Crozier Geotechnical Consultants
Unit 12/ 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
Phone: (02) 9939 1882
Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

PROPOSED NEW DEVELOPMENT

at

'THE BOATHOUSE', 1191 BARRENJOEY ROAD, PALM BEACH

Prepared For

London Lakes Partnership

Project No.: 2015-251

Document Revision Record

Issue No	Date	Details of Revisions
0	23rd March 2020	Original issue
1	19th April 2021	Updated Drawings

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for _____

Name of Applicant

Address of site ___ _1191 Barrenjoey Road, Palm Beach

Declaration made by geotechnical engineer or engineering geologist or coastal engineer (where applicable) as part of a geotechnical report

I, ***__Troy Crozier***_____ *on behalf of* ***___Crozier Geotechnical Consultants*** 19th April 2021 certify that I am a ~~geotechnical engineer or~~ engineering geologist ~~or coastal engineer~~ as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above ~~organisation~~/company to issue this document and to certify that the ~~organisation~~/company has a current professional indemnity policy of at least $2million.
I:

■ have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

☐ am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009

☐ have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.

☐ have examined the site and the proposed development/alteration in detail and I am of the opinion that the Development Application only involves Minor Development/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.

☐ have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.

☐ have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: Geotechnical Report for Proposed New Development

Report Date: 19th April 2021 **Project No.:** 2015-251

Author: Troy Crozier

Author's Company/Organisation: Crozier Geotechnical Consultants

Documentation which relate to or are relied upon in report preparation:

Architectural drawing by Canvas Architecture and Design; Drawing No.: DA00 to DA09, DA11, DA12, DA16 and DA17; Drawn by: RM and Date: 30/01/2021.
Survey Plan by C.M.S Surveyors Pty Ltd, Plan No.: 17534detail, Dated: 19/8/2019.

I am aware that the above Geotechnical Report, prepared for the abovementioned site is to be submitted in support of a Development Application for this site and will be relied on by Pittwater Council as the basis for ensuring that the Geotechnical Risk Management aspects of the proposed development have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

Signature .....

Name ...**Troy Crozier**.....

Chartered Professional Status...**RPGeo (AIG)**.....

Membership No.: ...**10197**.....

Company... **Crozier Geotechnical Consultants**

AUSTRALIAN INSTITUTE OF GEOSCIENTISTS
TROY CROZIER
10,197

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for_____
Name of Applicant
Address of site ___1191 Barrenjoey Road, Palm Beach _____

The following checklist covers the minimum requirements to be addressed in a Geotechnical Risk Management Geotechnical Report. This checklist is to accompany the Geotechnical Report and its certification (Form No. 1).

Geotechnical Report Details:

Report Title: Geotechnical Report for Proposed New Development
Report Date: 19th April 2021 **Project No.:** 2015-251
Author: Troy Crozier
Author's Company/Organisation: Crozier Geotechnical Consultants

Please mark appropriate box

- ■ Comprehensive site mapping conducted ____11th and 15th April 2016_____ (date)
- ☐ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- ☐ Subsurface investigation required
  - ☐ No Justification ....
  - ■ Yes Date conducted ...11th and 15th April 2016 and 28th February 2018.....
- ☐ Geotechnical model developed and reported as an inferred subsurface type-section
- ☐ Geotechnical hazards identified
  - ☐ Above the site
  - ☐ On the site
  - ☐ Below the site
  - ☐ Beside the site
- ☐ Geotechnical hazards described and reported
- ☐ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
  - ☐ Consequence analysis
  - ☐ Frequency analysis
- ☐ Risk calculation
- ☐ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☐ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☐ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
- ■ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- ■ Design Life Adopted:
  - ☐ 100 years
  - ■ Other .....50 years..... specify
- ■ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- ■ Additional action to remove risk where reasonable and practical have been identified and included in the report.
- ☐ Risk assessment within Bushfire Asset Protection Zone.

I am aware that Pittwater Council will rely on the Geotechnical Report, to which this checklist applies, as the basis for ensuring that the geotechnical risk management aspects of the proposal have been adequately addressed to achieve an "Acceptable Risk Management" level for the life of the structure, taken as at least 100 years unless otherwise stated, and justified in the Report and that reasonable and practical measures have been identified to remove foreseeable risk.

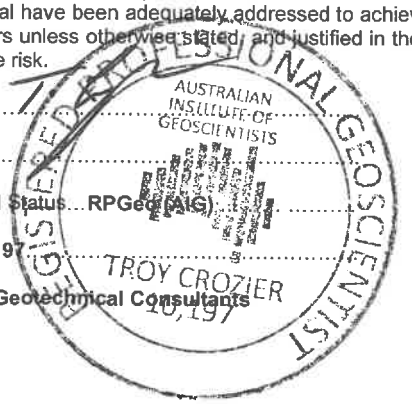
Signature .....

Name ...**Troy Crozier**.....

Chartered Professional Status...**RPGeo (AIG)**.....

Membership No. ...**10197**.....

Company... **Crozier Geotechnical Consultants**



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Crozier Geotechnical Consultants *ABN: 96 113 453 624*
Unit 12/ 42-46 Wattle Road *Phone: (02) 9939 1882*
Brookvale NSW 2100 *Fax :(02) 9939 1883*
Crozier Geotechnical Consultants is a division of PJC Geo-Engineering Pty Ltd

GEOTECHNICAL REPORT FOR PROPOSED NEW DEVELOPMENT 'THE BOATHOUSE' - 1191 BARRENJOEY ROAD, PALM BEACH, NSW

1. INTRODUCTION:

This report details the results of a geotechnical investigation carried out for a proposed new structure at 'The Boat House', 1191 Barrenjoey Road, Palm Beach, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of Blue Pacific Constructions on behalf of the client London Lakes Partnership.

The site is situated on the low western side of Barrenjoey Road within gently west sloping topography at the foreshore with Pittwater. It is currently occupied by a two storey timber building which is supported off various styles of pier footing with deck areas and a jetty extending out over the foreshore on the western side. An open garden seating area is located on the eastern side of the existing building.

It is understood that the proposed works involve the demolition of the existing structures, the construction of a new commercial building, a new sea wall with a new ancillary building to the south-east of the main building. The works also include landscaping and parking works to the east of the main building, including the construction of new parking areas and new dedicated pedestrian walkways to the north-east of the main building and dune stabilization works to the north of the boathouse ramp. Bulk excavations will be required for new drainage/sewage services potentially to RL-2.0 (approximately 4.5m depth). The new sea wall will also require excavation from RL-0.2 to RL-0.05.

The investigation comprised:

a) DBYD service location
b) Drilling of two augered bores using a hand tools along with Dynamic Cone Penetrometer testing (DCP) to investigate the subsurface geology and soil parameters.
c) Excavation of four test pits to expose existing pier footing and founding conditions.
d) Two standard Cone Penetration Test (CPT) holes to 9.00m and 13.75m depth using a truck mounted test rig to determine the underlying geology.
e) Geotechnical inspection of the site and supervision of testing by a Principal Engineering Geologist.

f) Collection of two soil samples for Acid Sulphate Soils assessment and testing at a NATA accredited laboratory (Envirolab).

The following documents were supplied for the work;

- Architectural drawings by Canvas Architecture and Design:
  - Drawing No. DA00 to DA09, DA11, DA12, DA16 and DA17; Drawn by: RM and Date: 30/01/2021.
- Site survey plan by C.M.S Surveyors PTY LTD, Drawing name: 17534detail, Issue I, Dated: 19th August 2019.
- Estuarine Risk Management Report by Cardno, Boat House, Palm Beach, Reference: 59916081, Dated: 21st March 2016
- Aquatic Ecology Report by Cardno, Reference: 59916081_R00X_evA_Marione Habitat, Dated: 27th November 2015
- Coastal Engineering Assessment by Cardno, , Reference: 59916081/R002, Dated: 8th August 2018

2. SITE FEATURES:

2.1. Description:

The site is located on the low west side of Barrenjoey Road within gently west sloping topography which forms the western foreshore of the sand spit that extends to Barrenjoey Headland. The site is irregular shaped with portions extending across the Mean High Water Mark. The portion of the site, within which the existing building is located, has a front east boundary of approximately 24.39m and a side north boundary of approximately 24.39m as referenced from the provided survey plan.

The existing building is located adjacent to the front east boundary of the site with an open paved garden area with tables, extending to Barrenjoey Road. Along the southern side of this area are several small temporary storage structures. The existing 'Boathouse' building is a two storey timber structure of at least 50 years of age located at the shoreline of Pittwater which is generally supported above the sandy beach/foreshore area by timber and concrete pier footings. On the western side of the building is a raised timber deck and then a timber jetty extending out into Pittwater.

2.2. Geology:

Reference to the Sydney 1: 100,000 Geological Series sheet (9130) indicates that the site is underlain by Quaternary sands (Qhf). These foredune sands consist of medium to fine 'marine' sand.

3. FIELD WORK:

3.1. Methods:

The preliminary field investigation comprised a walk over inspection of the site on the 11th and 15th April 2016 by a Geotechnical Engineer and Geologist. It included a photographic record of site conditions as well as the drilling of two auger boreholes (BH1 and BH2) using a hand auger to determine sub-surface geology and collect soil samples. Soil samples were collected and placed within sterile glass jars for testing for Acid Sulfate Soils purposes. The investigation was limited to the use of hand tools due to site access limitations.

A field investigation undertaken on the 28th February 2018, comprised of the supervision of two Cone Penetration Tests (CPT). Standard Cone Penetration Testing was carried out using a 22 tonne truck mounted probe operated by Insitu Geotech Services (IGS) Pty Ltd at two locations at the rear of the site, adjacent to the rear edge of the existing decks to investigate the underlying geology. The investigation coincided with the lowest possible tide available during the design phase. Access to the test locations was gained via the existing concrete boat ramp along the northern side of the site with track matting used to traverse the foreshore soils once they became exposed above the tide level, see Photograph: 1.

A CPT test involves a 35mm diameter cone tip followed by a 130mm long friction sleeve attached to rods of the same diameter. The cone is pushed into the soil by hydraulic thrust at a constant speed with strain gauges in the cone tip and sleeve measuring resistance to penetration with the digital results used to assess soil types and parameters.

Dynamic Penetrometer (DCP) testing was carried out through and adjacent to the boreholes and near existing piers in accordance with AS1289.6.3.2 – 1997, “Determination of the penetration resistance of a soil – 9kg Perth Penetrometer” to estimate near surface soil conditions.

Photograph: 1 – IGS Rig on CPT 1 test location.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1, along with detailed log sheets and laboratory results in Appendix: 2.

3.2. Field Observations:

The front of the site is near level and contains an open seating area within a garden adjacent to Barrenjoey Road. A series of timber and metal storage buildings are located to the south along with a narrow bitumen driveway. North of the garden, there is a bitumen surfaced car parking area providing access to a boat ramp on the foreshore, adjacent to the existing building.

At the foreshore edge, to the west of the garden, there is a two storey timber building 'The Boathouse' which contains a restaurant and other associated businesses. This structure is formed with a ground floor level (R.L. 2.51m) at a similar level as the ground surface of the garden however the foreshore drops away to the west below its eastern edge as a sandy beach. Therefore the building is raised upon timber, brick and concrete piers in various arrangements with a crude sea wall structure below its eastern edge. The footing piers are spaced up to 2.50m apart in an irregular pattern and appear of various ages and condition. To the west of the building is a timber deck (R.L. 1.78m) which is set slightly lower than the building floor level and supported off timber pier footings whilst a timber jetty strikes west from the southern side of the building.

To the north and south of the building are narrow gently sloping foreshore beaches with vegetated upper edges. Adjacent to the south-east corner of the site building a series of concrete blocks have been used to create a short length of sea wall.

3.3. Boreholes:

The boreholes were drilled adjacent to the timber storage building and Barrenjoey Road (BH 1) and adjacent to the timber deck near the north-west corner of the existing building within the foreshore beach (BH 2). The boreholes were discontinued at 2.40m depth (BH1) and at 0.50m depth (BH2) due to the boreholes collapsing below the water table.

Borehole 1 identified disturbed sandy fill at surface, classified as very loose to medium dense, fine grained, moist sand with some glass and gravels to 0.60m. The remainder of the borehole investigation identified natural, medium dense, fine grained moist sand with shell fragments with the grain size and moisture content increasing with depth. The ground water table was identified at 2.30m depth below ground surface level in BH1and at 0.20m depth in BH2.

Dynamic Penetrometer Tests (DCP) were carried out through and adjacent to the boreholes, with additional testing around the perimeter of the timber deck, see Figure: 1. DCP1 was discontinued at 1.20m depth on a suspected timber fragment or pipe whilst DCP1a refused at 0.40m depth on a similar buried object. DCP1b and DCP2a were discontinued at 3.00m depth due to the limit of the test equipment, whilst DCP3, DCP4, DCP5b and DCP6 were discontinued at 2.40m depth in medium dense sand due to access and tide issues.

The DCP tests (DCP 2) identified a thin layer of very loose sand from surface to 0.45m depth at the eastern end of the site overlying medium dense to 3.0m depth. At the southern end of the building (DCP1) the tests identified very loose sand at surface before medium dense to dense sand from 0.45m to1.80m depth before very loose sand was again encountered to 3.0m depth. The tests adjacent to the western side of the existing deck (DCP3, 4, 5, 6) identified very loose sands from surface to 1.80m depth before medium dense sands were identified.

3.4. Test Pits

Four test pits were excavated adjacent to concrete piers beneath ‘The Boathouse’ building to investigate the depth and foundation conditions of the existing footings. Access to this area was limited by the void height/head room between the floor and the ground whilst the water table and sandy soils made excavation to depth ineffective.

Test Pit 1 (TP 1) in the south-west corner identified the top of a horizontal concrete footing at 0.50m depth extending out from below the existing concrete pier footing towards the south. Several probes were driven into the sand in both a north and south direction to assess the continuity of this footing with the results showing the footing extending to the next pier to the south however its edge was identified 0.60m to the north.

A series of additional probes were then driven between piers to the north with the results suggesting that pairs of concrete piers are sitting on buried concrete strip footings orientated in a north south direction. The base of these footings could not be identified.

Test Pit 2 (TP2) was excavated to 0.70m depth and did not identify a horizontal footing or the base of the vertical pier before the pit collapsed due to the water table. Test Pit 3 (TP3) was abandoned due to the presence of a pipe at 0.30m depth below surface. Test Pit 4 (TP4) identified a concrete footing at 0.50m below surface, but it did not extend in an east west orientation. The depth to the base of this horizontal footing is unknown as the test pit collapsed at 0.90m depth whilst the lack of head room prevented effective probing to confirm the lateral extent in other directions.

The boreholes and test pits were conducted on the 15th April 2016, during and following the low tide of approximately 0.55m.

3.5. Laboratory Testing:

Of the soil samples collected, two representative samples were supplied to a NATA accredited laboratory (Envirolabs) for testing via the sPOCAS method, based on the recommendations of the Acid Sulphate Soils Laboratory Methods Guidelines, Version: 2.1, June 2004. A summary of the test results are listed in Table: 1 below.

Table: 3-1 – sPOCAS Test Results

Location	Depth (m)	pH	pH (oxidized)	TPA moles H^+ / t	Spos % w / w	Liming Rate kg CaCO3 / t
BH2	0.50	9.4	7.7	< 5	0.15	< 0.75
TP1	0.50	9.7	7.6	< 5	0.05	< 0.75

The full set of laboratory results analysis sheets are included in Appendix: 2. Within the raw laboratory test results BH 2 is referred to as BH 5.

3.6. Cone Penetration Testing (CPT)

The ground surface level at the test locations (R.L. -0.21 AHD) was taken from the supplied survey drawing (CMS Surveyors, Survey Instruction: 17534, Dated: 16/02/2018). The testing identified sandy soils with some thin (<0.50m) silty sand zones from surface to 13.75m depth, the limit of investigation. The following averaged profile is provided in Table: 1, which is based on published correlations and past experience. For detailed results at each test location the CPT test sheets within Appendix: 2 should be consulted.

Table: 3-2 – Geological profile from CPT testing

DEPTH TO BASE (M)	R.L. (M) (AHD)	MATERIAL	QC (MPA)	SOIL DENSITY
2.0	-2.21	Sand	0.1 – 0.4	Very Loose
7.0	-7.21	Sand	4.0 – 8.0	Dense
9.0	-9.21	Sand	2.0 – 2.5	Loose
13.5	-13.71	Sand	8.0 – 10.0	Dense

The water table was encountered from surface with all sandy soils expected to be saturated.

4. COMMENTS:

4.1. Geotechnical Assessment:

The preliminary site investigation identified the presence of a loose sand fill of shallow thickness (<0.60m) on the eastern side of the site overlying fine grained marine sand which extends across the foreshore and to >3.00m depth, with bedrock unidentified and expected at >10.0m depth. The sand grain size generally increased with depth with shell fragments also noted. The near surface soils (<0.60m) were generally of very low density before medium dense sand was encountered across the site. However very loose sands extended to 1.80m depth along the western side of the existing deck, in the location of the proposed pier wall. In this location medium dense sands extended from 1.80m depth to the limit of the investigation at 3.0m depth (≈ R.L. -2.70 NS). A very loose horizon was also identified on the southern side of the building from 1.80m depth to 2.50m depth (DCP 1b).

The Cone Penetration Test (CPT) results indicate that sand to slightly silty sand soils exist from surface to >13.75m depth (R.L. 13.90), the limit of the investigation. The sand is expected to be predominantly quartz sand based on samples at surface and previous experience in the local geological conditions. The sand is very loose near surface, which is expected to be due to previous erosion and lack of confinement and increases to dense below 2.00m depth, which is expected to be due to wave impact vibrations creating compaction. A loose zone was encountered from around 6.50m to 8.50m depth in CPT 1 and 7.50m to 9.00m in CPT 2 before dense sand was again intersected to 13.75m depth. Pore pressures will be based on tide levels due to the sandy conditions encountered during the testing.

The existing building is supported off both timber and concrete footings in various arrangements. The concrete pier footings along the rear western alignment appear to be supported in pairs off concrete strip footings that run in a north-south orientation. These strip footings are located from 0.50m depth below surface and extend to > 0.90m depth. The base of the footings could not be confirmed due to the water table and lack of space for testing below the existing structure.

The proposed works involve demolition of the existing structures and the construction of a new commercial structure with a sea wall and an ancillary building to the south-east. Landscaping works are also proposed to the east of the main building, including the construction of new parking areas, new dedicated pedestrian walkways and dune stabilization works to the north-east of the main building. The proposed works will require bulk excavation for the new drainage/sewage services (≤4.5m depth) and for the new sea wall (RL -0.05m).

Based on our site mapping no credible geological/geotechnical landslip hazards were identified which need to be considered in relation to the existing site and proposed development. As such a risk assessment is not required as the works are considered separate from, and not affected by, a geotechnical landslip hazard.

The entire site and surrounding slopes have been assessed as per the Pittwater Council Geotechnical Risk Management Policy 2009 and no credible landslip hazards were identified, therefore the site is considered to meet the 'Acceptable' risk management criteria for the design life of the development, taken as 50 years, provided the property is maintained as per the recommendations of this report.

The following soil parameters are considered suitable for the soils identified on site:

Depth to Base (m)	R.L. (m) (AHD)	Material	Qc (MPa)	Unit Weight (kN/m³)	Friction Angle (°)	Side Friction (fs) (kPa)	Modulus (MPa)
2.0	-2.21	Sand	0.1 – 0.4	16	30	0	0.30
7.0	-7.21	Sand	4.0 – 8.0	20	38	13 - 27	20.0
9.0	-9.21	Sand	2.0 – 2.5	18	36	8	8.0
13.5	-13.71	Sand	8.0 – 10.0	20	40	27 - 33	36.0

The site is estimated as a Class Ce (shallow soil) site based on the definitions of AS 1170, Earthquake Actions in Australia, the investigation results and expected soil depths/conditions.

For the design of pile footings, the following Geotechnical Strength Reduction factor (ϕ_{gb} = 0.53) is considered suitable from AS2159 based on the level of investigation undertaken. However, this will also be dependent on numerous factors including redundancy and testing/monitoring that require input by others.

The investigation results indicate that Piles founded within dense sand at >9.0m depth can be designed for a preliminary allowable end bearing pressure of 800kPa. Where piles are proposed to be founded above the loose sand horizon then additional settlement will be expected and further analysis required.

The recommendations and conclusions in this report are based on an investigation utilising limited sub-surface investigation. This test equipment provides limited data from small isolated test points across the entire site, therefore some minor variation to the interpreted sub-surface conditions is possible, especially between test locations. The results of the investigation provide a reasonable basis for the initial analysis and subsequent preliminary design of the proposed works.

4.2. Acid Sulphate Soils (ASS)

The soils are generally sandy and therefore would be considered as Coarse Texture – sands to loamy sands with clay contents ≤5% as per Table 4.4 – Acid Sulphate Soils Management Authority Committee (ASSMAC) – Acid Sulphate Soils Manual.

The results of the testing show that the soils below the western half of the site, from surface to directly below the water table are not Acid or Potential Acid Sulphate soils.

The loose sandy soils across the eastern side of the site, above the water table will also not be acid or potential acid sulfate due to their sandy nature and position above the water table.

Another investigation into Acid Sulphate Soils below the water table (to the east of the main structure) were undertaken in September 2020 at varying Levels between RL = -0.50m to RL = -2.90m. The investigation did not find the presence of AASS and PASS and an Acid Sulfate Soils Management Plan will not be required.

4.3. Design & Construction Recommendations:

4.3.1. New Footings:	
Site Classification as per AS2870 – 2011 for new footing design	Class 'A' for footings in sandy soils
Type of Footing	Strip/Pad , Piers/ Piles for new structures
Sub-grade material and Maximum Allowable Bearing Capacity	- Sand – Loose: 100kPa - Sand – Medium dense: 150kPa
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	Unconfirmed, expected Ce – shallow soil site
Remarks: All new footings must be inspected and tested by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity of the founding strata. This is mandatory to allow them to be 'certified' at the end of the project.	

It is understood from the Coastal Engineering (Cardno, 8th August 2018) that a piled wave screen may be implemented along the western side of the building to protect the deck and building structure from wave action forces.

In design of the piled wave screen the following preliminary information and parameters are provided:

Material	Unit Weight (kN/m3)	ϕ	Earth Pressure Coefficients		Modulus (MPa)	Nq
			Insitu (Ko)	Passive (Kp)		
Sand (Very loose)	18	ϕ' = 28°	0.53	2.77	10	60
Sand (Medium Dense)	20	ϕ' = 30°	0.50	3.00	20	100

The piles should be designed based on cyclic loading impacts and its reduction on confinement near surface along with vertical load support. This is critical if a structure is proposed to be supported by the piles.

The sea level and sandy conditions will reduce the suitability of most styles of footing other than driven timber or concrete piles. The energy imparted to the sediments adjacent as a result of the driving action has the potential to create settlement in the saturated very loose sands near surface, with impact to footings and structures founded at shallow depth within approximately 5.0m of the driven piles.

In the design of floating driven piles a soil-pile friction reduction value of 0.9 should be used based on driven concrete piles in sandy soils with a co-efficient of lateral earth pressure ratio (K*/Ko) = 1.5.
Should more detailed parameters or information to below R.L. – 2.0 AHD be required then additional testing will be required, however this will be difficult to achieve and require specialized equipment.

5. CONCLUSION:

The site investigation identified the presence of a sand fill of shallow thickness (<0.60m) on the eastern side of the site, overlying loose to medium dense, fine grained marine sand which extends across the remainder of the site and adjacent properties.

The proposed works involve demolition of the existing building structure and construction of a very similar new structure with new amenities buildings along the south boundary and some wave protection measures on the western side. The works will not require bulk excavation but will involve new footings.

The preliminary and subsequent investigation and testing into Acid or Potential Acid sulfate soils across the site above and below the water table did not identified the presence of Acid or Potential Acid Sulfate soils. Therefore, based on the test results and assessment an ASSMP is not required.

The site investigation works were limited by the existing structures and the site location, therefore should more detailed design data or parameters be required then additional testing with specialized investigation equipment will be necessary.

Updated By:

Marvin Lujan
Engineer

Reviewed By:

Troy Crozier
Principal
MEng, BSc, Dip. Civ. Eng
MAIG, PRGeo – Geotechnical and Engineering
Registration No.: 10197

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 1

Crozier Geotechnical Consultants
Unit 12/ 42-46 Wattle Road
Brookvale NSW 2100
ABN: 96 113 453 624
Phone: (02) 9939 1882
Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring 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.

Description and classification Methods

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

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. Sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows:

Classification	Undrained Shear Strength kPa
Very soft	Less than 12
Soft	12 - 25
Firm	25 – 50
Stiff	50 – 100
Very stiff	100 - 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300mm)	CPT Cone Value (Qc – MPa)
Very loose	less than 5	less than 2
Loose	5 – 10	2 – 5
Medium dense	10 – 30	5 -15
Dense	30 – 50	15 – 25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

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

Disturbed samples taken during drilling to allow 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 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.

Drilling Methods

The following is a brief summary of drilling methods currently adopted by the company and some comments on their use and application.

Test Pits – these are excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descent into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) – the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) 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 sampling.

Continuous Sample Drilling – the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers – the hole is advanced using 90 – 115mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPT's or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water 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 'feel' and rate of penetration.

Rotary Mud Drilling – similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. From SPT).

Continuous Core Drilling – a continuous core sample is obtained using a diamond-tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedures 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 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken

as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm 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 150mm of say 4, 6 and 7 as 4, 6, 7 then N = 13
- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm then as 15, 30/40mm.

The results of the test can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50mm diameter thin wall sample tubes in clay. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch Cone – abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australia Standard 1289, Test 6.4.1.

In tests, a 35mm diameter rod with a cone-tipped end is pushed continually into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separte 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected buy electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) their information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: -

- Cone resistance – the actual end bearing force divided by the cross-sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0 – 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0 – 50 MPa) is less sensitive and is shown as a full line. The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios 1% - 2% are commonly encountered in sands and very soft clays rising to 4% - 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range: -

Qc (MPa) = (0.4 to 0.6) N blows (blows per 300mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range: -

Qc = (12 to 18) Cu

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculations of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Dynamic Penetrometers

Dynamic penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer – a 16mm diameter flattened rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test 6.3.3). The test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289, Test 6.3.2). The test was developed initially for pavement sub-grade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is generally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Borehole Logs

The bore logs presented herein 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. 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 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, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Details of the type and method of sampling are given in the report and the following sample codes are on the borehole logs where applicable:

D	Disturbed Sample	E	Environmental sample	DT	Diatube
B	Bulk Sample	PP	Pocket Penetrometer Test		
U50	50mm Undisturbed Tube Sample	SPT	Standard Penetration Test		
U63	63mm " " " " "	C	Core		

Ground Water

Where ground water levels are measured in boreholes there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it 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.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations 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 interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. A three-storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty-storey building). If this happens, the Company 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 condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction**.** However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions – the potential for this will depend partly on bore spacing and sampling frequency,
- changes in policy or interpretation of policy by statutory authorities,
- the actions of contractors responding to commercial pressures,

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

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, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

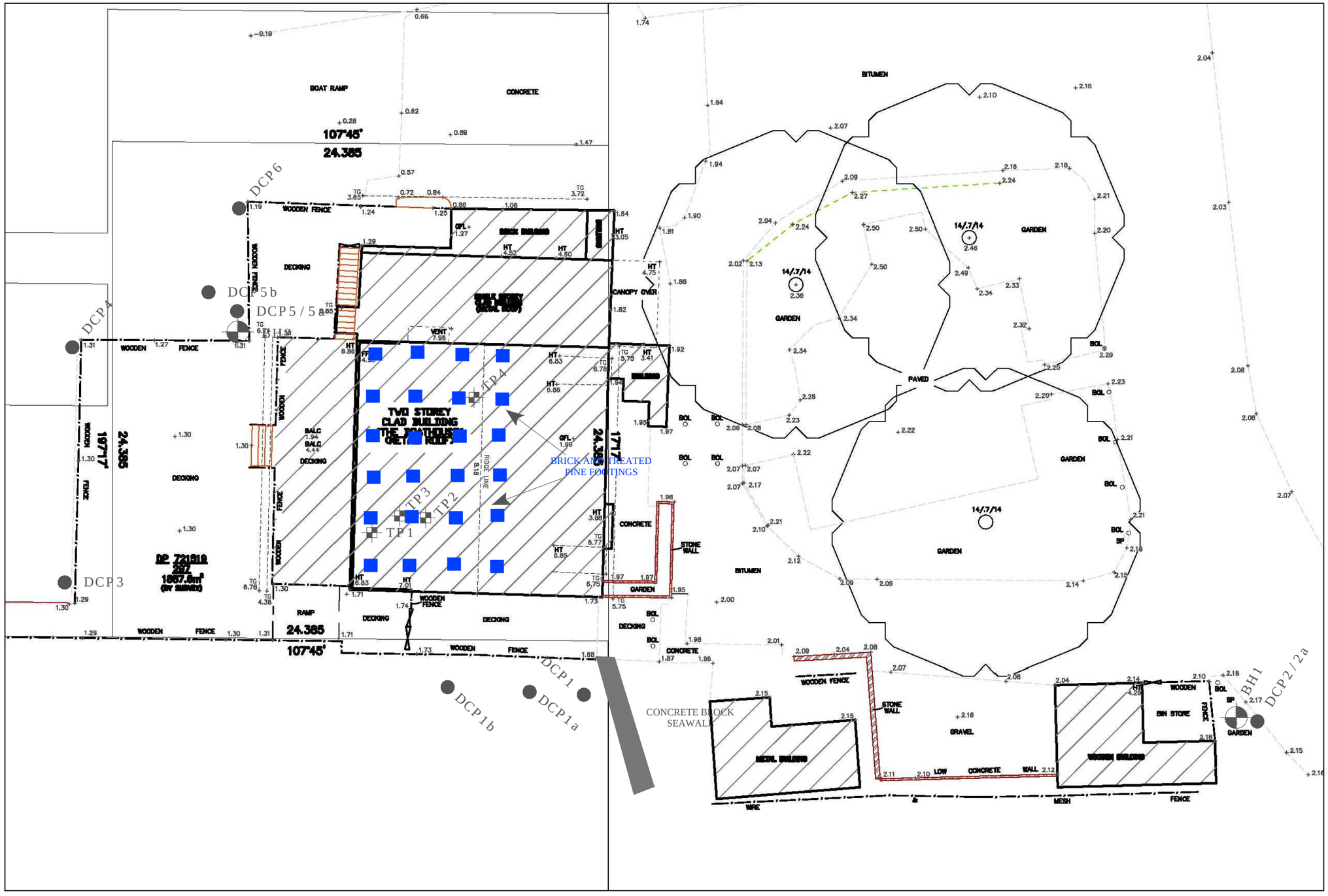
Attention is drawn to the document “Guidelines for the Provision of Geotechnical Information in Tender Documents”, published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including 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 special ally edited document. The Company 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 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.

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 2



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

SITE PLAN & TEST LOCATIONS FIGURE 1.

CROZIER GEOTECHNICAL CONSULTANTS

Crozier Geotechnical ABN: 96 113 453 624
Unit 12, 42-46 Wattle Road Phone: (02) 9939 1882
Brookvale NSW 2100 Fax: (02) 9939 1883
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

LEGEND

- BH — AUGER LOCATIONS
- TP1 — TEST PIT
- EXISTING FOOTING
- DCP — DYNAMIC CONE PENETROMETER TEST
- RETAINING WALL

SCALE: 1:200 @ A3	PREPARED FOR:
DRAWING: FIGURE 1	
DRAWN: KB	LONDON LAKES PARTNERSHIP
DATE: 27/04/2016	
APPROVED BY: TMC	ADDRESS:
PROJECT: 2015-251	THE BOATHOUSE PALM BEACH

TEST BORE REPORT

CLIENT: London Lakes Partnership **DATE:** 11/04/2016 **BORE No.:** 1

PROJECT: Alterations and additions **PROJECT No.:** 2015-251 **SHEET:** 1 of 1

LOCATION: The Boat House, Palm Beach **SURFACE LEVEL:** RL ≈ 2.10m AHD

Depth (m)	Description of Strata	Sampling		In Situ Testing		
	PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Type	Depth (m)	Type	Results	
0.00	FILL - Very loose, brown, fine grained, moist, sand fill with some glass and gravels					
	* 0.30m some roots					
	* 0.45m medium dense					
0.60	SAND - Dense, brown, fine grained, moist sand					
	* 0.75m medium dense					
	* 0.80m becoming light brown					
1.00	* 1.10m light brown-yellow, medium grained					
2.00	* 2.00m wet					
	* 2.30m saturated with some shell fragments					
2.40	HAND AUGER DISCONTINUED due to hole collapse at 2.40m in medium dense sand					

RIG: None DRILLER: KB LOGGED: BL

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: Water at 2.30m below ground surface

REMARKS: BH correlates to DCP2, 2a. CHECKED:

TEST BORE REPORT

CLIENT: London Lakes Partnership **DATE:** 15/04/2016 **BORE No.:** 2

PROJECT: Alterations and additions **PROJECT No.:** 2015-251 **SHEET:** 1 of 1

LOCATION: The Boat House, Palm Beach **SURFACE LEVEL:** RL ≈ 0.65m AHD (estimated)

Depth (m)	Description of Strata	Sampling		In Situ Testing		
	PRIMARY SOIL - strength/density, colour, grainsize/plasticity, moisture, soil type incl. secondary constituents, other remarks	Type	Depth (m)	Type	Results	
0.00						
	SAND - Very loose, dark brown, fine grained, wet sand					
	* 0.05m light brown sand					
	* 0.20m saturated, grey sand					
		D	0.30			
0.50		D	0.50	sPOCAS		
	BOREHOLE DISCONTINUED due to hole collapse at 0.50m in medium dense sand					
1.00						
2.00						

RIG: None DRILLER: KB LOGGED: ER

METHOD: Hand Auger

GROUND WATER OBSERVATIONS: Water table at 0.20m depth

REMARKS: Corresponds with DCP5,5a, 5b CHECKED:

DYNAMIC PENETROMETER TEST SHEET

CLIENT: London Lakes Partnership **DATE:** 11/04/2016

PROJECT: Alterations and additions **PROJECT No.:** 2015-251

LOCATION: The Boat House, Palm Beach **SHEET:** 1 of 1

	Test Location							
Depth (m)	DCP1	DCP1a	DCP1b	DCP2	DCP2a	DCP3	DCP4	
0.00 - 0.15	1	1	1	0	-	0	0	
0.15 - 0.30	1	1	3	1	-	3	2	
0.30 - 0.45	1	5 (B)	8	1	-	0	3	
0.45 - 0.60	2	Refusal at 0.40m	11	6	-	1	1	
0.60 - 0.75	6		12	12	-	1	2	
0.75 - 0.90	11		9	8	-	1	1	
0.90 - 1.05	6		6	7	-	2	1	
1.05 - 1.20	12		7	10	-	2	1	
1.20 - 1.35			10		8	4	1	
1.35 - 1.50			8		8	1	0	
1.50 - 1.65			5		7	1	0	
1.65 - 1.80			3		6	0	2	
1.80 - 1.95			2		6	3	3	
1.95 - 2.10			0		5	6	3	
2.10 - 2.25			0		6	6	5	
2.25 - 2.40			1		7	5	6	
2.40 - 2.55			1		6			
2.55 - 2.70			2		5			
2.70 - 2.85			2		5			
2.85 - 3.00			2		4			

TEST METHOD: AS 1289. F3.3, PERTH SAND PENETROMETER

REMARKS:

(B) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

DYNAMIC PENETROMETER TEST SHEET

CLIENT: London Lakes Partnership **DATE:** 11/04/2016

PROJECT: Alterations and additions **PROJECT No.:** 2015-251

LOCATION: The Boat House, Palm Beach **SHEET:** 2 of 2

	Test Location							
Depth (m)	DCP5	DCP5a	DCP5b	DCP6				
0.00 - 0.15	0	1	1	0				
0.15 - 0.30	2	2	4	3				
0.30 - 0.45	3 (B)	1 (B)	2	4				
0.45 - 0.60	Disct at 0.40	Disct at 0.30m	3	4				
0.60 - 0.75			2	2				
0.75 - 0.90			0	1				
0.90 - 1.05			4	2				
1.05 - 1.20			3	3				
1.20 - 1.35			2	2				
1.35 - 1.50			3	2				
1.50 - 1.65			3	1				
1.65 - 1.80			2	1				
1.80 - 1.95			3	3				
1.95 - 2.10			6	6				
2.10 - 2.25			6	8				
2.25 - 2.40			8	9				
2.40 - 2.55								
2.55 - 2.70								
2.70 - 2.85								
2.85 - 3.00								

TEST METHOD: AS 1289. F3.3, PERTH SAND PENETROMETER

REMARKS:

(B) Test hammer bouncing upon refusal on solid object

-- No test undertaken at this level due to prior excavation of soils

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

CERTIFICATE OF ANALYSIS 251401

Client Details

Client	Crozier Geotechnical Consultants
Attention	Troy Crozier
Address	Unit 12/42-46 Wattle Rd, Brookvale, NSW, 2100

Sample Details

Your Reference	**2015-251, Palm Beach, The Boathouse**
Number of Samples	4 Soil
Date samples received	16/09/2020
Date completed instructions received	16/09/2020

Analysis Details

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

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

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

Report Details

Date results requested by	23/09/2020
Date of Issue	23/09/2020

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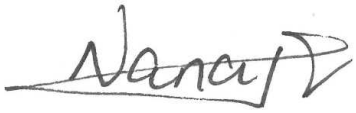
Results Approved By
Diego Bigolin, Team Leader, Inorganics
Nick Sarlamis, Inorganics Supervisor

Authorised By



Nancy Zhang, Laboratory Manager

sPOCAS + %S w/w					
Our Reference		251401-1	251401-2	251401-3	251401-4
Your Reference	UNITS	BH1	BH1	BH2	BH2
Depth		3.00-3.45	4.50-4.95	3.00-3.45	5.40-5.50
Date Sampled		16/09/2020	16/09/2020	16/09/2020	16/09/2020
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	21/09/2020	21/09/2020	21/09/2020	21/09/2020
Date analysed	-	21/09/2020	21/09/2020	21/09/2020	21/09/2020
pH $_{kcl}$	pH units	9.6	9.7	9.9	10.0
TAA pH 6.5	moles H^+ /t	<5	<5	<5	<5
s-TAA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01
pH $_{Ox}$	pH units	7.8	7.8	8.0	7.9
TPA pH 6.5	moles H^+ /t	<5	<5	<5	<5
s-TPA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01
TSA pH 6.5	moles H^+ /t	<5	<5	<5	<5
s-TSA pH 6.5	%w/w S	<0.01	<0.01	<0.01	<0.01
ANC_E	% $CaCO_3$	16	8.3	13	7.9
a-ANC_E	moles H^+ /t	3,200	1,600	2,500	1,600
s-ANC_E	%w/w S	5.2	2.6	4.0	2.5
S_{KCl}	%w/w S	0.01	0.008	0.02	0.02
S_P	%w/w	0.06	0.02	0.06	0.03
S_{POS}	%w/w	0.05	0.009	0.04	0.01
a-S_{POS}	moles H^+ /t	29	6	26	8
Ca_{KCl}	%w/w	1.3	0.94	1.4	1.3
Ca_P	%w/w	6.3	2.5	6.6	3.4
Ca_A	%w/w	5.0	1.5	5.2	2.1
Mg_{KCl}	%w/w	0.087	0.054	0.10	0.079
Mg_P	%w/w	0.33	0.12	0.36	0.16
Mg_A	%w/w	0.24	0.067	0.26	0.086
S_{HCl}	%w/w S	NA	NA	NA	NA
S_{NAS}	%w/w S	NA	NA	NA	NA
a-S_{NAS}	moles H^+ /t	NA	NA	NA	NA
s-S_{NAS}	%w/w S	NA	NA	NA	NA
Fineness Factor	-	1.5	1.5	1.5	1.5
a-Net Acidity	moles H^+ /t	<5	<5	<5	<5
s-Net Acidity	%w/w S	<0.01	<0.01	<0.01	<0.01
Liming rate	kg $CaCO_3$ /t	<0.75	<0.75	<0.75	<0.75
s-Net Acidity without -ANCE	%w/w S	0.046	<0.01	0.041	0.013
a-Net Acidity without ANCE	moles H^+ /t	29	5.6	26	7.9
Liming rate without ANCE	kg $CaCO_3$ /t	2.2	<0.75	1.9	<0.75

Soil Aggressivity		
Our Reference		251401-1
Your Reference	UNITS	BH1
Depth		3.00-3.45
Date Sampled		16/09/2020
Type of sample		Soil
pH 1:5 soil:water	pH Units	8.9
Electrical Conductivity 1:5 soil:water	µS/cm	110
Chloride, Cl 1:5 soil:water	mg/kg	34
Sulphate, SO4 1:5 soil:water	mg/kg	22

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-064	sPOCAS determined using titrimetric and ICP-AES techniques. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: sPOCAS + %S w/w						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			21/09/2020	1	21/09/2020	21/09/2020		21/09/2020	[NT]
Date analysed	-			21/09/2020	1	21/09/2020	21/09/2020		21/09/2020	[NT]
pH $_{kcl}$	pH units		Inorg-064	[NT]	1	9.6	9.6	0	97	[NT]
TAA pH 6.5	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	90	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
pH $_{Ox}$	pH units		Inorg-064	[NT]	1	7.8	7.8	0	92	[NT]
TPA pH 6.5	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	100	[NT]
s-TPA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
TSA pH 6.5	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	[NT]	[NT]
s-TSA pH 6.5	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
ANC_E	% $CaCO_3$	0.05	Inorg-064	<0.05	1	16	17	6	[NT]	[NT]
a-ANC_E	moles H^+/t	5	Inorg-064	<5	1	3200	3400	6	[NT]	[NT]
s-ANC_E	%w/w S	0.05	Inorg-064	<0.05	1	5.2	5.5	6	[NT]	[NT]
S_{KCl}	%w/w S	0.005	Inorg-064	<0.005	1	0.01	0.01	0	[NT]	[NT]
S_P	%w/w	0.005	Inorg-064	<0.005	1	0.06	0.06	0	[NT]	[NT]
S_{POS}	%w/w	0.005	Inorg-064	<0.005	1	0.05	0.04	22	[NT]	[NT]
a-S_{POS}	moles H^+/t	5	Inorg-064	<5	1	29	26	11	[NT]	[NT]
Ca_{KCl}	%w/w	0.005	Inorg-064	<0.005	1	1.3	1.3	0	[NT]	[NT]
Ca_P	%w/w	0.005	Inorg-064	<0.005	1	6.3	5.6	12	[NT]	[NT]
Ca_A	%w/w	0.005	Inorg-064	<0.005	1	5.0	4.3	15	[NT]	[NT]
Mg_{KCl}	%w/w	0.005	Inorg-064	<0.005	1	0.087	0.084	4	[NT]	[NT]
Mg_P	%w/w	0.005	Inorg-064	<0.005	1	0.33	0.28	16	[NT]	[NT]
Mg_A	%w/w	0.005	Inorg-064	<0.005	1	0.24	0.20	18	[NT]	[NT]
S_{HCl}	%w/w S	0.005	Inorg-064	<0.005	1	NA	NA		[NT]	[NT]
S_{NAS}	%w/w S	0.005	Inorg-064	<0.005	1	NA	NA		[NT]	[NT]
a-S_{NAS}	moles H^+/t	5	Inorg-064	<5	1	NA	NA		[NT]	[NT]
s-S_{NAS}	%w/w S	0.01	Inorg-064	<0.01	1	NA	NA		[NT]	[NT]
Fineness Factor	-	1.5	Inorg-064	<1.5	1	1.5	1.5	0	[NT]	[NT]
a-Net Acidity	moles H^+/t	5	Inorg-064	<5	1	<5	<5	0	[NT]	[NT]
s-Net Acidity	%w/w S	0.01	Inorg-064	<0.01	1	<0.01	<0.01	0	[NT]	[NT]
Liming rate	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	1	<0.75	<0.75	0	[NT]	[NT]
s-Net Acidity without -ANCE	%w/w S	0.01	Inorg-064	<0.01	1	0.046	0.042	9	[NT]	[NT]

QUALITY CONTROL: sPOCAS + %S w/w						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
a-Net Acidity without ANCE	moles H^+/t	5	Inorg-064	<5	1	29	26	11	[NT]	[NT]
Liming rate without ANCE	kg $CaCO_3$/t	0.75	Inorg-064	<0.75	1	2.2	2.0	10	[NT]	[NT]

QUALITY CONTROL: Soil Aggressivity						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	99	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	108	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	102	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	106	[NT]

Result Definitions

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

Quality Control Definitions

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

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

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

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

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

Spikes for Physical and Aggregate Tests are not applicable.

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

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

CROZIER
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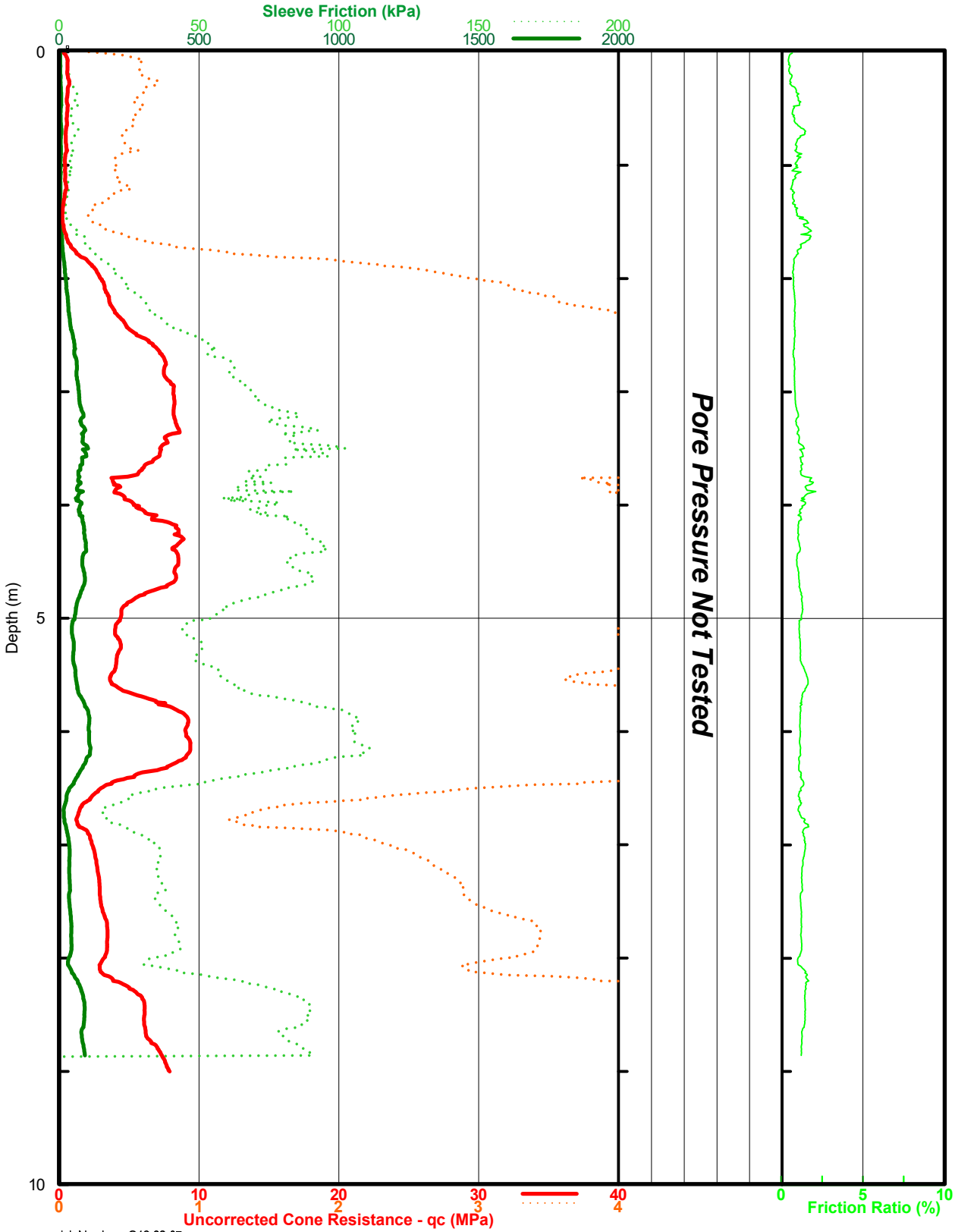
Appendix 3

CONE PENETROMETER TEST RESULT

Crozier Geotechnical Consultants
2015251
Palm Beach NSW

CPT-01



Job Number : G18-02-07
Test Date : 28/02/2018
GPS Position : 56 H 0344461, 6282351
GPS Format : WGS 84
Rig : Eunice
Cone Number : S15CFII.D22
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Engineers Request

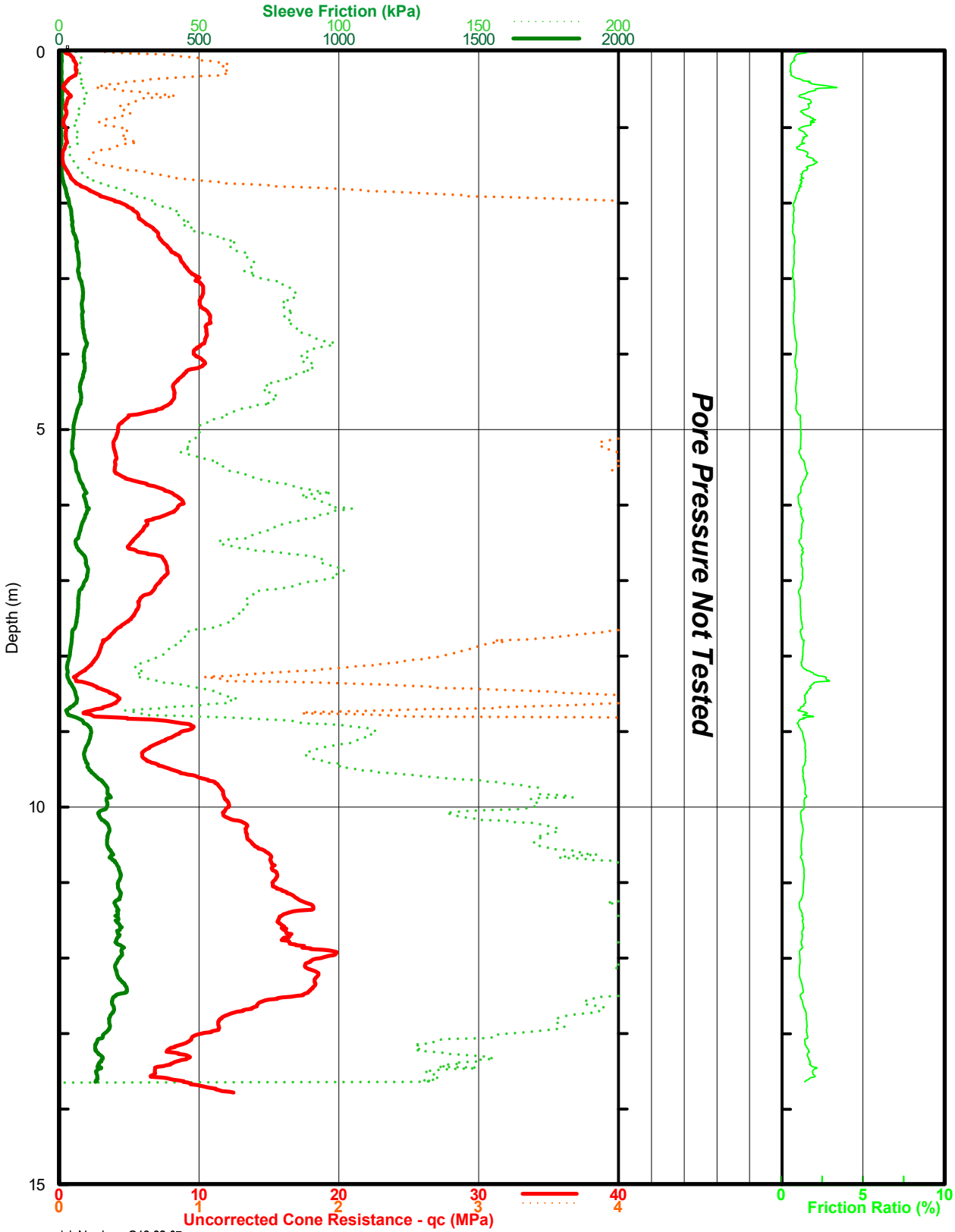
Tested By : Russell Vincenzi
Test Category : IGS-2S
Checked By : Justian Russell

Insitu Geotech Services Pty Ltd IGS

CONE PENETROMETER TEST RESULT

Crozier Geotechnical Consultants
2015251
Palm Beach NSW

CPT-02



Job Number : G18-02-07
Test Date : 28/02/2018
GPS Position : 56 H 0344472, 6282360
GPS Format : WGS 84
Rig : Eunice
Cone Number : S15CFII.D22
Predrill Depth : 0.00m
Dissipation Tests @ : N/A
Terminated Due To : Engineers Request

Tested By : Russell Vincenzi
Test Category : IGS-2S
Checked By : Justian Russell

Insitu Geotech Services Pty Ltd IGS