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Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

GEOTECHNICAL INVESTIGATION INTO ACID SULFATE SOILS

for

PROPOSED NEW DEVELOPMENT

at

'THE BOATHOUSE', 1191 BARRENJOEY ROAD, PALM BEACH, NSW

Prepared For

London Lakes Partnership

Project No.: 2015-251

Document Revision Record

Issue No	Date	Details of Revisions
0	25th September, 2020	Original issue
1	19th April, 2021	Updated Drawings and Reports

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Date: 19th April 2021
Project No: 2015-251
Pages: 1 of 6

GEOTECHNICAL INVESTIGATION INTO ACID SULFATE SOILS FOR PROPOSED NEW DEVELOPMENT AT 'THE BOATHOUSE' – 1191 BARRENJOEY ROAD, PALM BEACH, NSW

1. INTRODUCTION:

This report details the results of an investigation to assess the potential risk from Potential Acid Sulphate Soils (PASS) and Actual Acid Sulphate Soils (AASS) associated with the proposed works within the site 1191 Barrenjoey Road, Palm Beach, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of Blue Pacific Constructions on the behalf of the client London Lakes Partnership.

The site is classified under Pittwater Council Local Environmental Plan 2014, Acid Sulfate Soils Map Sheet ASS_014, as being within 'Class 1' and 'Class 3' Acid Sulfate soils hazard zone, with the 'Class 1' land defined as west of the Mean High Water Mark (MHWM), which passes through the centre of the site in a north-south orientation.

This investigation adds to previous investigations to the site. These include a previous investigation (April 2020) that consisted of a preliminary assessment for PASS and AASS via preliminary pH and pH fox along with sPOCAS methods at two locations to directly below the water table (R.L.= 0.00m to R.L.= 0.15m), related to the initial shallow footing/ remediation works. The previous investigation did not identify PASS and AASS, hence excluding the need for an Acid Sulphate Soils Management Plan (ASSMP) for excavation works above the water table.

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.

Excavations will be required for new drainage/sewage services potentially to RL-2.0m (approximately 4.5m depth). The new sea wall will also require excavation from RL-0.2m to RL-0.05m. The western side of the site is classified as Class 1 ASS, whilst identifying that where PASS or AASS are encountered then an ASSMP will be required.

The investigation comprised:

a) DBYD service location
b) Onsite clearance of borehole locations by an accredited service locator
c) Drilling of two boreholes to 6.45m depth (BH101, R.L.= -4.05m) and to 7.05m depth (BH102, R.L.= -4.55m) along with SPT testing every 1.50m depth interval.
d) Collection of soil samples and submission to a NATA registered chemistry laboratory for assessment of PASS and AASS via sPOCAS method and also test for exposure conditions for piles (Soil aggressivity).
e) All fieldwork was conducted under the full-time supervision of an experienced or Geotechnical Professional who completed logging of soils and ensured the quality of all geotechnical data.

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.
- Drainage Services Ground Floor Plan by ADCAR Consulting, Drawn: MA, Project No.: ADC200108, Drawing No.: H-300 and Revision: A.
- Storm Erosion Protection Wall design by McKee & Associates Pty Ltd - Structural Engineers, Project No.: 25722, Print Date: 21.02.2020 and Drawings: EPW01 and EPW02.
- 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. FIELD WORK:

2.1. Methods:

The field investigation comprised the drilling of two boreholes (BH101 and BH102) using a Multi-purpose CE180 rig on the 16th September 2020 by a Geotechnical Engineer and BG Drilling to investigate sub-surface geology and collect samples for Acid Sulfate Soils analysis.

Test locations are shown on Figure: 1, Appendix: 2 along with detailed log sheets. Explanatory notes are included in Appendix: 1.

2.2. Ground Conditions:

Based on the borehole logs and SPT test results, the sub-surface conditions at the project site can be classified as follows:

- **GRAVELLY SAND HARDSTAND/ FILL** – this layer was encountered in both locations up to 0.15m depth.
- **SAND –** this layer was encountered underlaying the fill. It was classified as generally loose to 3.00m depth, becoming very loose to 4.50m depth and then loose through to the maximum investigated depths of 6.45m (BH101) and 7.05m (BH102). The sand was generally pale brown, fine to medium grained at shallow depths through to 4.50m depth, whilst then becoming orange/ brown, medium to coarse grained (with a coarse texture) with trace of oyster shells (up to ≤20 mm diameter), moist to varying depths between 2.00m and 2.10m, within BH101 and BH102, respectively and then saturated through to the maximum investigated depth.

The groundwater table was encountered in both boreholes at varying depths between 2.00m and 2.10m within BH1 and BH2, respectively. The approximate Reduced Level (R.L.) of the groundwater level encountered within each borehole are summarised in Table 1 below.

Table 1: Groundwater observations

Test Location	Ground Surface Level (m RL)	Groundwater Encountered Drilled depth (m)	Groundwater Encountered (m RL)
BH 101	2.40	2.00	0.40
BH 102	2.50	2.10	0.40

2.3. Acid Sulfate Soils Testing

Of the soil samples collected, representative samples were kept on ice and transported to NATA accredited laboratory (Envirolab) for testing via the SPOCAS, pH and pHFOX methods, based on the recommendations of the Acid Sulfate Soils Laboratory Methods Guidelines, Version: 2.1, June 2004. A summary of the test results are listed in Table: 2 below. The laboratory test report sheets are included in Appendix: 3.

Table: 2 – sPOCAS Test Results

Location	Depth (m)	R.L.	pH	pH (oxidized)	TPA moles H^+ / t	Spos % w / w	Liming Rate kg CaCO3 / t
BH 101	3.00 – 3.45	-0.60	9.6	7.8	< 5	0.05	< 0.75
BH 101	4.50 – 4.95	-2.10	9.7	7.8	< 5	0.0009	< 0.75
BH 102	3.00 – 3.45	-0.50	9.9	8.0	< 5	0.04	< 0.75
BH 102	5.40 – 5.50	-2.90	10.0	7.9	< 5	0.01	< 0.75

* Results in **Bold** exceed the Acid Sulfate Soils Advisory committee (ASSMAC) Action Criteria for disturbance of <1000 tonnes of soil (refer Section 4.2)

2.4. Corrosion Potential

One selected soil sample recovered from BH101 was to determine the corrosion potential of the site soils to provide durability classification for a new steel pile and concrete structures as per AS2159. The reported results are summarised in Table 3 below:

Table 3: Summary of reported Chemical Analysis

Sample Location		pH	Electrical Conductivity (µS/cm)	Chloride, Cl (mg/kg)	Sulphate, SO4 (mg/kg)
BH 101	3.00-3.45	8.9	110	34	22

3. ASSESSMENT AND CONCLUSIONS:

3.1. Acid Sulfate Soils Testing:

The soils are 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 test results show that the tested soils below the water table (with varying Reduced Levels of R.L. -0.50m and -2.90m) are not considered Actual Acid Sulphate Soils (AASS) or Potential Acid Sulphate Soils (PASS). Previous testing identified the soils above the water table were also not AASS or PASS.

As such, in line with the ASSMAC guidelines there is no requirement for an Acid Sulphate Management Plan based on the proposed works (as per the supplied design drawings).

3.2. Corrosion Resistance:

The results of the soil chemical testing undertaken on the soil samples were compared against the Australian Standard AS 2159-2009 Pile Design and Installation.

The results were compared against Table 6.4.2 (C) Exposure Classification for Concrete Piles – Piles in Soil. The results indicate that the soils are 'non-aggressive' to concrete from pH, chloride and sulphate.

The results were also compared against Table 6.5.2 (C) Exposure Classification for Steel Piles – Piles in Soil. The results indicate that the soil is 'non-aggressive' to steel with regard to pH, chloride and sulphate.

We hope the above comments meet your present needs, should you require any further advice or clarification then please don't hesitate to contact the undersigned.

Prepared By:	Reviewed By:
Marvin Lujan	Troy Crozier
Engineer	Principal
	MAIG, RPGeo – Geotechnical and Engineering
	Registration No.: 10197

4. REFERENCES:

1. Acid Sulfate Soil Manual, New South Wales Acid Sulfate Soil Management Advisory Committee, August 1998.
2. AS 2159 – Piling – Design and Installation 2009 - Standards Australia

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 1

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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.

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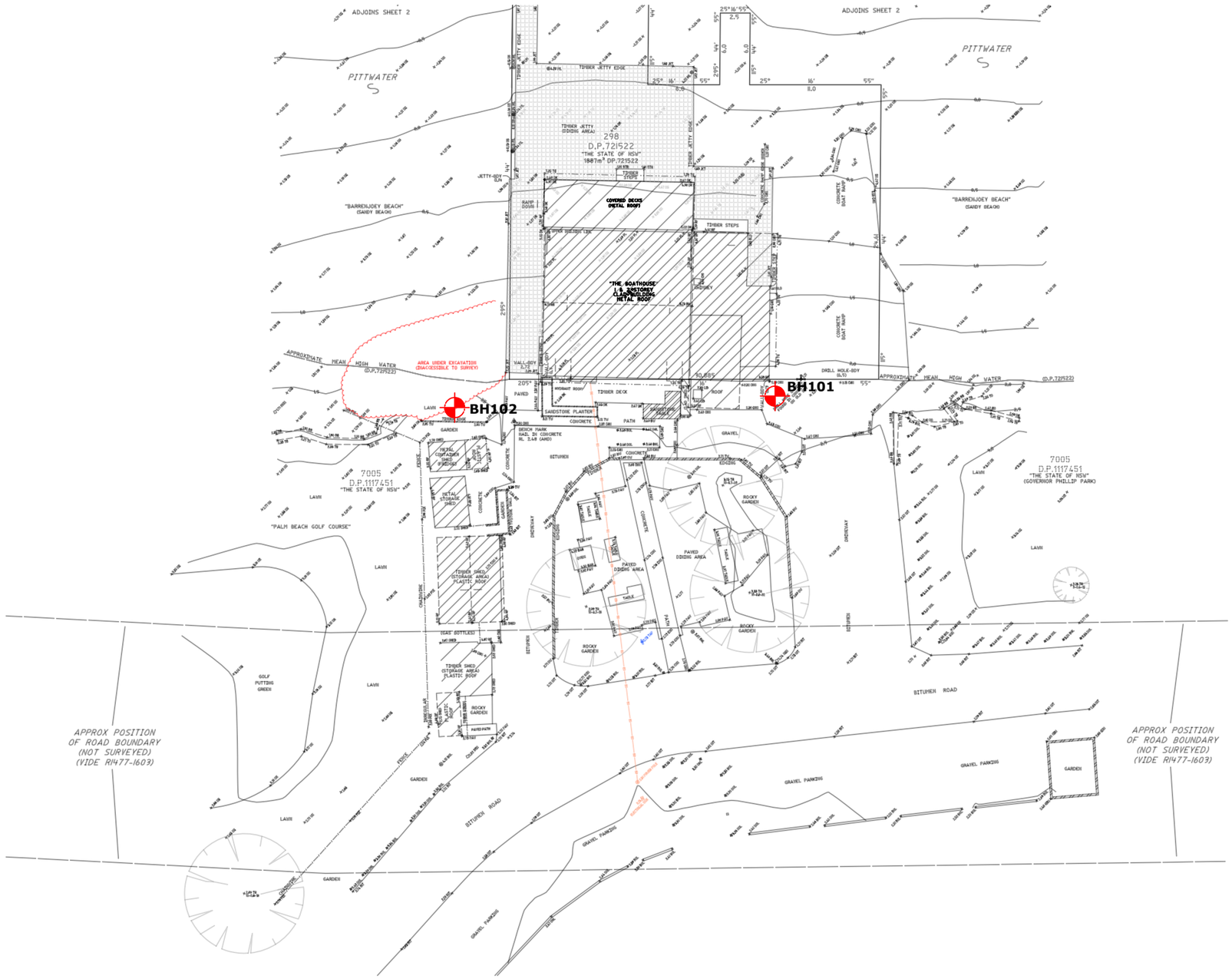
Appendix 2



0 10 20

SCALE: 1:400

SITE PLAN & TEST LOCATIONS FIGURE 1.

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LEGEND

BH BOREHOLE LOCATIONS

SCALE:	1:400
DRAWING:	ML
DATE:	25/09/2020
APPROVED BY:	TMC
DRAWN BY:	ML
PROJECT:	2015-251

PREPARED FOR:
LONDON LAKES PARTNERSHIP

ADDRESS:
'THE BOATHOUSE'
1191 BARRENJOEY ROAD,
PALM BEACH

BOREHOLE LOG

CLIENT: London Lakes Partnership **DATE:** 16/09/2020 **BORE No.:** 101

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

LOCATION: The Boat House, Palm Beach **SURFACE LEVEL:** R.L.= 2.40m

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00						
0.15		GRAVELLY SAND HARDSTAND				
	SM	SAND: Loose, pale brown, fine to medium grained, moist, sand		1.40		
			D	1.50		
			SPT			4,4,5
2.00		é wet (water table), with some fine oyster shells		1.95		N= 9
3.00		é very loose		3.00		
			SPT			0,0,0
				3.45		N= 0
				4.40		
4.50		é loose, becoming medium to coarse grained, orange/brown with some coarser oyster shells	D	4.50		
			SPT			1,2,4
				4.95		N= 6
				5.90		
6.00		... side walls collapsing, casing technique from 6.00m depth	D	6.00		
			SPT (No sample recovered)			1,2,6
6.45				6.45		N= 8
		END OF BOREHOLE at 6.45m on wet sand				

RIG: Multi-purpose CE180 DRILLER: BG Drilling

METHOD: Spiral flight auger with tungsten carbide bit. LOGGED: ML

GROUND WATER OBSERVATIONS: Groundwater table encountered at 2.00m depth

REMARKS: CHECKED: TMC

BOREHOLE LOG

CLIENT: London Lakes Partnership **DATE:** 16/09/2020 **BORE No.:** 102

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

LOCATION: The Boat House, Palm Beach **SURFACE LEVEL:** R.L.= 2.50m

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
0.00			Type	Tests	Type	Results
0.15		GRAVELLY SAND HARDSTAND				
	SM	SAND: Loose, pale brown, fine to medium grained, moist, sand				
				1.50		
			SPT	1.95		3,2,3 N= 5
2.10		é wet (water table), with trace of fine shells				
				2.90		
3.00		é very loose, pale brown/ pale grey	D	3.00		
3.10		é orange/ grey	SPT	3.45		1,1,1 N= 2
				3.90		
			D	4.00		
4.50		é loose, orange/ red, medium to coarse grained with trace of shells (Ø20mm)		4.50		
			D (SPT)	4.95		0,1,2 N= 3
				5.40		
5.50		... side walls collapsing, casing technique from 5.50m depth	D	5.50		
			SPT (No sample recovered)	5.95		6,5,6 N= 11
6.00		é orange/ brown				
				6.50		
			D	6.60		
7.05		END OF BOREHOLE at 7.00m on wet sand				

RIG: Multi-purpose CE180 DRILLER: BG Drilling

METHOD: Spiral flight auger with tungsten carbide bit. LOGGED: ML

GROUND WATER OBSERVATIONS: Groundwater table encountered at 2.10m depth

REMARKS: CHECKED: TMC

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Appendix 3

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
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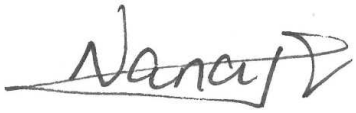

Nancy Zhang, Laboratory Manager

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.