
Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 401
PROJECT No: 49797.01
DATE: 30/5-1/6/18
SHEET 3 OF 3



Depth (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
20.5	SANDY SILTY CLAY - Stiff, brown-orange, fine grained sandy silty clay, silt content increasing with depth, M>Wp		S S			pp = 190-210 7,8,7 N = 15 3,7,6 N = 13
23.0	SANDY GRAVEL - Brown, fine to coarse grained sandy gravel, gravel medium to cobble sized with possible boulders					
24.1	SILTSTONE - Extremely low to very low strength, slightly weathered, dark grey stained orange siltstone, some fine grained sand		S			pp >600 32,-,- refusal
24.5	CORE LOSS - 0.05m - probable siltstone	24.5m: CORE LOSS: 50mm	C	98	74	
24.55	SILTSTONE - Extremely to very low strength, slightly weathered, dark grey siltstone stained orange					
24.6	SILTSTONE - Medium strength, slightly weathered, dark grey siltstone, slightly fractured From 25.7m, fresh	24.63m: J, 30°, ir, ro, stnfe 24.72m: J, 40°, ir, ro, stnfe 24.82m: J, 10°, ir, ro, stnfe 24.84m: J, 10°, ir, ro, stnfe 24.96m: PT, sh, ir, ro, stnfe From 25m to 25.25m, J, 10°, pl, ro, stnfe, spaced generally 50mm 25.4m: PT, sh, pl, ro, stnfe 25.48m: PT, sh, pl, ro, stnfe 26.28m: PT, sh, pl, sm 26.74m: PT, sh, ro 26.78m: PT, sh, ro	C C	98 100	74 100	PL(A) = 0.4 PL(A) = 0.71 PL(D) = 0.83 PL(A) = 0.98 PL(D) = 0.52
27.8	TUFFACEOUS SILTSTONE - Low to medium strength, fresh, pale white tuffaceous siltstone	27.67m: Cs, sh, pl, inf, 3mm clay 27.89m: PT, sh, ir, ro				PL(A) = 0.37
28.05	SILTSTONE - Medium strength, fresh, dark grey siltstone, slightly fractured					PL(A) = 0.9 PL(D) = 0.93
28.4	Bore discontinued at 28.4m, limit of investigation					

RIG: TD106 **DRILLER:** Total Drilling (Keirnan) **LOGGED:** Parkinson **CASING:** HQ to 6m
TYPE OF BORING: Wash bore to 13m, rock roller to 24.5m, NMLC core to 28.4m
WATER OBSERVATIONS: No free groundwater observed observations obscured by drilling fluids
REMARKS: Strengths and strata pre 19m inferred from CPT 201

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 403
PROJECT No: 49797.01
DATE: 29-30/5/18
SHEET 1 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low, Very Low, Low, Medium, High, Very High, Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		FILLING - Generally comprising brown fine to medium grained sand filling with some brick, trace wire, humid										
	0.8	SILTY CLAY - Dark grey silty clay, some fine to medium grained sand, M>Wp										
	5.0	CLAYEY SAND - Brown, fine to medium grained clayey sand										
	6.0	SANDY CLAY - Brown, fine to medium grained sandy clay										

RIG: TD106 **DRILLER:** Total Drilling (Mark) **LOGGED:** Parkinson **CASING:** HW to 6m, HQ to 21m

TYPE OF BORING: Wash bore to 23.8m (refusal), NMLC core to 25m, rock roller from 25m to 26m, NMLC core to 29.1m

WATER OBSERVATIONS: No free groundwater observed observations obscured by drilling fluids

REMARKS: From 17.7m to 21m, gravel based on drilling observations and cuttings due to bore collapse. Strengths and strata pre ???m inferred from CPT 203

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 403
PROJECT No: 49797.01
DATE: 29-30/5/18
SHEET 2 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low, Very Low, Low, Medium, High, Very High, Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
		SANDY CLAY - Brown, fine to medium grained sandy clay *(continued)*										
	11											
	12											
	13 13.0	SAND AND GRAVEL - Dense, brown, medium to coarse grained sand and gravel, gravel fine to coarse sized and subrounded with some possible cobbles										
	14								S			11,16,15 N = 31
	15											
	16								S			11,15,18 N = 33
	17								S			10,8,13 N = 21
	18								(S)			23,25/110mm,- refusal
	19	From 19.5m to 20m, possible large gravel / cobble										
	20.0											

RIG: TD106 **DRILLER:** Total Drilling (Mark) **LOGGED:** Parkinson **CASING:** HW to 6m, HQ to 21m

TYPE OF BORING: Wash bore to 23.8m (refusal), NMLC core to 25m, rock roller from 25m to 26m, NMLC core to 29.1m

WATER OBSERVATIONS: No free groundwater observed observations obscured by drilling fluids

REMARKS: From 17.7m to 21m, gravel based on drilling observations and cuttings due to bore collapse. Strengths and strata pre ???m inferred from CPT 203

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Proposed Administration Building
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 403
PROJECT No: 49797.01
DATE: 29-30/5/18
SHEET 3 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering	Rock Strength	Water	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
		SANDY SILTY CLAY - Stiff, brown-orange fine grained sandy silty clay, silt content increasing with depth, M>Wp								
	21						S			pp = 150 8,10,13 N = 23
	22						S			pp = 180 5,6,8 N = 14
	23.8	SANDY GRAVEL - Brown, fine to coarse grained sandy gravel, gravel medium to cobble sized and subrounded, possible boulders					C	60	0	
	24.08	CORE LOSS - 0.53m				24.08m: CORE LOSS: 540mm	C	54	0	
	24.62	SANDY GRAVEL - Brown, fine to coarse grained sandy gravel, gravel medium to cobble sized and subrounded, possible boulders								
	25.0	ROCK ROLLER - Inferred siltstone at 25.3m depth from drilling observations				25m: CORE LOSS: 1000mm	C	0	0	
	26.0	SILTSTONE - Medium strength, fresh, grey siltstone, trace coarse pebbles in parts, slightly fractured	FR	Medium		26.04m: PT, 20°, pl, sm 26.09m: PT, 20°, pl, sm 26.24m: J, 10°, ir, ro 26.28m: J, 20°, ir, ro 26.61m: PT, sh, pl, ro 26.65m: PT, sh, pl, ro 27.08m: PT, sh, pl, sm 28.23m: PT, sh, pl, ro 28.74m: J, 10°, ir, ro, vn clay 28.81m: J, 10°, ir, ro, vn clay	C	100	94	PL(A) = 0.42 PL(D) = 0.12 PL(A) = 0.53 PL(D) = 0.44 PL(A) = 0.67 PL(D) = 0.61 PL(A) = 0.5 PL(D) = 0.53
	29.1	Bore discontinued at 29.1m, limit of investigation								

RIG: TD106 **DRILLER:** Total Drilling (Mark) **LOGGED:** Parkinson **CASING:** HW to 6m, HQ to 21m

TYPE OF BORING: Wash bore to 23.8m (refusal), NMLC core to 25m, rock roller from 25m to 26m, NMLC core to 29.1m

WATER OBSERVATIONS: No free groundwater observed observations obscured by drilling fluids

REMARKS: From 17.7m to 21m, gravel based on drilling observations and cuttings due to bore collapse. Strengths and strata pre ???m inferred from CPT 203

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

CONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PROPOSED OFFICES

LOCATION: 263 HIGH STREET, MAITLAND

REDUCED LEVEL: Ground level

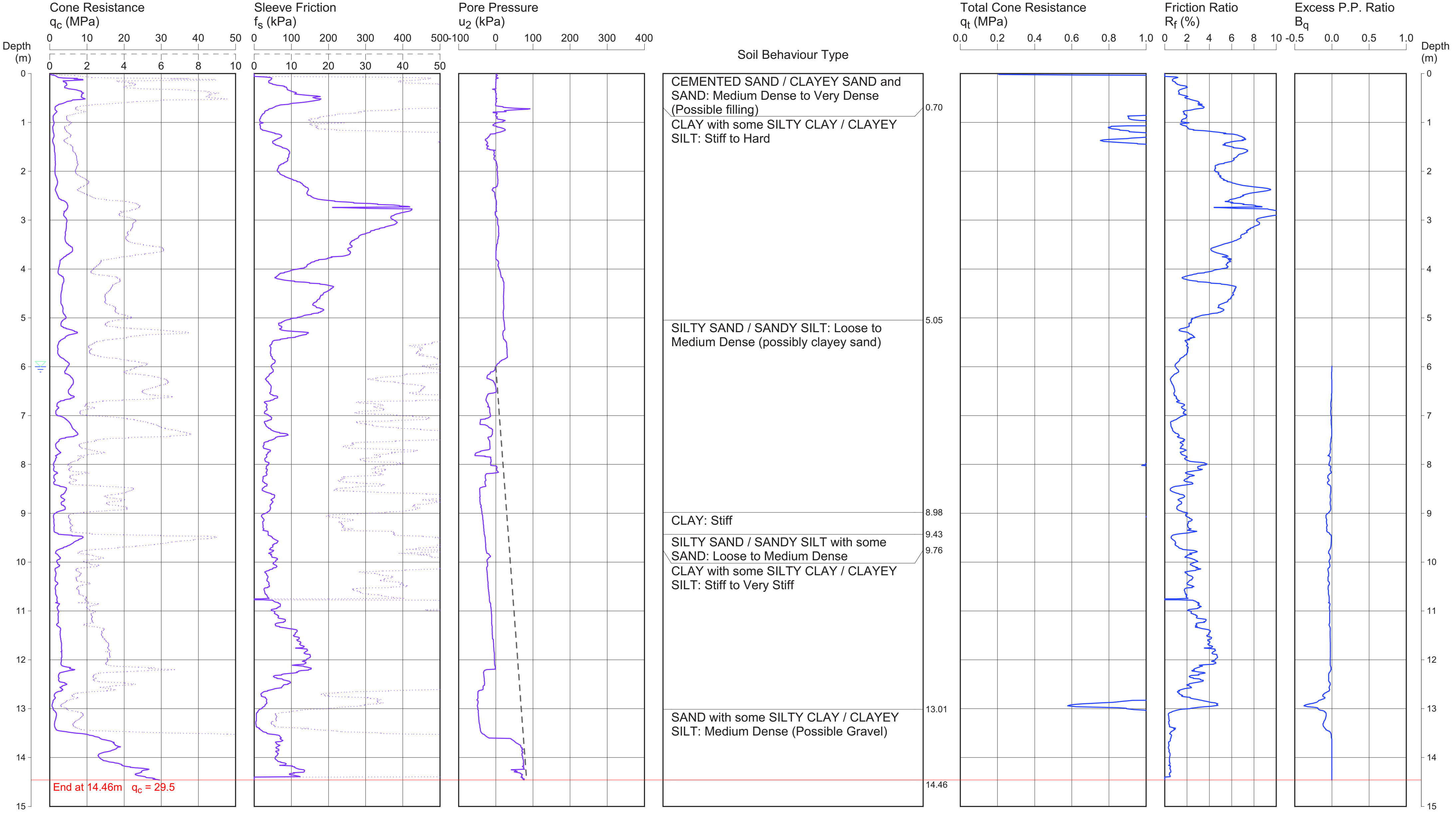
COORDINATES:

CPT-1

Page 1 of 1

DATE 4 August 2011

PROJECT No: 49797



CEMENTED SAND / CLAYEY SAND and SAND: Medium Dense to Very Dense (Possible filling)

CLAY with some SILTY CLAY / CLAYEY SILT: Stiff to Hard

SILTY SAND / SANDY SILT: Loose to Medium Dense (possibly clayey sand)

CLAY: Stiff

SILTY SAND / SANDY SILT with some SAND: Loose to Medium Dense

CLAY with some SILTY CLAY / CLAYEY SILT: Stiff to Very Stiff

SAND with some SILTY CLAY / CLAYEY SILT: Medium Dense (Possible Gravel)

REMARKS: Converted from NEWSYD data (GEF) file

Water depth after test: 6.00m depth (measured)

File: P:\49797\Field\DP CPT\CPT 1.CP5
Cone ID: Unknown **Type:** ? NEWSYD

ConePlot Version 5.9.1

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CONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PROPOSED OFFICES

LOCATION: 263 HIGH STREET, MAITLAND

REDUCED LEVEL: Ground level

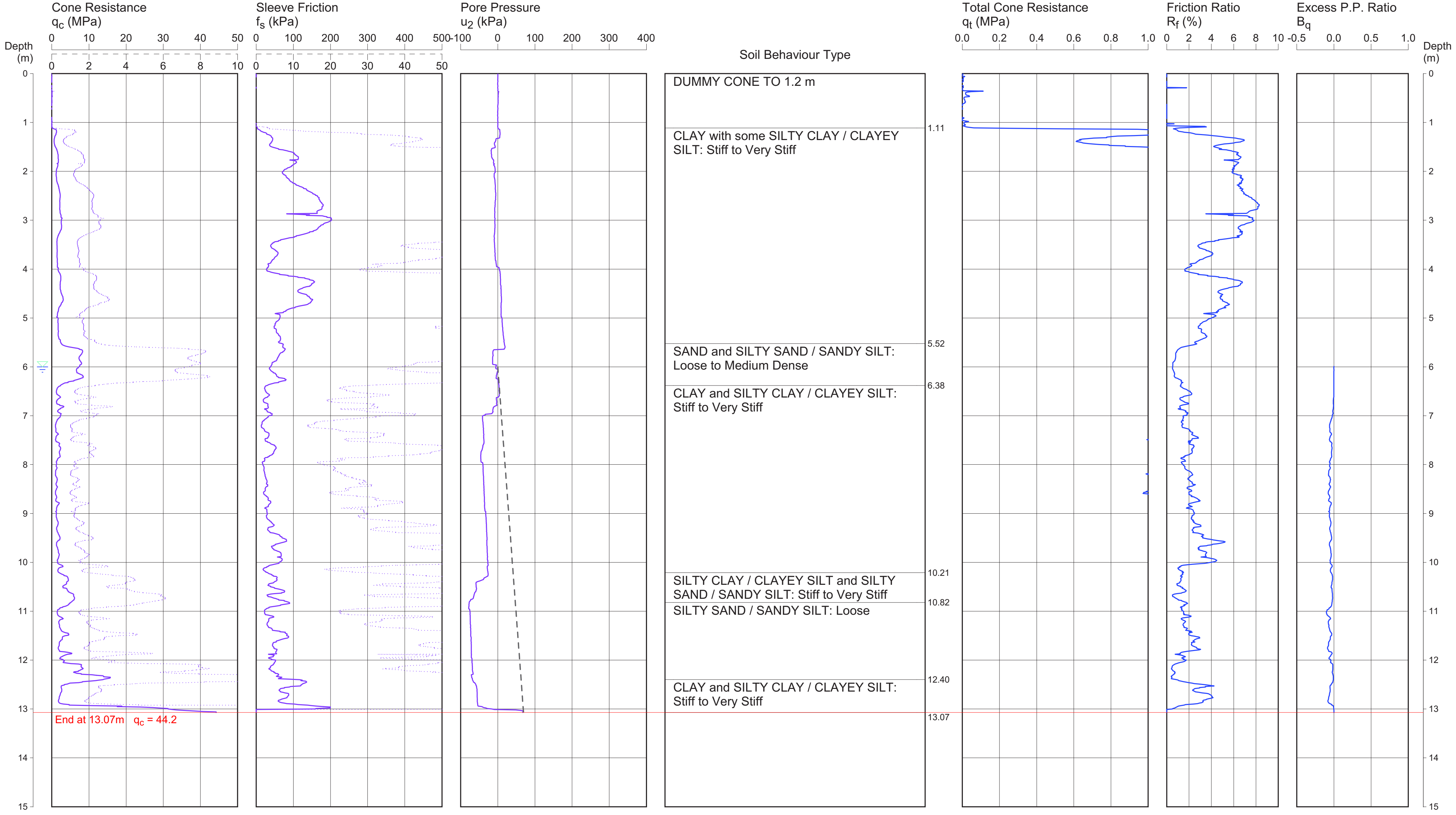
COORDINATES:

CPT-2

Page 1 of 1

DATE 4 Aug 2011

PROJECT No: 49797



REMARKS: Converted from NEWSYD data (GEF) file

Water depth after test: 6.00m depth (measured)

File: P:\49797\Field\DP CPT\CPT 2.CP5
Cone ID: Unknown **Type:** ? NEWSYD

ConePlot Version 5.9.1

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CONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PRPOSED OFFICES

LOCATION: 263 HIGH STREET, MAITLAND

REDUCED LEVEL: Ground level

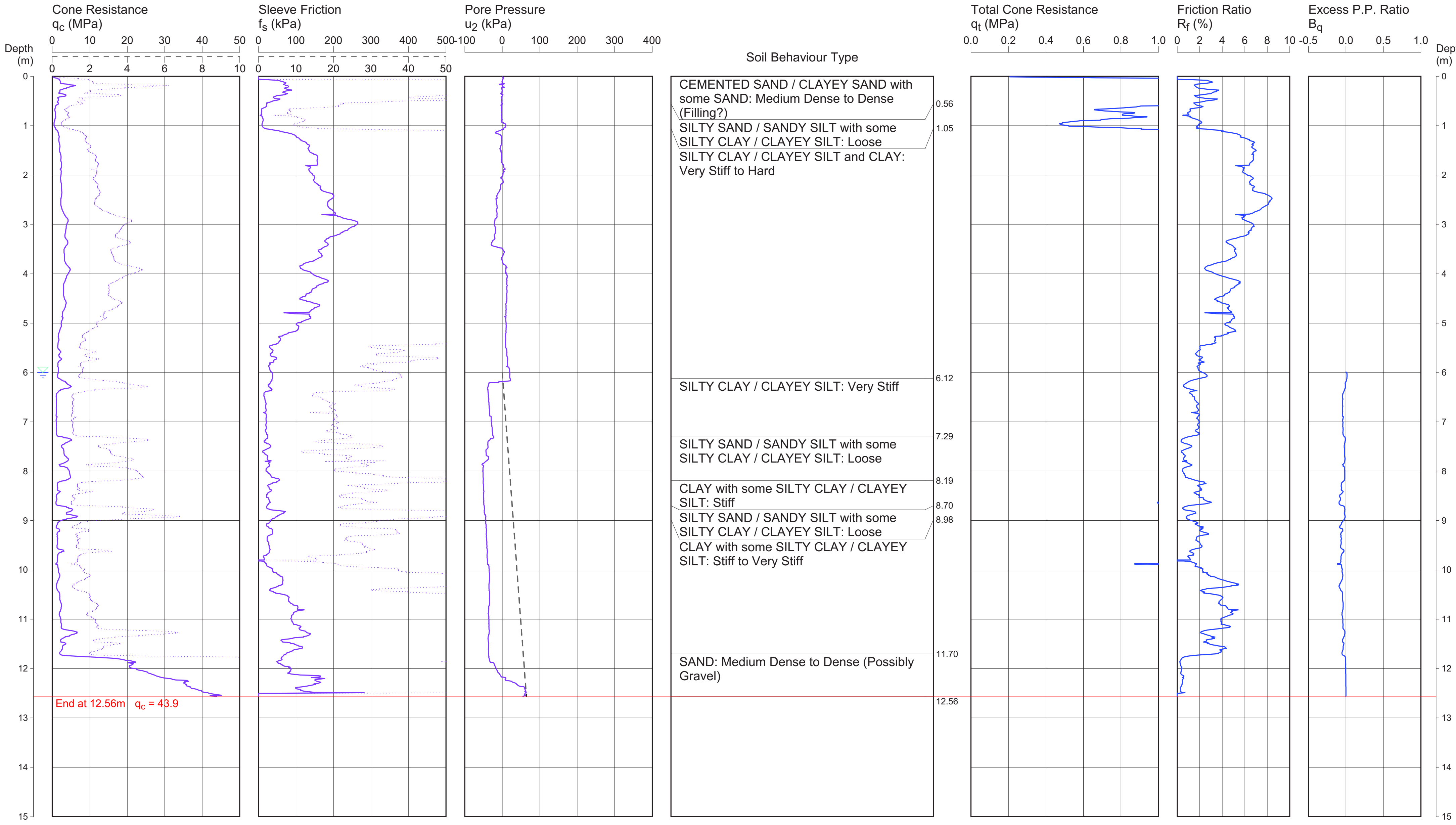
COORDINATES:

CPT-3

Page 1 of 1

DATE 4 Aug 2011

PROJECT No: 49797



REMARKS: Converted from NEWSYD data (GEF) file

Water depth after test: 6.00m depth (measured)

File: P:\49797\Field\DP CPT\CPT 3.CP5
Cone ID: Unknown **Type:** ? NEWSYD

ConePlot Version 5.9.1

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CONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PROPOSED OFFICES

LOCATION: 263 HIGH STREET, MAITLAND

REDUCED LEVEL: Ground level

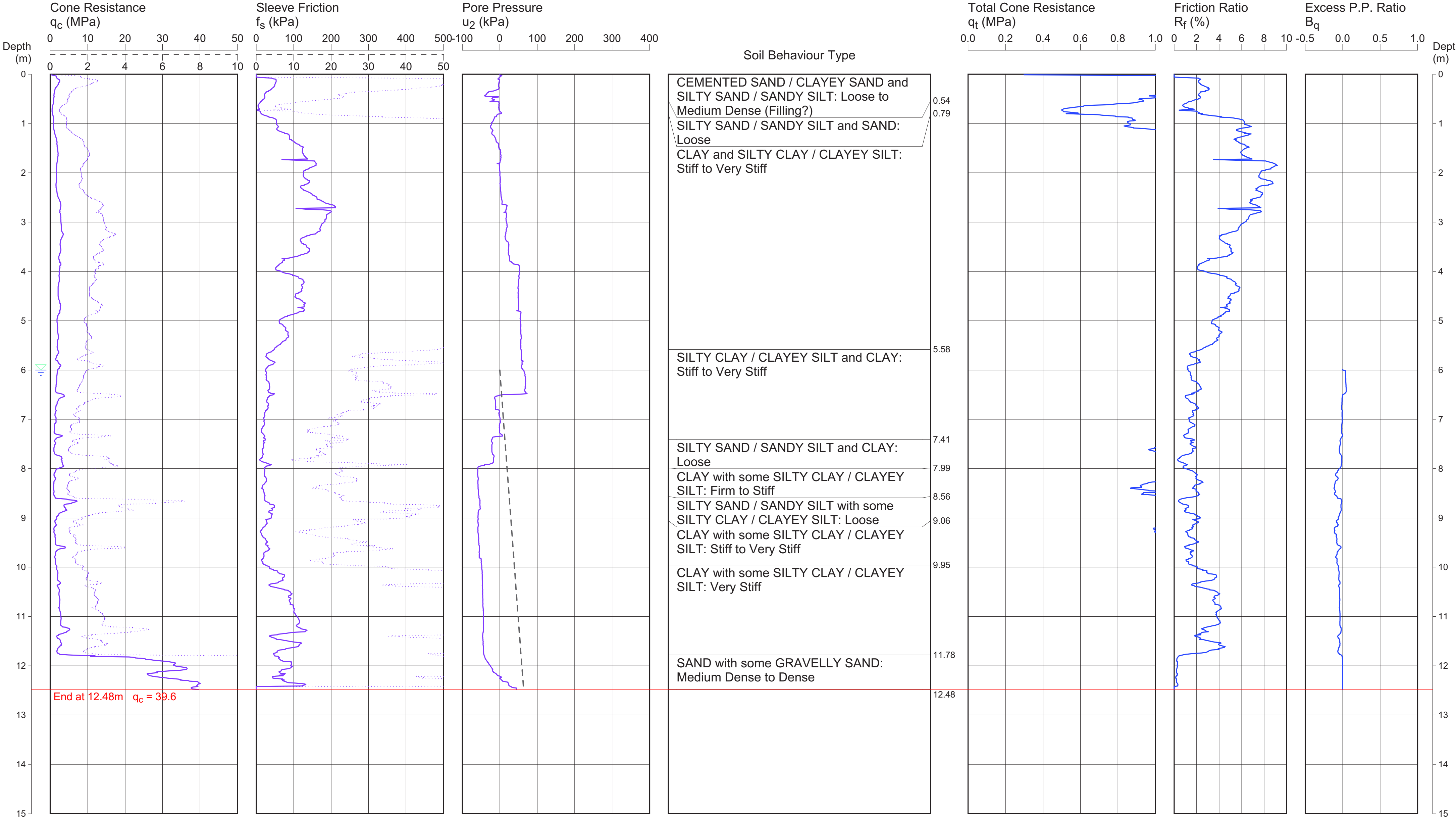
COORDINATES:

CPT-4

Page 1 of 1

DATE 4 Aug 2011

PROJECT No: 49797



Soil Behaviour Type

CEMENTED SAND / CLAYEY SAND and SILTY SAND / SANDY SILT: Loose to Medium Dense (Filling?)

0.54

0.79

SILTY SAND / SANDY SILT and SAND: Loose

CLAY and SILTY CLAY / CLAYEY SILT: Stiff to Very Stiff

5.58

SILTY CLAY / CLAYEY SILT and CLAY: Stiff to Very Stiff

7.41

SILTY SAND / SANDY SILT and CLAY: Loose

7.99

CLAY with some SILTY CLAY / CLAYEY SILT: Firm to Stiff

8.56

SILTY SAND / SANDY SILT with some SILTY CLAY / CLAYEY SILT: Loose

9.06

CLAY with some SILTY CLAY / CLAYEY SILT: Stiff to Very Stiff

9.95

CLAY with some SILTY CLAY / CLAYEY SILT: Very Stiff

11.78

SAND with some GRAVELLY SAND: Medium Dense to Dense

12.48

REMARKS: Converted from NEWSYD data (GEF) file

Water depth after test: 6.00m depth (measured)

File: P:\49797\Field\DP CPT\CPT 4.CP5
Cone ID: Unknown **Type:** ? NEWSYD

ConePlot Version 5.9.1

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CONE PENETRATION TEST

CLIENT: MAITLAND CITY COUNCIL

PROJECT: PROPOSED OFFICES

LOCATION: 263 HIGH STREET, MAITLAND

REDUCED LEVEL: Ground level

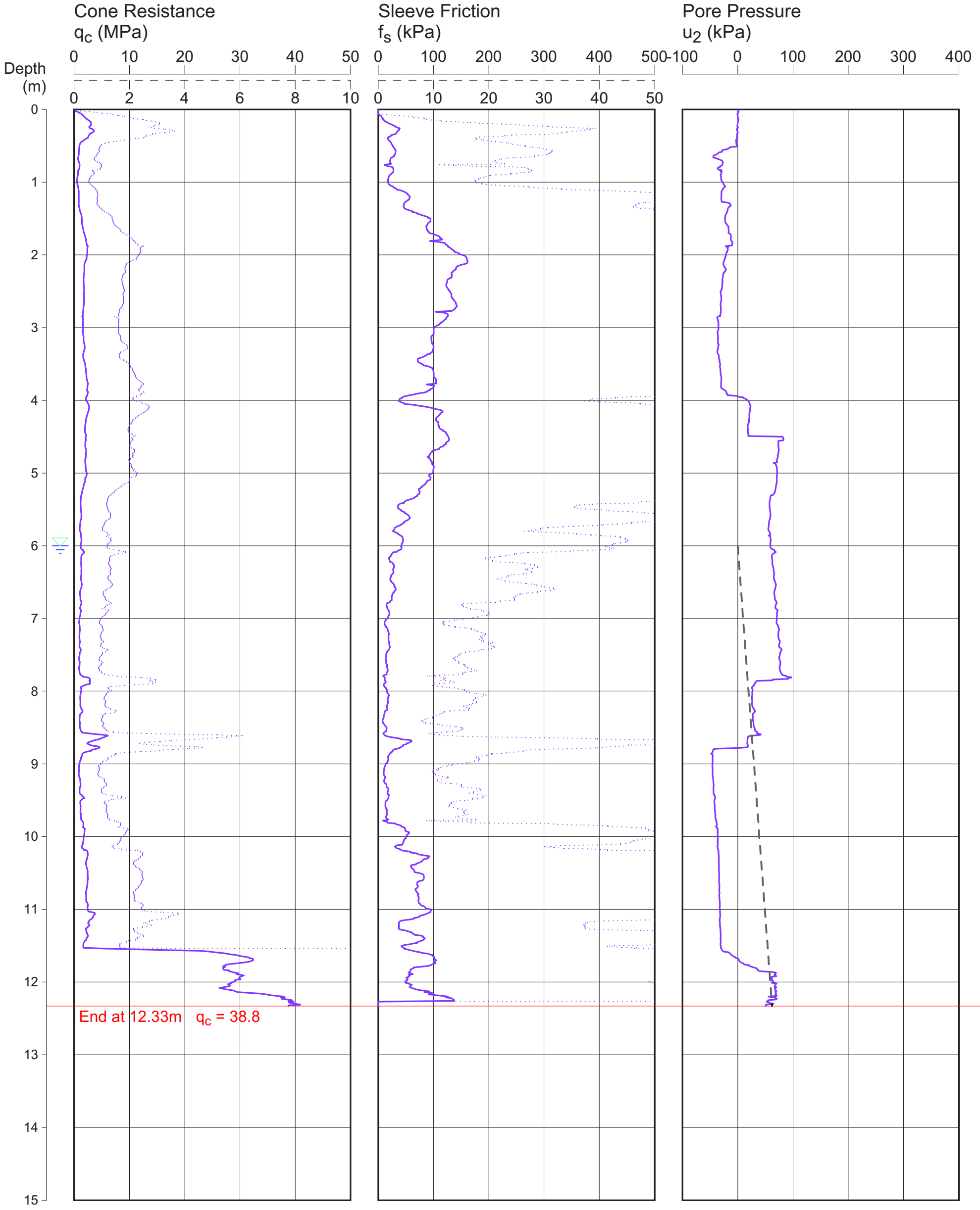
COORDINATES:

CPT-5

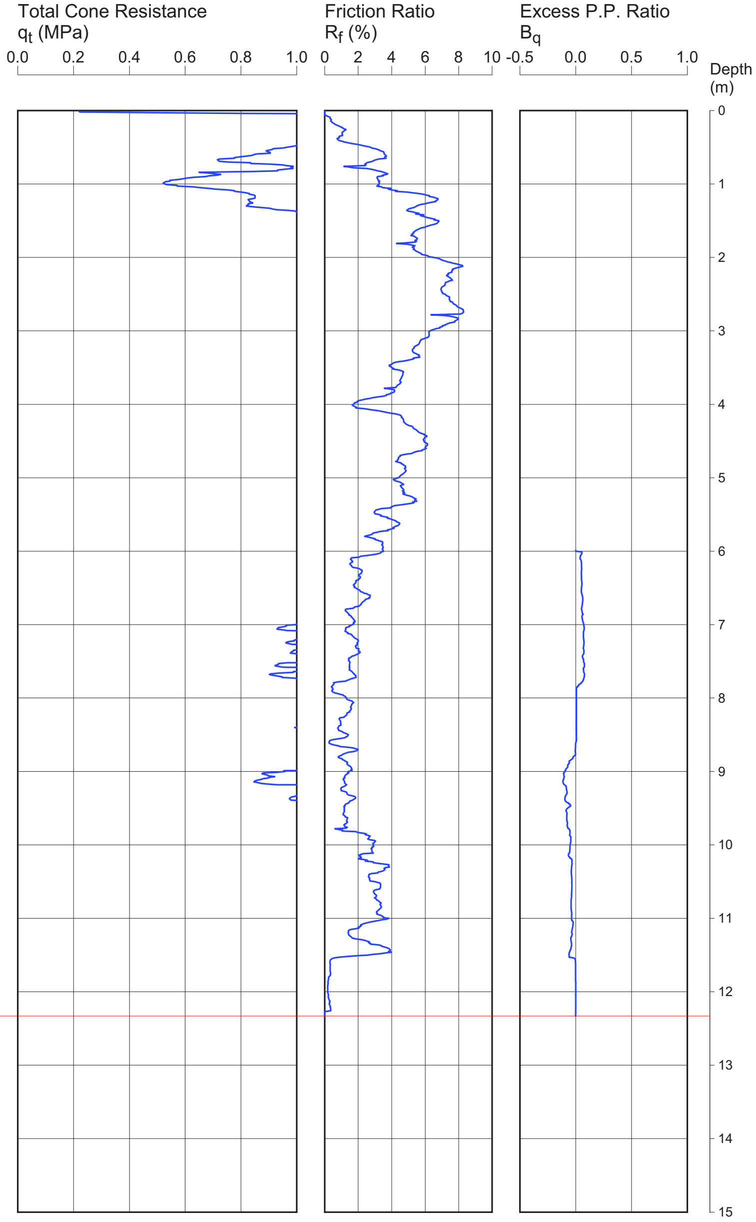
Page 1 of 1

DATE 4 Aug 11

PROJECT No: 49797



Soil Behaviour Type	
GRAVELLY SAND and SAND: Medium Dense (Fill)	0.40
SILTY SAND / SANDY SILT and SILTY CLAY / CLAYEY SILT: Loose	1.01
CLAY and SILTY CLAY / CLAYEY SILT: Stiff to Very Stiff	3.87
SILTY CLAY / CLAYEY SILT and SILTY SAND / SANDY SILT: Very Stiff	4.13
CLAY: Stiff to Very Stiff	6.04
CLAY with some SILTY CLAY / CLAYEY SILT: Stiff	8.54
SILTY CLAY / CLAYEY SILT and SILTY SAND / SANDY SILT: Stiff to Very Stiff	8.96
CLAY with some SILTY CLAY / CLAYEY SILT: Firm to Stiff	9.81
CLAY with some SILTY CLAY / CLAYEY SILT: Very Stiff	11.48
SAND with some GRAVELLY SAND: Medium Dense to Dense	12.33



REMARKS: Converted from NEWSYD data (GEF) file

File: P:\49797\Field\DP CPT\CPT 5.CP5
Cone ID: Unknown **Type:** ? NEWSYD

ConePlot Version 5.9.1
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Water depth after test: 6.00m depth (measured)

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TEST PIT LOG

CLIENT: Maitland City Council
PROJECT: Preliminary Soil Assessment
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 107
PROJECT No: 49797
DATE: 3/8/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
				Type	Depth	Sample	Results & Comments		
		FILLING - Grey brown clayey silty sand filling with bricks, moist	▨	D, PID	0.0 0.2		<1 ppm		
	0.3	Pit discontinued at 0.3m, slow progress on bricks							

RIG: Hand Tools

LOGGED: Sebastian

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed during drilling

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Maitland City Council
PROJECT: Preliminary Soil Assessment
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: 108
PROJECT No: 49797
DATE: 3/8/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing Type	Sampling & In Situ Testing Depth	Sampling & In Situ Testing Sample	Sampling & In Situ Testing Results & Comments	Water	Dynamic Penetrometer Test (blows per mm) 5 10 15 20
		FILLING - Dark grey brown silty clayey sand filling with some crushed concrete/mortar (coarse sand/fine grained size), trace coal, trace brick fragments and ceramic (china), moist		D, PID	0.05		<1 ppm		
				D, PID	0.2		<1 ppm		
	0.3	SILTY CLAYEY SAND (FILLING?) - Grey brown fine to medium grained silty clayey sand, moist		D, PID	0.35		<1 ppm		
	0.4	Pit discontinued at 0.4m, limit of investigation							

RIG: Hand Tools

LOGGED: Sebastian

SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed during drilling

REMARKS: At CPT4 location

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Preliminary Soil Assessment
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 101
PROJECT No: 49797
DATE: 3/8/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Sampling & In Situ Testing: Depth	Sampling & In Situ Testing: Sample	Sampling & In Situ Testing: Results & Comments	Water	Well Construction Details
		FILLING - Grey brown fine to medium grained clayey silty sand filling, moist		A, PID	0.1		<1 ppm		
	0.2	FILLING - Dark grey brown fine to medium grained clayey silty sand filling, with trace bricks and tiles, moist		A, PID	0.5		<1 ppm		
	1			A, PID	1.0		<1 ppm		
	1.3	CLAYEY SILTY SAND - Brown fine to medium grained clayey silty sand, moist		A, PID	1.5		<1 ppm		
	1.8	SILTY CLAY - Dark brown silty clay with some sand, M<Wp From 2.0m, becoming light brown		A, PID	2.0		<1 ppm		
				A, PID	2.5		<1 ppm		
	3			A, PID	3.0		<1 ppm		
	3.2	SANDY CLAY - Light brown medium grained sandy clay, M>Wp		A, PID	3.5		<1 ppm		
	4			A, PID	4.0		<1 ppm		
	4.05	Bore discontinued at 4.05m, limit of investigation							
	5								
	6								
	7								
	8								
	9								

RIG: BA Mack II **DRILLER:** Fico **LOGGED:** Sebastian **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: No free groundwater observed during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Preliminary Soil Assessment
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 102
PROJECT No: 49797
DATE: 3/8/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - Grey/brown fine to medium grained clayey silty sand filling with some building rubble inclusions (concrete, glass, bricks) moist		A, PID	0.1		<1 ppm		
	0.2	FILLING - Dark grey/brown fine to medium grained clayey silty sand filling, moist		A, PID	0.5		<1 ppm		
	1			A, PID	1.0		<1 ppm		
	1.2	SILTY CLAY - Dark brown silty clay with trace sand, M<Wp		A, PID	1.5		<1 ppm		
	2			A, PID	2.0		<1 ppm		
				A, PID	2.5		<1 ppm		
	3	From 2.7m, light brown silty clay with some sand		A, PID	3.0		<1 ppm		
	3.4	SANDY CLAY/CLAYEY SAND - Light brown fine grained sandy clay, dry to moist		A, PID	3.5		<1 ppm		
	4			A, PID	4.0		<1 ppm		
				A, PID	4.5		<1 ppm		
	5			A, PID	5.0		<1 ppm		
	6	From 6.0m, moisture content increasing, slight hydrocarbon odour		A, PID	6.0		<1 ppm		
	7	From 7.50m, saturated						▼	
	8			A, PID	8.0		<1 ppm		
	8.05	Bore discontinued at 8.05m, limit of investigation							
	9								

RIG: BA Mack II **DRILLER:** Fico **LOGGED:** Sebastian **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 7.5m during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Preliminary Soil Assessment
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 103
PROJECT No: 49797
DATE: 3/8/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		FILLING - Brown fine to medium grained clayey silty sand filling with rootlet inclusions, moist		A, PID	0.1		<1 ppm		
	0.2	FILLING - Brown, dark brown clayey silty sand filling with building rubble inclusions (brick, tiles), moist		A, PID	0.5		<1 ppm		
	1			A, PID	1.0		<1 ppm		
				A, PID	1.5		<1 ppm		
	2			A, PID	2.0		<1 ppm		
	2.4	SILTY CLAY - Dark brown silty clay, with some sand, M~Wp		A, PID	2.5		<1 ppm		
	3			A, PID	3.0		<1 ppm		
		From 3.5m, sand content increasing, light brown		A, PID	3.5		<1 ppm		
	4			A, PID	4.0		<1 ppm		
				A, PID	4.5		<1 ppm		
	5			A, PID	5.0		<1 ppm		
	5.3	CLAYEY SAND - Light brown grey medium grained clayey sand, moist							
	6			A, PID	6.0		<1 ppm		
	7	From 7.0m, saturated		A, PID	7.0		<1 ppm	▼	
	7.3	Bore discontinued at 7.3m, limit of investigation							
	8								
	9								

RIG: BA Mack II **DRILLER:** Fico **LOGGED:** Sebastian **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 7.0m during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Preliminary Soil Assessment
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 104
PROJECT No: 49797
DATE: 3/8/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
	0.3	FILLING - Brown fine to medium grained clayey silty sand filling with rootlet inclusions, moist		A, PID	0.1		<1 ppm		
		FILLING - Dark brown clayey sandy silt filling with trace building rubble inclusions (brick, tiles), moist		A, PID	0.5		<1 ppm		
				A, PID	1.0		<1 ppm		
				A, PID	1.5		<1 ppm		
				A, PID	2.0		<1 ppm		
	2.8			A, PID	2.5		<1 ppm		
		SILTY CLAY - Brown medium grained silty clay with trace sand, M<Wp		A, PID	3.0		<1 ppm		
		From 3.30m, light brown		A, PID	3.5		<1 ppm		
	5.5	From 3.8m, more moist		A, PID	4.0		<1 ppm		
	7.1	CLAYEY SAND - Light brown clayey sand, moist From 7.0m, saturated		A, PID	7.0		<1 ppm	▼	
		Bore discontinued at 7.1m, limit of investigation							

RIG: BA Mack II **DRILLER:** Fico **LOGGED:** Sebastian **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 7.0m during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Preliminary Soil Assessment
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 105
PROJECT No: 49797
DATE: 3/8/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		FILLING - Brown clayey silty sand filling with rootlet inclusions, moist		A, PID	0.1		<1 ppm		
	0.3	FILLING - Dark brown clayey silty sand filling with building rubble inclusions (bricks, tiles, concrete), moist		A, PID	0.5		<1 ppm		
				A, PID	1.0		<1 ppm		
				A, PID	1.5		<1 ppm		
				A, PID	2.0		<1 ppm		
	2.2	SILTY CLAY - Dark brown fine to medium grained silty clay, M⩽Wp		A, PID	2.5		<1 ppm		
				A, PID	3.0		<1 ppm		
	3.3	SANDY CLAY - Light brown fine grained sandy clay, M<Wp		A, PID	3.5		<1 ppm		
				A, PID	4.0		<1 ppm		
	4.1	Bore discontinued at 4.1m, limit of investigation							

RIG: BA Mack II **DRILLER:** Fico **LOGGED:** Sebastian **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: No free groundwater observed during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Maitland City Council
PROJECT: Preliminary Soil Assessment
LOCATION: 263 High Street, Maitland

SURFACE LEVEL: --
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

BORE No: 106
PROJECT No: 49797
DATE: 3/8/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
		FILLING - Brown fine to medium grained clayey silty sand filling with rootlet inclusions, moist	▨	A, PID	0.1		<1 ppm		
	0.3	FILLING - Brown medium grained silty sandy clay filling with building rubble inclusions (glass, bricks, concrete), moist	▨	A, PID	0.5		<1 ppm		
				A, PID	1.0		<1 ppm		
				A, PID	1.5		<1 ppm		
	1.7	SILTY SANDY CLAY - Dark brown medium grained silty sandy clay, M⩽Wp	▨	A, PID	2.0		<1 ppm		
				A, PID	2.5		<1 ppm		
	2.8	SANDY CLAY - Light brown fine grained sandy clay, moist, M~Wp	▨	A, PID	3.0		<1 ppm		
				A, PID	3.5		<1 ppm		
	3.7	Bore discontinued at 3.7m, limit of investigation							

RIG: BA Mack II **DRILLER:** Fico **LOGGED:** Sebastian **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: No free groundwater observed during drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Appendix C

Laboratory Test Results

Material Test Report

Douglas Partners
Geotechnics | Environment | Groundwater
Douglas Partners Pty Ltd
Newcastle Laboratory
15 Callistemon Close Warabrook Newcastle NSW 2310
Phone: (02) 4960 9600
Fax: (02) 4960 9601
Email: Peter.Gorseski@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

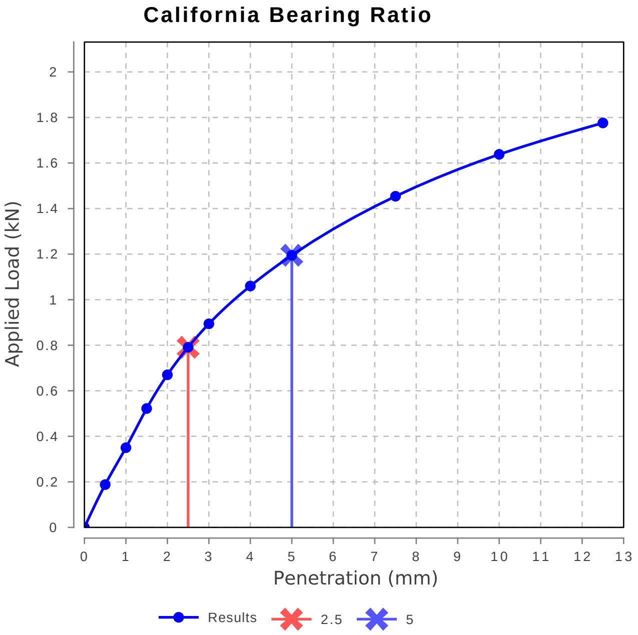
Approved Signatory: Peter Gorseski
Laboratory Manager
NATA Accredited Laboratory Number: 828

Report Number: **49797.01-2**
Issue Number: 1
Date Issued: 15/10/2018
Client: Maitland City Council
PO Box 220, Maitland NSW 2320
Project Number: 49797.01
Project Name: Proposed Administration Building
Project Location: 263 High Street, Maitland
Work Request: 2128
Sample Number: 18-2128A
Date Sampled: 19/05/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **302 (0.7 - 0.9m)**
Material: FILLING: Sandy Silt

Moisture Content (AS 1289 2.1.1)	
Moisture Content (%)	25.1

Dry Density - Moisture Relationship (AS 1289 5.1.1 & 2.1.1)	
Mould Type	1 LITRE MOULD A
Compaction	Standard
No. Layers	3
No. Blows / Layer	25
Maximum Dry Density (t/m^3)	1.57
Optimum Moisture Content (%)	23.0
Oversize Sieve (mm)	19
Oversize Material (%)	0
Method used to Determine Plasticity	Visual Assessment
Curing Hours	48

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**6**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.57		
Optimum Moisture Content (%)	23.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	101.5		
Dry Density after Soaking (t/m^3)	1.55		
Field Moisture Content (%)	25.1		
Moisture Content at Placement (%)	23.5		
Moisture Content Top 30mm (%)	27.6		
Moisture Content Rest of Sample (%)	26.3		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	48		
Swell (%)	1.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Newcastle Laboratory
15 Callistemon Close Warabrook Newcastle NSW 2310
Phone: (02) 4960 9600
Fax: (02) 4960 9601
Email: Peter.Gorseski@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Peter Gorseski
Laboratory Manager

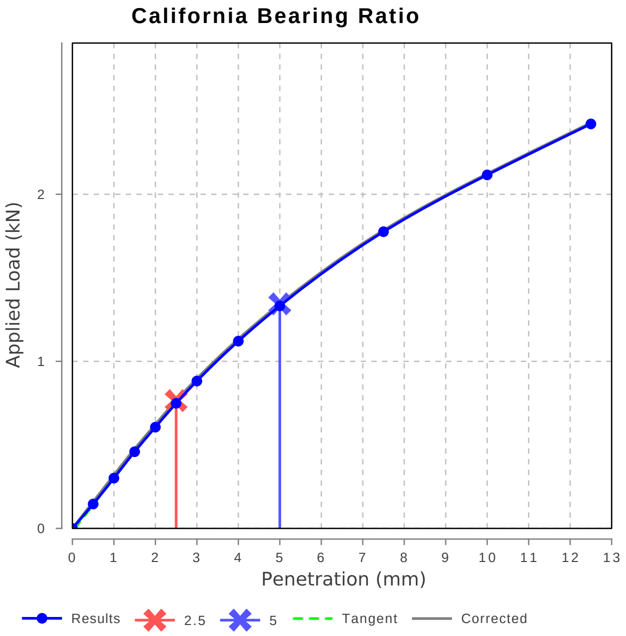
NATA Accredited Laboratory Number: 828

Report Number:	**49797.01-2**
Issue Number:	1
Date Issued:	15/10/2018
Client:	Maitland City Council PO Box 220, Maitland NSW 2320
Project Number:	49797.01
Project Name:	Proposed Administration Building
Project Location:	263 High Street, Maitland
Work Request:	2128
Sample Number:	18-2128B
Date Sampled:	19/05/2018
Sampling Method:	Sampled by Engineering Department
Sample Location:	**304 (0.7 - 1.0m)**
Material:	Silty Clay

Moisture Content (AS 1289 2.1.1)	
Moisture Content (%)	17.6

Dry Density - Moisture Relationship (AS 1289 5.1.1 & 2.1.1)	
Mould Type	1 LITRE MOULD A
Compaction	Standard
No. Layers	3
No. Blows / Layer	25
Maximum Dry Density (t/m^3)	1.63
Optimum Moisture Content (%)	20.5
Oversize Sieve (mm)	19
Oversize Material (%)	0
Method used to Determine Plasticity	Visual Assessment
Curing Hours	24

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**7**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.63		
Optimum Moisture Content (%)	20.5		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	101.0		
Dry Density after Soaking (t/m^3)	1.62		
Field Moisture Content (%)	17.6		
Moisture Content at Placement (%)	20.6		
Moisture Content Top 30mm (%)	23.1		
Moisture Content Rest of Sample (%)	22.6		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	24		
Swell (%)	1.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Douglas Partners
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Report Number:	**49797.01-2**
Issue Number:	1
Date Issued:	15/10/2018
Client:	Maitland City Council PO Box 220, Maitland NSW 2320
Project Number:	49797.01
Project Name:	Proposed Administration Building
Project Location:	263 High Street, Maitland
Work Request:	2128
Sample Number:	18-2128C
Date Sampled:	19/05/2018
Sampling Method:	Sampled by Engineering Department
Sample Location:	**301 (1.3 - 1.7m)**
Material:	Silty Clay

NATA WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing

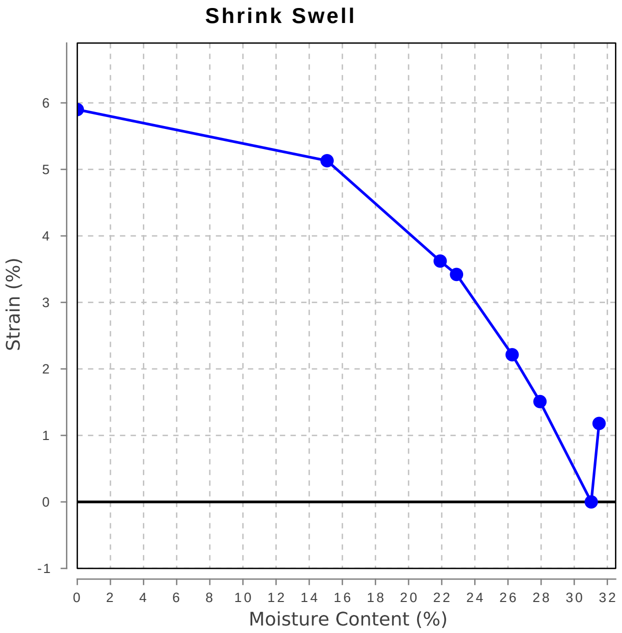
Approved Signatory: Peter Gorseski
Laboratory Manager

NATA Accredited Laboratory Number: 828

Shrink Swell Index (AS 1289 7.1.1 & 2.1.1)	
Iss (%)	**3.3**
Visual Description	Silty Clay
* Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.	

Core Shrinkage Test	
Shrinkage Strain - Oven Dried (%)	**5.9**
Estimated % by volume of significant inert inclusions	0
Cracking	Slightly Cracked
Crumbling	No
Moisture Content (%)	31.0

Swell Test	
Initial Pocket Penetrometer (kPa)	90
Final Pocket Penetrometer (kPa)	110
Initial Moisture Content (%)	30.4
Final Moisture Content (%)	31.5
Swell (%)	**-1.2**
* NATA Accreditation does not cover the performance of pocket penetrometer readings.	



Material Test Report

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Report Number: **49797.01-2**
Issue Number: 1
Date Issued: 15/10/2018
Client: Maitland City Council
PO Box 220, Maitland NSW 2320
Project Number: 49797.01
Project Name: Proposed Administration Building
Project Location: 263 High Street, Maitland
Work Request: 2128
Sample Number: 18-2128D
Date Sampled: 19/05/2018
Sampling Method: Sampled by Engineering Department
Sample Location: **306 (0.6 - 0.7m)**
Material: Silty Clay

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing

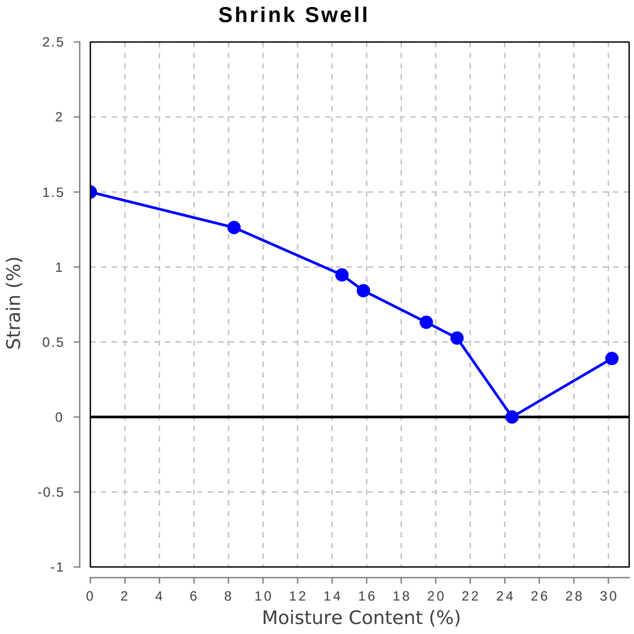
Approved Signatory: Peter Gorseski
Laboratory Manager

NATA Accredited Laboratory Number: 828

Shrink Swell Index (AS 1289 7.1.1 & 2.1.1)	
Iss (%)	**0.8**
Visual Description	Silty Clay
* Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.	

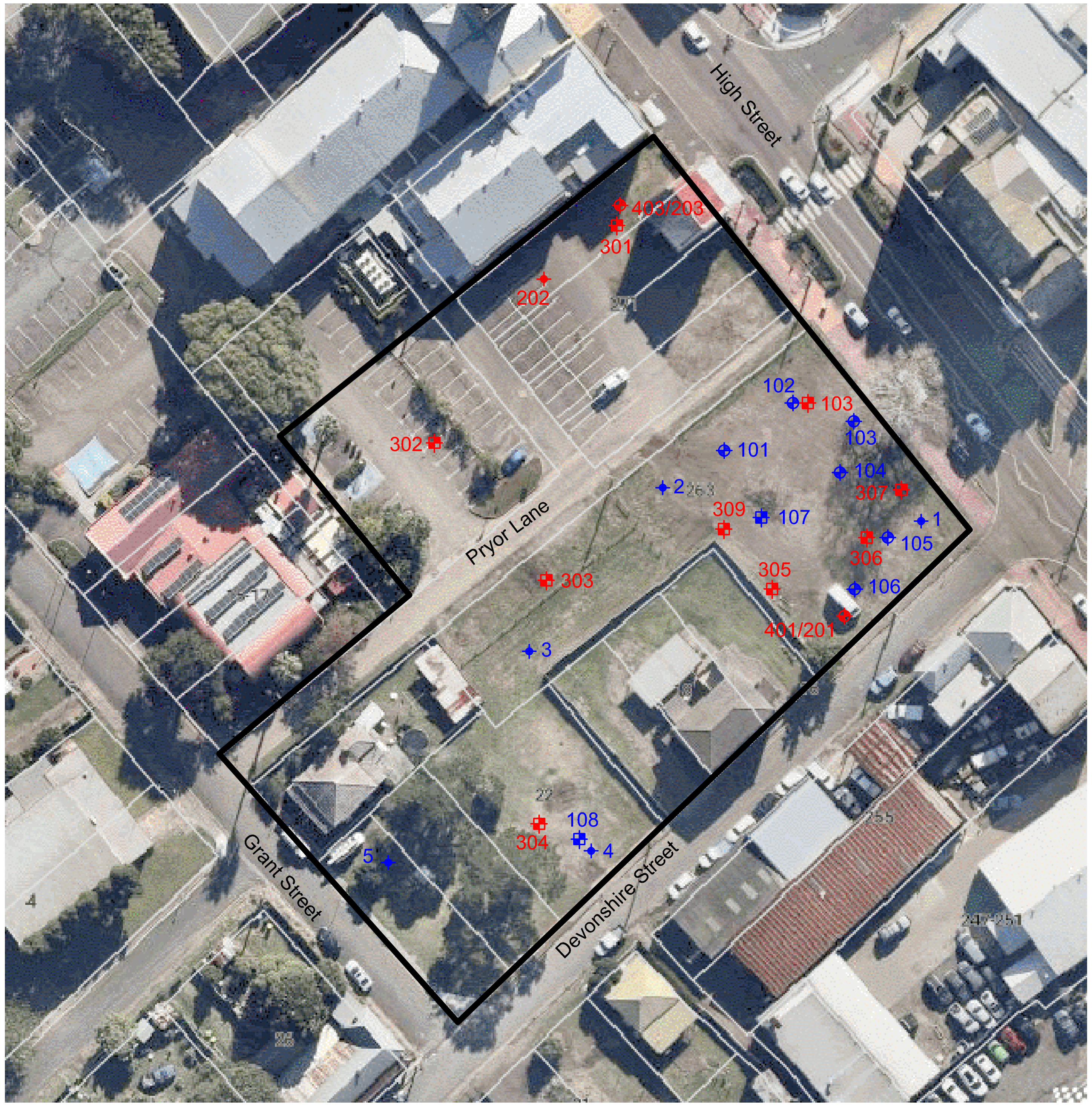
Core Shrinkage Test	
Shrinkage Strain - Oven Dried (%)	**1.5**
Estimated % by volume of significant inert inclusions	5
Cracking	Moderately Cracked
Crumbling	Yes
Moisture Content (%)	24.4

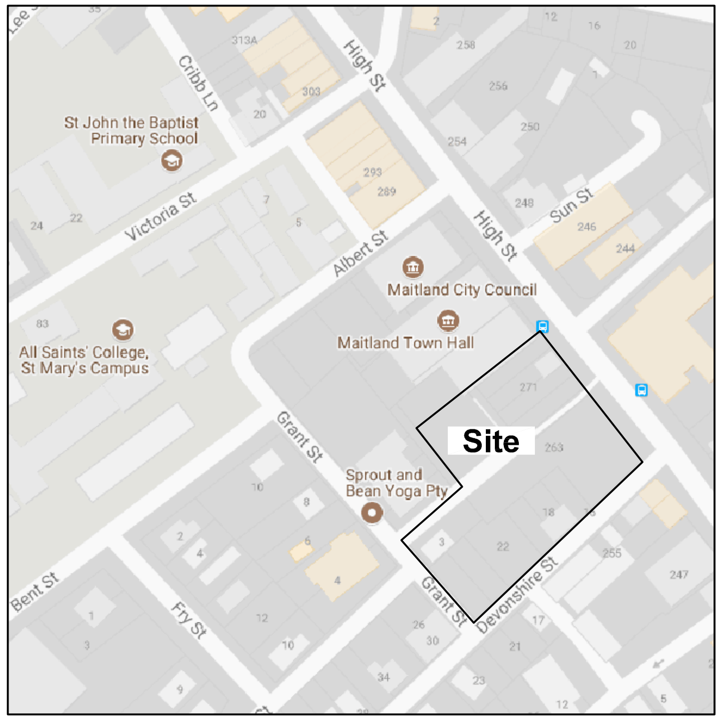
Swell Test	
Initial Pocket Penetrometer (kPa)	140
Final Pocket Penetrometer (kPa)	320
Initial Moisture Content (%)	27.2
Final Moisture Content (%)	30.2
Swell (%)	**-0.4**
* NATA Accreditation does not cover the performance of pocket penetrometer readings.	



Appendix D

Drawing 1 – Test Location Plan





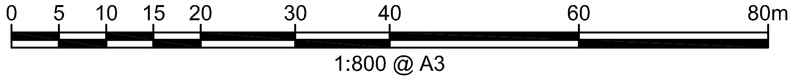
Locality Plan

NOTES

1. Drawing adapted from Nearmap Image dated 14.6.2018.
2. Test locations are approximate only and were located using Hand-held GPS / Tape measurement from existing site features.

LEGEND

✦	Cone Penetration Test Location (DP 2011)
✦	Cone Penetration Test Location (DP 2018) (200 series)
◈	Borehole Location (DP 2011)
⊞	Test Pit Location (DP 2011)
⊞	Test Pit Location (DP 2018) (300 series)
◈	Borehole Location (DP 2018) (400 series)
▬	Site Boundary



Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Maitland City Council
OFFICE: Newcastle
DRAWN BY: PLH
SCALE: 1:800@A3 Sheet
DATE: 12.09.2018

TITLE: **Test Location Plan**
Proposed Administration Building
High Street, Maitland

N

PROJECT No: 49797.01
DRAWING No: 1
REVISION: 1