Douglas Partners
Geotechnics / Environment / Groundwater

Report on
Geotechnical Investigation

Dee Why RSL, Proposed Eastern Development
932 Pittwater Road, Dee Why

Prepared for
Dee Why RSL Club

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

	Signature	Date
Author		13/3/2018
Reviewer		13/3/2018

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au
96 Hermitage Road
West Ryde NSW 2114
PO Box 472
West Ryde NSW 1685
Phone (02) 9809 0666
Fax (02) 9809 4095

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1. Introduction

This report presents the results of a geotechnical investigation undertaken at the Dee Why RSL Club, 932 Pittwater Road, Dee Why, for the proposed upgrade of the car park portion of the site.

The revised geotechnical report was commissioned in an email dated 15 February 2018 by Mr Marcel Batrac of Dee Why RSL Club and was undertaken in accordance with Douglas Partners Pty Ltd (DP) proposal SYD161224 (Rev2) dated 9 November 2016 and subsequent modifications to the proposed development. The primary change being a revised basement layout which incorporates split level parking to create a smaller footprint for the excavation and a slightly deeper basement. The changes result in a reduction in the excavation volume of 800 m^3.

The proposed development includes the demolition of part of the existing two-level car park, construction of a new multi-storey split level car park with four-five basement levels (final finished level of circa RL - 6.1 m, relative to the Australian Height Datum – AHD, maximum excavation depth of circa 15.3 m below existing ground level) and two above ground levels of parking, an enlargement of the existing loading dock, a new level of club (restaurants, central bar, coffee and cocktail lounge), plus associated services infrastructure and landscape improvements. The location of the development site area is shown on Drawing 1.

The current investigation included the drilling of four cored boreholes, installation of two new standpipe piezometers, rising head permeability testing in three standpipes, groundwater level measurements and sampling, and laboratory testing of selected soil and rock samples. Details of previous investigations on the site are presented in Section 2 below.

The details of the field work are presented in this report, together with comments relevant to geotechnical design and construction.

Also included as appendices are:

- GHD Pty Ltd (Report Reference 2126065-87884) peer review comments on previous geotechnical report
- Project 84926.03.R.006.Rev4 Geotechnical Investigations - Response to Peer Review, Proposed Eastern Development, 932 Pittwater Road, Dee Why
- Project 84926.03.R.005.Rev3, Report on Preliminary Shoring Wall Analysis Proposed Car Park Eastern Development, Dee Why RSL, 932 Pittwater Road, Dee Why
- Project 84926.03.R.006.Rev4, Groundwater Analysis and Preliminary Modelling, Dee Why RSL Club, Proposed Eastern Development Car Park Upgrade, 932 Pittwater Road, Dee Why
- A total of 57 test locations across the whole of the Dee Why RSL Club site

Architectural drawings prepared by ALTIS Architecture Pty Ltd (Drawing SK167 (Rev C) dated 3 May 2017) for the development application submission.

2. Background

During its history, Douglas Partners Pty Ltd (DP) has previously carried out numerous geotechnical investigations on the site, including:

- cored boreholes drilled for the original RSL Club (Project 4549, dated 1974);
- cone penetration tests (CPTs) and boreholes drilled for the two storey car park (Project 7806, dated 1982);
- cored boreholes and CPTs for the extensions to the RSL Club (Project 29420, dated 2000, and Project 29420A, dated 2001);
- test pits at the proposed site of a basement, for a groundwater assessment (project 84926.00, dated 2015); and
- boreholes for the proposed car park upgrade, including three cored boreholes and the installation of one standpipe piezometer (Project 84926.01, dated 2016).

The results of these tests indicate that the subsurface conditions at the proposed car park site comprise sand filling and sand overlying clay and sandy clay with bedrock at levels ranging from RL1.2 m to greater than RL-11.4 m (refer Drawing 2 for a compilation of test locations and the encountered elevations of the top of rock). Previous groundwater measurements from test pits or during drilling, and from a standpipe piezometer screened within clay and sandstone, indicated the groundwater was generally 2 – 3 m below the ground surface within either filling materials, estuarine or alluvial soils, and followed the sloping topography (RL4 m to RL8 m).

Other investigations completed by DP for the DYRSL Eastern Development site include;

- a preliminary site investigation (PSI: Report 84926.02.R.001.Rev0, dated June 2016);
- a hazardous building materials report (HAZMAT: Report 84926.03.R.001.Rev0, dated November 2016);

The PSI concluded that intrusive investigation was recommended to assess the risk of contamination for the proposed development before the commencement of works, which should include further assessments for waste classification purposes and for the presence and extent of acid sulphate soils.

The following reports were then prepared:

- preliminary waste classification and acid sulfate soil assessment (WC and ASS: Report 84926.03.R.003.Rev4, dated March 2017); and
- acid sulfate soil management plan (ASSMP: Report 84026.04.R001.Rev4, dated March 2017).

3. Site Description

The site currently accommodates an existing two level above ground car park, which is an irregular shape approximately 80 m long and 50 m wide and the porte cochere. The site is bounded by Clarence Avenue to the east, the existing RSL club building to the north with residential properties to the west (Oceangrove) and residential and commercial properties to the south including a childcare. The car park and porte cochere are located to the south east of the main RSL building and is accessed from Clarence Avenue. The car park consists of two levels with the top level being an open deck. The car park slopes gently from south west to north east towards Clarence Avenue and then Dee Why Lagoon.

Reference to the Sydney 1:100 000 Geological Series Sheet (Ref 3) indicates that the site is underlain by Hawkesbury Sandstone, but is close to alluvial deposits associated with the nearby Dee Why Lagoon. The geological map also indicates that there are several igneous dykes in the vicinity of the site.

Hawkesbury Sandstone is generally a medium to coarse grained, massive and cross-bedded quartz sandstone, horizontally bedded and vertically jointed, with minor shale and laminite layers. At this location, the site is inferred to be near the base of the Hawkesbury Sandstone formation, overlying the Narrabeen Group, which tends to be more variable in lithology with interbedded shales, siltstone, claystone and laminate. It is noted, however, that the boreholes drilled during the current phase of investigation (to around RL-9 m) did not encounter rocks belonging to this group.

Reference to the 1:25 000 Acid Sulphate Soil Risk map for Sydney Heads (Ref 5) indicates that the site is located close to an area with a risk for acid sulphate soils (Dee Why Lagoon).

The conditions encountered during the investigation confirmed the presence of Hawkesbury Sandstone.

4. Field Work Methods

The field work for the geotechnical investigation included the drilling of four boreholes (Boreholes 301 to 304) at the locations shown on Drawing 2, in Appendix B.

Due to the low height of the ground level of the car park, each of the boreholes were drilled through the suspended concrete floor slab, from the upper level of the car park, using a bobcat-mounted drilling rig. Borehole surface levels were interpolated from the survey drawing provided, at the positions where each borehole encountered the car park ground level (i.e. the asphalt surface). Upon completion, the concrete cored locations (upper level) were covered with steel plates and affixed to the concrete with “dynabolts”.

Drilling of soils was commenced using solid flight augers, until about 1 m below the observed (drilling) groundwater level. The boreholes were continued using rotary mud flush drilling methods until rock was encountered (at depths of between 7.3 m to 16 m), with standard penetration tests (SPTs) undertaken within the soil at regular intervals. After rock was encountered, each hole was advanced using NMLC-sized diamond core drilling equipment to obtain 50 mm diameter continuous samples of the rock for identification and strength testing purposes. It is noted that sandstone boulders were encountered in Borehole 301 above the top of weathered sandstone bedrock (between 12.2 m to 14.6 m depth). To enable the hole to be advanced to the required depth, this interval was also cored.

Standpipe piezometers were installed in Boreholes 301 and 304 to monitor groundwater levels within either the soil or the rock, and covered at the surface with a gatic cover. Slotted casing was installed between depths of 0.75 m and 18.75 m in Borehole 301 (soil and rock), and between 10.0 m and 18.0 m depth in Borehole 304 (rock only) - refer to borehole logs for further details.

The water levels in Boreholes 301 and 304 were measured and then developed on 21 November 2016, with 380 litres pumped from each standpipe. Borehole 205 was also measured on 11 November 2016 and 22 November 2016. This standpipe, screened within clay and sandstone, ran dry four times, with a total volume of 40 litres pumped out, prior to undertaking a rising head test (without data logger: refer to field notes attached in Appendix C).

Water levels in each of the three standpipes were re-measured on 24 November 2016, with 260 litres and 340 litres pumped from Borehole 301 and Borehole 304 (respectively) to conduct a rising head test using a submersible data logger (refer to rising head test reports in Appendix C). Following the conclusion of drilling, four further measurements of the water levels in the standpipes have been completed.

5. Field Work Results

The subsurface conditions encountered in the bores are presented in the borehole logs in Appendix C. Notes defining descriptive terms and classification methods are also included in Appendix C.

The subsurface profile encountered from ground level in the boreholes can be summarised as:

PAVEMENT:	approximately 300 mm of asphaltic concrete, road base and sand filling material with some gravel and tiles;
FILLING:	sand with crushed sandstone or brick fragments to depths of between 0.85 m to 1.2 m in Boreholes 301 and 302;
SAND, CLAYEY SAND, SANDY CLAY:	interbedded loose, medium dense and dense sands and clayey sands and soft to hard sandy clays to the top of rock. Some organic clay lenses (with sulphurous odour) in Boreholes 301, 303 and 304, with some iron-cemented sandstone boulders in Borehole 301 between 12.2 m and 14.6 m depth (similar in description as those encountered in Borehole 105 within alluvium in 2001, and Borehole 202 within filling in 2016).
SANDSTONE:	comprising generally extremely low strength sandstone at depths ranging between 14.8 m and 15.4 m, in Boreholes 301 and 303 (respectively), increasing to medium strength within 0.6 m to 0.8 m from the rock surface, or medium strength sandstone below silty or sandy clay at depths of 7.3 m and 9.55 m in Boreholes 304 and 302 (respectively).

The elevations of top of rock levels are shown on Drawing 2, for both previous and current investigation locations at the site. Interpolation of rock contours in a previous geotechnical report for the site (Report 29420, dated 2000: not reproduced in this report) indicates that the rock surface beneath the site forms a small, rounded ridge, approximately reflecting the surface topography, but dipping towards the south-east and north-east. This report also indicates that investigation drilling for the existing RSL Club pile locations encountered medium strength sandstone at depths of between 0 m to 5.5 m (average 1.5 m depth), with one pile location borehole drilled to a depth of 9.4 m to find a consistent band of medium strength rock more than 1 m thick. Weathered seams or clay bands were also observed to occur within the medium strength sandstone.

Four cross-sections along the boundaries of the car park site are presented as Drawings 3 to 6 in Appendix B, and include some of the data from the previous borehole, CPT and Dutch Cone testing.

Table 1 summarises the levels at which different materials were encountered in the 2016 boreholes (includes those from Report 84926.01, with amended ground surface levels using the latest provided survey plan from LTS Lockley Survey, 43018DT, dated 24/3/2016). Reference to Drawing 2 should be made for the location of these investigations. The borehole logs and core photographs from the previous report are also included in Appendix C.

Groundwater level observations from standpipe piezometers are summarised in Table 2. It is noted that the standpipe piezometer screened wholly within the low and medium strength rock (Borehole 304) indicates a groundwater level of 3 m compared with the level encountered during drilling (RL5.6 m).

The results of the rising head permeability testing indicated hydraulic conductivities for the clay and weathered rock (Borehole 205) of 1.1 x 10^{-6} m/sec, the sandy alluvium (Borehole 301) of 4.3 x 10^{-6} m/sec, and the low and medium strength sandstone (Borehole 304) of 1.0 x 10^{-6} m/sec. The test results are presented in Appendix C.

Free groundwater was observed in all recent boreholes during drilling (i.e. Borehole 301) at depths of between 1.5 m and 3.3 m below ground level (RL5.6 m to RL8.4 m).

Table 1: Summary of Material Strata Levels, and Groundwater Observations during Drilling

Stratum	Level of Top of Stratum in borehole (m, AHD)								
	201	202	203	204	205	301	302	303	304
Ground Surface/ Filling / Pavement	9.4	9.8	9.4	8.6	9.2	9.7	9.3	9.0	8.9
Sandy Clay – very soft	NE	NE	8.8	8.0	NE	NE	NE	8.7	8.5
Sand and clayey sand – loose, medium dense and dense	7.0	NE	8.2	6.8	8.7	8.9	8.1	5.3	7.8
Clay and sandy clay – stiff, very stiff and hard	6.7	NE	NE	NE	4.3	2.7^	2.8	-1.7	5.4
Sandstone	-8.3	9.2*	5.6	-1.6	1.1	-5.7	-0.3	-5.8	1.6
Medium Strength Sandstone	-9.7	NE	0.8	NE	1.0	-6.3	-0.3	-6.5	1.6
Groundwater during drilling	7.2	NE	7.2	6.3	6.9	8.4	8.0	7.3	5.6

Notes: * Considered to be a boulder within filling; NE = not encountered; ^ = includes sandstone boulders

Table 2: Groundwater Observations

Bore No	SL	Screen interval (m RL)	Standing Water Level Measurements (m RL)						
			11/11/16	21/11/16	24/11/16	23/12/16	10/1/17	23/1/17	10/2/17
205	9.2	3.2 to -0.2	8.1	8.0*	7.9	8.0	7.9	7.8	8.0
301	9.7	8.95 to -9.1	-	8.5	8.5	8.4	8.3	8.2	8.5
304	8.9	-1.1 to -9.1	-	7.8	8.6	8.4	8.3	8.1	8.1

Notes: SL = Surface elevation (in RL), * = observations made on 22/11/2016; purging of groundwater from the standpipes occurred on 21/11/2016 and 22/11/2016; elevations are relative to the Australian Height Datum.

6. Laboratory Testing

Twenty-nine samples selected from the better quality rock core were tested for axial point load strength index ($Is_{(50)}$). The results ranged from 0.1 MPa to 1.2 MPa which corresponds to very low to medium strength rock, respectively. These $Is_{(50)}$ results suggest an unconfined compressive strength (UCS) in excess of 20 MPa for the medium strength rock encountered during the investigation.

Sixty seven (67) soil samples were selected following drilling for analysis at a chemical testing laboratory, as follows:

- four samples tested for pH, sulphate and chloride concentration, and electrical conductivity, to indicate soil aggressiveness to buried concrete and steel elements;
- three samples tested for chromium reducible sulfur and the acid base accounting analysis suite; and
- 60 samples tested for soil pH (as both a soil:water mixture and in potassium chloride ((pH$_{KCl}$”)) and following reaction with hydrogen peroxide (“pH$_{Fox}$”), to indicate actual and potential acid sulphate soil conditions.

The results of the soil aggressiveness testing are presented in Table 3, and the laboratory test results are presented in Appendix D. Presentation and assessment of the testing for acid sulphate soils, and contaminant testing for a preliminary waste classification, is presented under separate cover, however, it is noted that only a few of the soil pH results were less than 4.5, a value which is usually taken to indicate a “severe” exposure classification for buried concrete.

Table 3: Laboratory Test Results for Soil Aggressiveness to Buried Concrete and Steel

Borehole ID	Sample Depth (m)	Material Type	pH	Chloride (mg/kg)	Sulphate (mg/kg)	EC (µS/cm)
BH301	2.7 - 2.95	Sandy clay, grey (alluvium)	5.4	<10	10	27
BH302	4.5 - 4.95	Clayey sand, light grey (alluvium)	5.1	<10	20	31
BH303	6.5 - 6.95	Sand, brown-grey (alluvium)	5.6	<10	<10	14
BH304	6.0 - 6.45	Silty Clay, light grey (alluvium)	6.0	10	<10	15

Note: Each analyte was tested as a 1:5 mixture of soil:water

In accordance with AS 2159-2009, the results of the chemical lab testing indicate that the samples tested from Boreholes 301 and 302 are moderately aggressive to buried concrete and non-aggressive to buried steel, whilst the samples tested from Boreholes 303 and 304 are non-aggressive to buried concrete and steel.

7. Geotechnical Model

The geotechnical model for the site is characterised by a shallow thickness of filling, thicker in the south-east of the site, overlying very soft to soft, estuarine silty clay or sandy clay with organic matter in the eastern and north-eastern part of the site (absent, up to 3.4 m thick in Borehole 303), over loose to dense alluvial sand and clayey sand, and then stiff to hard alluvial clay and sandy clay overlying a sandstone profile which has an apparent slope to the east. The sandstone is initially extremely weathered and extremely low to very low strength, rapidly becoming slightly weathered to fresh and medium or high strength. The geotechnical model for the site is presented as four cross sections in Appendix B: Section A-A’ to Section D-D’, Drawings 3 to 6.

The alignment of each cross-section has been selected to be parallel to the proposed excavation boundaries. It is noted that the profiles are accurate at the borehole locations only, and that geological interpretation between the boreholes could vary from that shown on the cross-sections. Note, the strata units or layers have been shown on the cross-sections as inferred strata boundaries only.

8. Proposed Development

The proposed development includes the demolition of part of the existing two-level car park, construction of a new multi-storey split level car park with four-five basement levels (final finished level of circa RL - 6.1 m, relative to the Australian Height Datum – AHD, maximum excavation depth of circa 15.3 m below existing ground level) and two above ground levels of parking, an enlargement of the existing loading dock, a new level of club (restaurants, central bar, coffee and cocktail lounge), plus associated services infrastructure and landscape improvements.

Column loads for the building were not provided at the time of reporting.

The geotechnical issues considered relevant to the proposed development include excavation, excavation support, groundwater, foundations and earthquake provisions.

9. Comments

9.1 Groundwater

During the current investigation, groundwater levels observed during drilling were between 1.7 m and 3.3 m below the ground surface. These levels are similar to those observed during drilling of boreholes earlier in the year 2016 (2.2 m to 2.3 m, Borehole 201 and Boreholes 203 to 205: refer Table 1), and at similar depths to the groundwater level measurements at the northern end of the RSL site in the year 2000 (DP report 29420).

The volumes of water extracted from the standpipe piezometers screened within the alluvium, and the observed rapid rate of recharge, indicate an unconfined aquifer with a steady state piezometric surface of around RL 8.5 m. The standpipe piezometer screened wholly within the sandstone (Borehole 304) also had a relatively rapid recharge rate and high available quantity of water, with an apparent steady state piezometric surface of around RL 8.1 m.

The level in Borehole 304 indicates the sandstone is a potentially confined, relatively permeable aquifer, with groundwater pressures similar to the overlying sandy alluvium. Consequently, a water-tight or 'tanked' basement will be required for the full height of the excavation (about 15.3 m depth), in both soil and rock.

In accordance with the provided survey plan, ground surface levels within the site vary between RL8.15 m and RL10.02 m. On the basis of the measured water levels and allowing for increases in water levels due to heavy rainfall, flooding and construction of new basements, it is recommended that a design groundwater level for the site of RL8.15 m be adopted.

Preliminary analysis of inflow rates during construction has been carried out with the results presented in a separate report in Appendix G.

9.2 Excavations

Excavation is expected within filling and sandy and clayey soils for most of the basement. Excavation of these materials should be readily achieved using conventional earthmoving equipment such as excavator with bucket attachment. Interstitial water within the dewatered soils suggest some form of management, such as placement of a bridging layer or working platform may be required for constructability purposes.

In the north-western and central areas of the basement excavation, the boreholes indicate that sandstone up to medium strength will be encountered above the proposed basement finished level (RL -6.1 m). Excavation in low strength and stronger rock will probably require the use of ripping equipment, rock saws or rock hammers. Rock saws should be used on the boundaries to minimise over break.

In the north and east of the site, alluvial and possibly residual clay will be exposed. Placement of a granular working platform is likely to be required to keep this material trafficable by construction plant.

It should be noted that any off-site disposal of material will require assessment for re-use or classification of the soil in accordance with *Environmental Guidelines: Assessment, Classification and Management of Non-Liquid Wastes* (NSW EPA, 2014: Reference 4), prior to disposal to an appropriately licensed landfill. Any acid sulphate soils identified on the site will need to be treated and then disposed of to a licensed landfill facility. These issues are further discussed in a preliminary waste classification report, and acid sulphate soil management plan (ASSMP), under separate covers.

9.3 Vibration Control

Noise and vibration will be caused by excavation work on the site. The use of rock hammers will need to be controlled and monitored to ensure no damage is caused to nearby structures and that disturbance to occupants is minimised. Measures to control vibration include:

- the size of and frequency at which they operate;
- trialling of equipment to develop appropriate hammering techniques;
- monitoring of construction operations with vibration monitors

It is suggested that vibrations be provisionally limited to a peak particle velocity (PPV) of 8 mm/s at the foundation level of the adjacent buildings to protect their architectural features and to reduce discomfort for the occupants. This level complies with AS/ISO 2631.2 – 2014 (Reference 2) and is well below the normal building damage threshold level. The owners of any in-ground utilities on and around the property should also be consulted in regards to vibration levels.

It is also recommended that dilapidation surveys be carried out on adjacent properties including structures, pathways, walls or roadways within about 30 m of the proposed excavation, prior to commencement of the works. The dilapidation survey should document existing conditions and the presence of defects and thereby allow appropriate responses should any claims arise from construction at this site.

9.4 Acid Sulphate Soils

Reference to the Acid Sulphate Soil Risk Map for Sydney Heads, prepared by the former Department of Land and Water Conservation, indicates that the site is located within an area designated as “No known occurrence”. However, the map also indicates that there is a high probability of acid sulphate soils located in the vicinity of Dee Why Lagoon, with its nearest designated areas located about 100 m to the north-east of the site, and 4 m lower.

An acid sulfate soil assessment has been carried out for the site (Project 84926.03.R003 dated March 2017) indicating that acid sulfate soils are present on the site and will require management if more than 1000 tonnes are disturbed.

An acid sulfate soil management plan (ASSMP: Project 84026.04.R001.Rev4, dated March 2017) has been prepared, setting out how to manage the ASS soils excavated.

9.5 Excavation Support

9.5.1 General

The excavation will need to be supported by basement walls that are keyed into the rock to isolate the basement from the surrounding groundwater. Embedment of approximately 1 m into rock of at least medium strength is recommended. This requires construction of vertical, continuous water-tight 'cut-off' walls to depths in excess of 22 m (pile toe depths in the range RL5.8 m to RL-12.4 m). Care will be required in the south-western corner, where boulders were encountered above the rock. Suitable wall types include, but are not limited to:

- Diaphragm walls or similar methods with tight construction controls on verticality and watertightness, constructed using a clam shell bucket to excavate the material and bentonite slurry to temporarily support the side walls until a steel reinforcement cage and concrete is placed, is preferred where the basement is greater than 2 levels in depth;
- Secant pile wall (typically limited to 2 levels in depth), which is constructed using 'hard' and 'soft' flight auger piles where each successive hard pile cut into the soft grout previously drilled. These are normally drilled through a top template to guide the piles and therefore reduce the incidence of misalignment. Alternatively, segmentally cased auger piles could be used to increase uniformity and ensure verticality. However, at depths of 8 m (2 levels) there can still be gaps in the piles near the bottom, which will need to be repaired with grout to provide a fully water-tight structure, which is difficult to do.

Non-watertight methods of shoring (e.g. contiguous piles) will not form a sufficient cut-off and are therefore not suitable for the proposed development, unless they are used in conjunction with jet grouting.

Lateral support will need to be provided by means of temporary ground anchors. If temporary anchors are used they will only be necessary until the basement slabs and ground floor slabs provide internal support for the walls. The toe of the piles will need to be anchored if they are above the base of the excavation.

The medium strength rock is considered to be self-supporting, however inspection of the excavation faces should be undertaken in maximum 1.5 m or 2.0 m 'drops' as excavation proceeds, to identify adverse defects which may require additional stabilisation measures (e.g. rock bolts).

It is understood from the project's structural engineer that the Oceangrove Retirement Village and the RSL Club buildings are supported on piles founded in medium strength rock, and that the Childcare Centre is supported on steel screw piles, 6 m in length and with termination levels of around RL4 m.

A summary of suitable cut-off wall types, and their advantage and disadvantages, is presented in Table 4.

Table 4: Cut-off Wall Types

Wall Type	Advantages	Disadvantages
Diaphragm Wall	• Good technical solution • Watertight and can support the structure • Can use precast panels • Several contractors can install, but they need to be specialists with local experience	• Expensive • Can be messy on site due to bentonite and concrete spillage • Close construction supervision needed
Secant pile wall	• Cheaper than diaphragm wall • Can be watertight if constructed properly • Several contractors can install them • Verticality can be improved by using guide template, or segmental casing • Production increased by using double auger system	• Difficulty in maintaining verticality • Often leak water due to misalignment • May need to grout behind wall • More care needed in set-up than CFA piles

The tabulated list above is not exhaustive. Support for deep excavations that need to be water-tight is a specialist construction procedure, therefore it would be prudent to seek advice from piling contractors (such as Vibropile, Bachy or Keller) in developing the concept design and preliminary costing.

9.5.2 Earth Pressures

The basement wall will be subject to earth pressures from the ground surface down to the top of medium strength rock. Table 5 outlines material and strength parameters that could be used for design of the excavation support structure.

The lateral earth pressure distribution for a wall with multiple rows of lateral support is complex. For preliminary design purposes, the magnitude of lateral earth pressure acting on perimeter shoring walls may be approximated as a uniform rectangular pressure of 4H (kPa) (or 8H (kPa) for sensitive structures), where H is the height of the retained material down to the top of rock, in metres. Detailed design should ideally be undertaken using a computer program such as WALLAP, FLAC or PLAXIS to model soil-structure interactions and refine the preliminary design.

Surcharge pressures from adjacent structures, construction machinery and traffic should also be incorporated into the detailed design of the wall, as necessary.

Table 5: Material and Strength Parameters for Preliminary Design Purposes

Material	**Dry Unit Weight (kN/m^3)**	**Saturated Unit Weight (kN/m^3)**	**Coefficient of Active Earth Pressure (K_a)**	**Coefficient of Earth Pressure at Rest (K_o)**	**Passive Earth Pressure***
Filling	20	10	0.40	0.60	N/A
L to md Sand	20	10	0.35	0.53	K_p = 2.5
st-vst Clay	20	10	0.30	0.45	100 kPa
ELS Sandstone	22	12	0.1	0.15	250 kPa

Notes: L = loose; vl = very loose; md = medium dense; st = stiff, vst = very stiff; ELS = Extremely Low Strength

* Ultimate values and only below bulk excavation level

Preliminary modelling of wall deflections using WALLAP has been prepared under separate cover (DP Report 84926.03.R.005.Rev2) and included in Appendix F, to indicate the order of magnitude of deflection of the walls, based on assumed parameters and anchor arrangements. The lateral deflections calculated in this analysis are in the order of 10 mm at the top of the wall, with lateral deflections anticipated to decrease with increasing distance from the back of the wall. It is noted that the three structures piled to rock are positioned up to approximately 4 m from the back of the wall, therefore minimal impact to these structures is to be expected. More detailed assessment of these impacts will be completed in conjunction with the wall design, and as part of this process lateral movements are to be minimised.

The preliminary number and extent of anchors included in the WALLAP analysis report may change depending on the final wall design.

9.5.3 Temporary Ground Anchors

Structures adjoining or near to the proposed basement excavation, including the Oceangrove retirement village (west of the proposed excavation), the RSL Club buildings (north of the proposed excavation) and the existing two storey carpark, are considered to be within the excavation's "zone of influence", as are services within Clarence Avenue. The childcare centre at No. 2 Clarence Avenue (south of the proposed excavation) is considered to outside the zone of influence of the excavation. The basement walls will need to be temporarily restrained to minimise ground movements within the zone of influence.

Inclined tie-back (ground) anchors could be used for the temporary lateral restraint of the basement walls. The ground anchors should be inclined below the horizontal to allow anchorage into the denser materials. The preliminary design of temporary ground anchors may be carried out using the ultimate average bond stresses at the grout-soil interface given in Table 6.

Table 6: Ultimate Bond Stresses for Preliminary Anchor Design

Material Description	Ultimate Bond Stress (kPa)
Loose to medium dense Sands	25
Stiff to very stiff Clays	40
Extremely low strength and very low strength Sandstone	100
Low strength and medium strength Sandstone	300

Ground anchors should be designed to have an appropriate free length (minimum of 3 m) and have a minimum 3 m bond length. After installation they should be proof loaded to 125% of the design working load and locked-off at no higher than 80% of the working load. Periodic checks should be carried out during the construction phase to ensure that the lock-off load is maintained and not lost due to creep effects or other causes.

The parameters given in Table 6 assume that the anchor holes are clean, with grouting and other installation procedures carried out carefully and in accordance with good anchoring practice. Careful installation and close supervision by a geotechnical specialist may allow increased bond stresses to be adopted during construction, subject to testing.

It will be necessary to obtain permission from neighbouring landowners prior to installing anchors that will extend beyond the perimeter of the site. In addition, care should be taken to avoid damaging buried services and pipes, or drilling through foundation piles during anchor installation.

Assuming that the car park structure will have an insufficient mass to counteract the buoyancy effects, temporary and/or permanent uplift support, in the form of vertically oriented permanent anchors (bar anchors preferred) and / or tension piles, could also be designed using the parameters shown in Table 6. The designer should check the cone-pull-out failure mechanism by assuming a 45 degree cone for the rock underlying the site. Only experienced contractors should be engaged to install anchors, because anchors in sand often “slip” a little, resulting in some wall movement. Care should also be taken with corrosion protection for permanent anchors.

9.6 Dewatering

It will be necessary to construct a cut-off wall around the perimeter of the proposed basement prior to dewatering and excavation, to reduce the risk associated with lowering of the water table on adjacent sites. Lowering of the water table can increase the risk of damage to adjoining structures. Diaphragm walls or secant piles keyed into the rock identified in the boreholes should be suitable for ‘cutting off’ the basement from the surrounding groundwater (refer Table 4).

The cut-off walls should prevent the need for continuous large-volume dewatering during construction, and the tanked basement will prevent the need for constant dewatering over the long-term. Temporary dewatering within the cut-off wall, via ‘spear points’, or wells installed within the excavation to below the bulk excavation level, will be required to keep the water level at least 1 m below the exposed excavation surface and to provide access to construct a suitable working platform. It is anticipated that the cut-off walls will limit the dewatering effects on adjacent properties (such as the

Oceangrove Retirement Village and the Childcare Centre), and hence little to no impact on these properties is expected due to dewatering-induced settlement.

The volume of water entering the excavation through the rock should reduce over time, and leaks through the wall are expected to be relatively slow. Alternatively, vertical support to resist uplift (buoyancy) pressures will be required until permanent structures are installed.

Dewatering will need to be continued until such a time as sufficient uplift resistance for the tanked basement is provided. The design groundwater uplift should be calculated taking into account the potential groundwater level rises as discussed above. This uplift resistance may be resisted by the weight of the building, friction piles, ground anchors, or any combination. In normal circumstances, the weight of the finished structure is used to resist uplift in the long-term, therefore temporary dewatering needs to continue until the dead load of the structure is sufficient to restrain the structure from upward movement.

Extending the cut-off wall to the medium strength rock, such as to RL -10 m in the south-east corner (refer Drawings 3 and 6), should result in an adequate factor of safety against piping under normal groundwater conditions, however, if the groundwater levels outside the basement area rise significantly during a flood event, then the factor of safety will reduce. During the final design process, a formal analysis of up-flow velocities and piping should be carried out to ensure that piping will not occur during construction.

Preliminary groundwater modelling to indicate groundwater inflow volumes to the excavation has been prepared under separate cover (DP Report 84926.03.R.006.Rev2, dated March 2017) and is included in Appendix G.

The likelihood of dewatering within the basement footprint resulting in acid conditions, as a result of the oxidation of any potential or actual acid sulphate soils, has been assessed under separate cover (DP Report 84926.03.R.003.Rev2, dated March 2017) and included with the development application.

The indicated slightly acidic soil conditions may impact upon the integrity of the structural concrete elements in contact with the soil, and appropriate measures should be made to ensure concrete integrity.

9.7 Foundations

At basement excavation level, it is expected that the exposed material could comprise sandstone in the north-western and central sections, and clays and sandy clays over the other parts of the site. Some areas of sandstone boulders are also indicated in the south-eastern part of the site. It is considered good practice to found on a uniform bearing stratum and it is therefore suggested that the building is founded on medium strength, sandstone bedrock.

Where rock is exposed at or close to the bulk excavation level, shallow spread footings will be appropriate. Elsewhere, it is considered that the loads should be transferred into the underlying bedrock by the use of piles. Conventional bored piers, possibly with temporary casing, or continuous flight auger (CFA) piles are likely to be the most suitable pile types for supporting the proposed structure. CFA piles are constructed by inserting a hollow stem auger into the ground to the nominated depth. Concrete or grout is then injected through the stem of the augers as the auger is withdrawn. A column of concrete or grout is then formed upon completion of the auger withdrawal, when a steel reinforcement cage can be lowered into the grout column to complete the pile.

Bored or CFA piles could be designed using the parameters provided in Table 7.

Table 7: Design Parameters for CFA Piles

Material Description	Allowable End-Bearing Pressure (kPa)	Allowable Shaft Adhesion (kPa)*	Ultimate End-Bearing Pressure (kPa)	Ultimate Shaft Adhesion (kPa)*	Young's Modulus, E (MPa)
ELS to VLS Sandstone	1,000	100	3,000	200	100
LS to MS Sandstone	3,500	350	20,000	1,000	500

Notes: ELS = extremely low strength; VLS = very low strength; LS = low strength; MS = medium strength *Reduce by 50% for uplift loads and ensure cone-pull-out criteria are met.

It should be noted that the serviceability limit-state is likely to govern the design of the piles, and the ultimate bearing pressures provided in Table 7 are unlikely to be the worst case. An appropriate geotechnical strength reduction factor should be applied when using the limit-state approach as outlined in AS 2159 – 2009 *Piling – Design and installation*.

Soil decompression can occur during CFA piling, when a strong stratum is encountered. This occurs when the augers continue to rotate but the rate of auger progression decreases, displacing soil from around the auger upwards towards the surface. Decompression can cause weakening and settlement of the soils adjacent to the pile and should be avoided by monitoring auger speed and progression closely.

Temporary casing for bored piers may be required to control water inflow and support the walls of the pile holes. It should be noted that a high torque will be required to penetrate boulders (near the south western corner) and to construct the socket in high strength rock.

9.8 Seismic Design

In accordance with the Earthquake Loading Standard, AS 1170.4 – 2007 (Reference 1), the site has a hazard factor (z) of 0.08 and, given that part of the basement is to be within rock, and assuming that all major structural loads are carried to rock of at least extremely low strength, a site sub-soil class of rock (B_e) is considered appropriate.

10. References

1. Australian Standard AS 1170.4 – 2007, “Structural design actions, Part 4: Earthquake actions in Australia”.
2. Australian / International Standard AS/ISO 2631.2 – 2014, “Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Vibration in buildings (1 Hz to 80 Hz)”.
3. Herbert C., 1983, Sydney 1:100 000 Geological Sheet 9130, 1st edition. Geological Survey of New South Wales, Sydney.
4. NSW Environment Protection Authority (EPA), 2014. “Environmental Guidelines: Assessment, Classification and Management of Non-Liquid Wastes”.
5. The Department of Land and Water Conservation, 1995. 1:25 000 Acid Sulphate Soil Risk map for Sydney Heads.

11. Limitations

Douglas Partners (DP) has prepared this revised report for this updated project in accordance with in an email dated 15 February 2018 from Mr Marcel Batrac of Dee Why RSL Club and in accordance with DP’s revised proposal SYD161224 (Rev2) dated 9 November 2016, and amended Consultant Agreement dated 18 November 2016. The work was carried out under an amended Dee Why RSL Club Ltd Consultant Agreement, dated 18 November 2016. This report is provided for the exclusive use of the Dee Why RSL Club for this project only and for the purposes as described in the report. It should not be used for other projects or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

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

The scope for work for this investigation included the assessment of sub-surface materials and groundwater for contaminants, which is being reported under separate cover. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

Asbestos has not been detected by observation or by laboratory analysis, either on the surface of the site, or in filling materials at the test locations sampled and analysed. Building demolition materials, such as concrete, brick and tile, were, however, located in previous below-ground filling, and these are considered as indicative of the possible presence of hazardous building materials (HBM), including asbestos.

Although the sampling plan adopted for this investigation is considered appropriate to achieve the stated project objectives, there are necessarily parts of the site that have not been sampled and analysed. This is either due to undetected variations in ground conditions or to budget constraints (as discussed above), or to parts of the site being inaccessible and not available for sampling. It is therefore considered possible that HBM, including asbestos, may be present in unobserved or untested parts of the site, between and beyond sampling locations, and hence no warranty can be given that asbestos is not present.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

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

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

Copyright

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

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

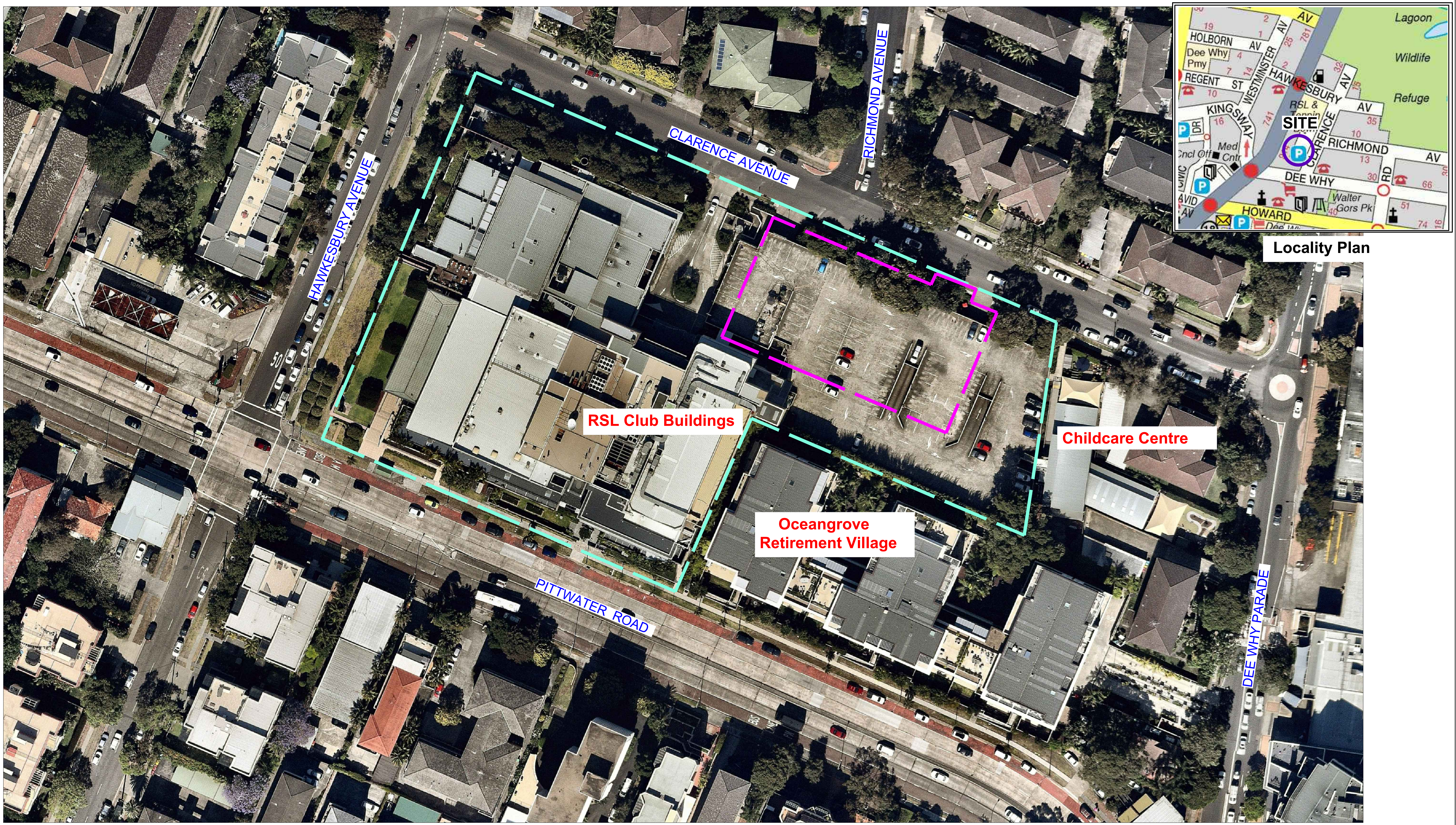
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate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

Site Inspection

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

Appendix B

Drawings



LEGEND

🟩 Dee Why RSL site

🟪 Car park development area (Refer Altis Architecture Drawing SK168, Issue C (Draft), dated May 2017

NOTE:
1: Base image from Nearmap.com
(Nov.2016)

0 10 20 30 40 50 75 100m
1:1000 @ A3

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Dee Why RSL Club		TITLE: **Site Plan** **Dee Why RSL Car Park** **932 Pittwater Road, DEE WHY**	PROJECT No: 84926.03
OFFICE: Sydney	DRAWN BY: PSCH		DRAWING No: 1
SCALE: 1:1000 @ A3	DATE: 2.03.2018		REVISION: 3

NOTE:
1: Base image from Nearmap.com (Nov.2016)
2: Test locations are approximate only and are shown with reference to existing features, and from previous DP report 29420, year 2000)

0 10 20 30 40 50 75 100m

1:1000 @ A3

LEGEND

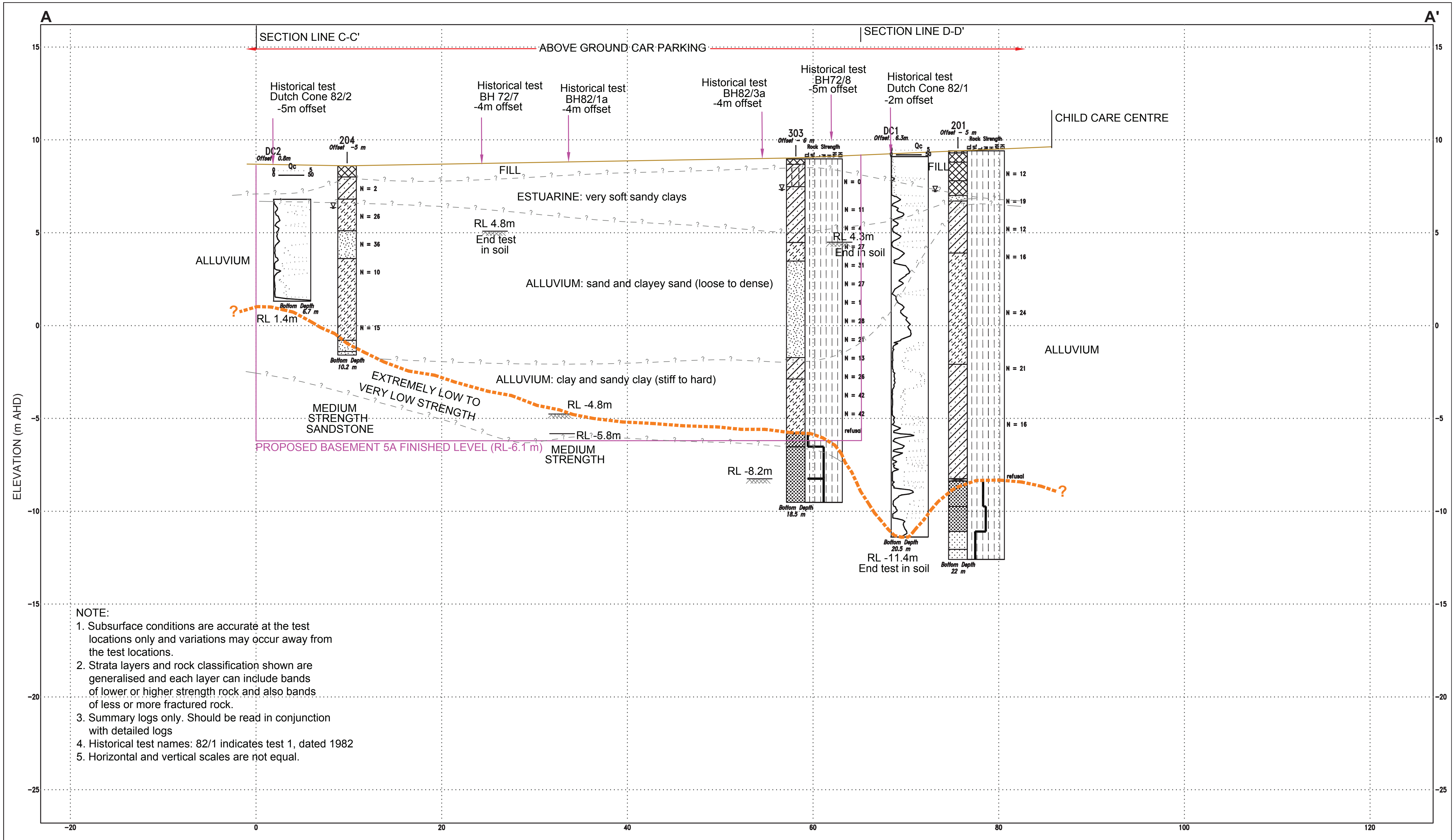
- Borehole (current report, year 2016)
- Borehole (DP Report 84926.01, year 2016)
- Cone penetrometer test (DP report 29420, year 2000)
- Cone penetrometer test location, and other test sites (refer DP report 7806 and 29420)
- Borehole (DP report 29420B, year 2001)
- Test pit (DP report 84926.00, year 2015)
- P Standpipe piezometer
- *-2.8* Elevation of top of rock (metres RL)
- A A' Geotechnical Cross-section

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Dee Why RSL Club		
OFFICE: Sydney	DRAWN BY: PSCH	
SCALE: 1:1000 @ A3	DATE: 2.03.2018	

TITLE: **Geotechnical Test Location Plan**
Dee Why RSL Car Park
932 Pittwater Road, DEE WHY

PROJECT No:	84926.03
DRAWING No:	2
REVISION:	2



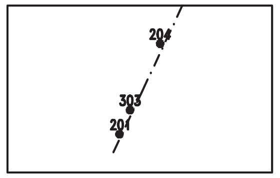
NOTE:
1. Subsurface conditions are accurate at the test locations only and variations may occur away from the test locations.
2. Strata layers and rock classification shown are generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs
4. Historical test names: 82/1 indicates test 1, dated 1982
5. Horizontal and vertical scales are not equal.

LEGEND

☒	Core Loss	⬚	Sand	▨	Silty Clay
■	Asphaltic Concrete	▩	Sandstone coarse grained		
▨	Clayey Sand	⬚	Sandstone fine grained		
▩	Filling	▨	Sandy Clay		

TESTS / OTHER
N - Standard penetration test value
▽ - Water level

SITE MAP



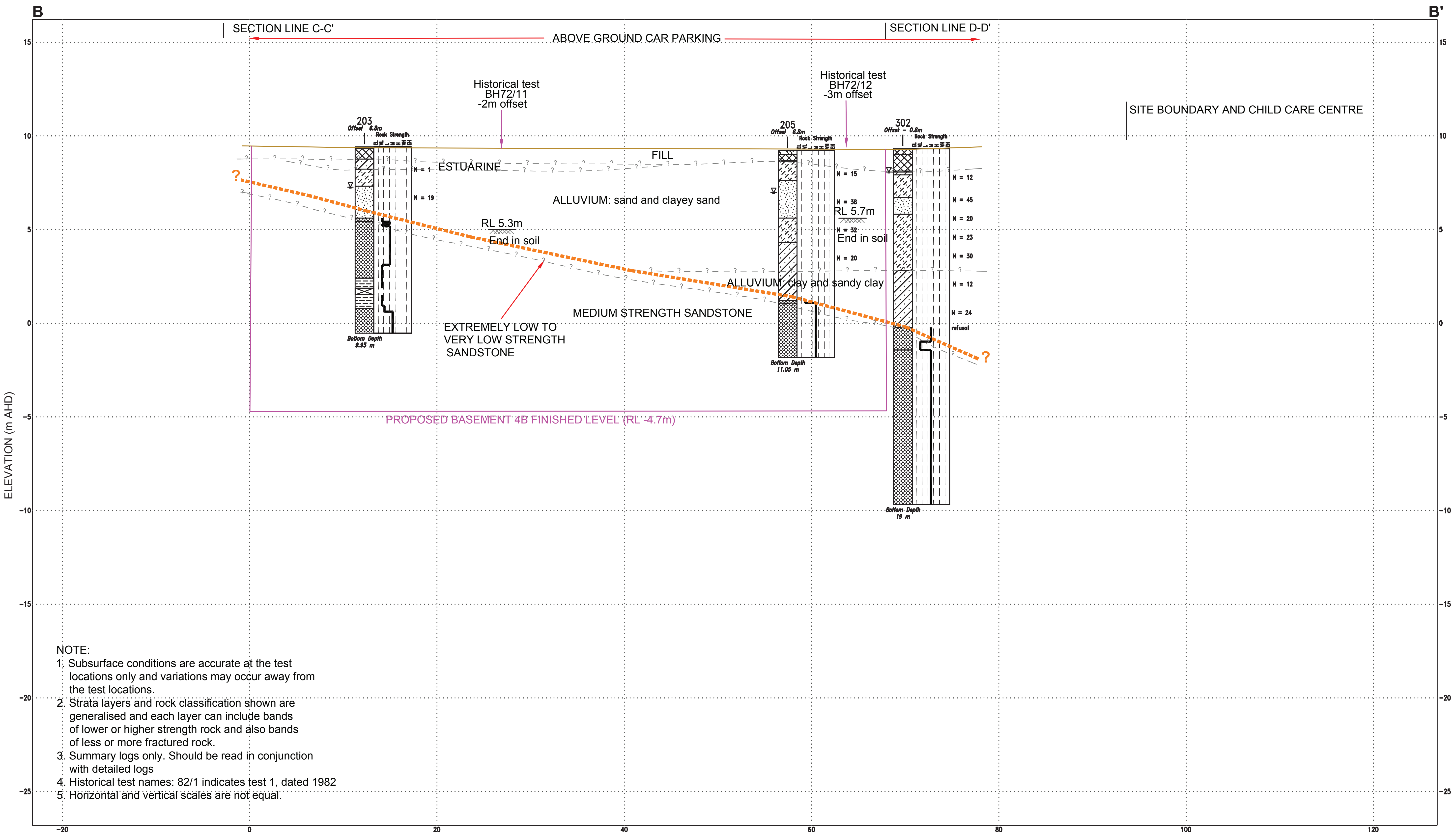
Horizontal Scale (metres)
Vertical Exaggeration = 2.0

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Dee Why RSL
OFFICE: Sydney
DRAWN BY: HDS
SCALE: 1:400 (H) 1:200 (V) @ A3
DATE: 9.03.2018

TITLE: **Geotechnical Cross-Section A-A'**
Proposed Car Park Upgrade
932 Pittwater Road, Dee Why

PROJECT No: 84926.03
DRAWING No: 3
REVISION: 4



NOTE:

1. Subsurface conditions are accurate at the test locations only and variations may occur away from the test locations.
2. Strata layers and rock classification shown are generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs
4. Historical test names: 82/1 indicates test 1, dated 1982
5. Horizontal and vertical scales are not equal.

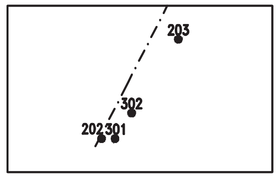
LEGEND

- ☒ Core Loss
- ■ Asphaltic Concrete
- ▨ Clayey Sand
- ▨ Cobbles and Boulders
- ▨ Filling
- ▨ Roadbase
- ▨ Sand
- ▨ Sandstone coarse grained
- ▨ Sandy Clay
- ▨ Shale

TESTS / OTHER

N - Standard penetration test value
∇ - Water level

SITE MAP

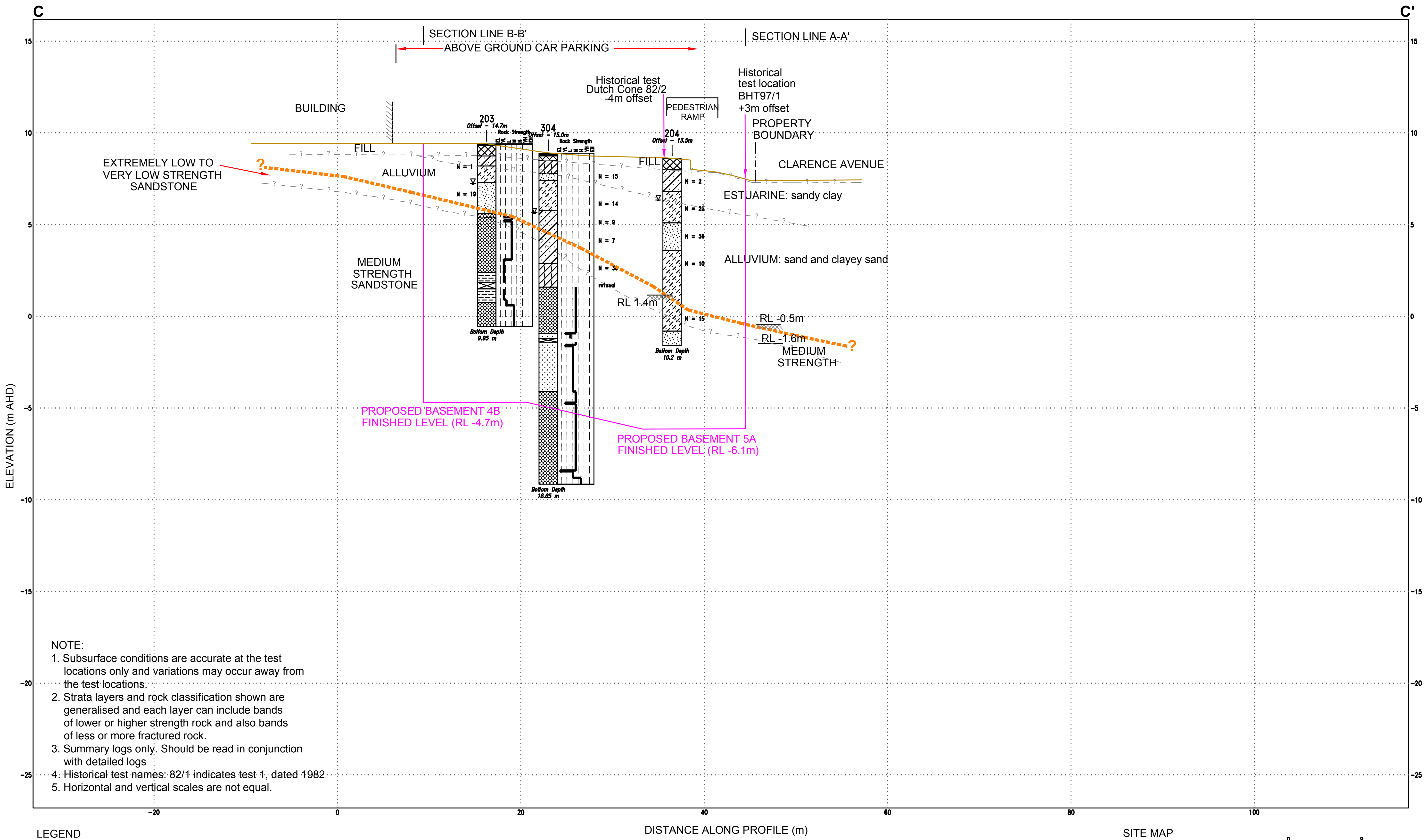


0 8

Horizontal Scale (metres)
Vertical Exaggeration = 2.0

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Dee Why RSL		TITLE: **Geotechnical Cross-Section B-B'** **Proposed Car Park Upgrade** **932 Pittwater Road, Dee Why**	PROJECT No: 84926.03
OFFICE: Sydney	DRAWN BY: HDS		DRAWING No: 4
SCALE: 1:400 (H) 1:200 (V) @ A3	DATE: 9.03.2018		REVISION: 4



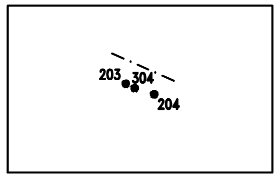
NOTE:
1. Subsurface conditions are accurate at the test locations only and variations may occur away from the test locations.
2. Strata layers and rock classification shown are generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs
4. Historical test names: 82/1 indicates test 1, dated 1982
5. Horizontal and vertical scales are not equal.

LEGEND

☒	Core Loss	▨	Sand	▤	Shale
■	Asphaltic Concrete	▩	Sandstone coarse grained	▧	Silty Clay
▨	Clayey Sand	▨	Sandstone fine grained		
▩	Filling	▧	Sandy Clay		

TESTS / OTHER
N - Standard penetration test value
▽ - Water level

SITE MAP



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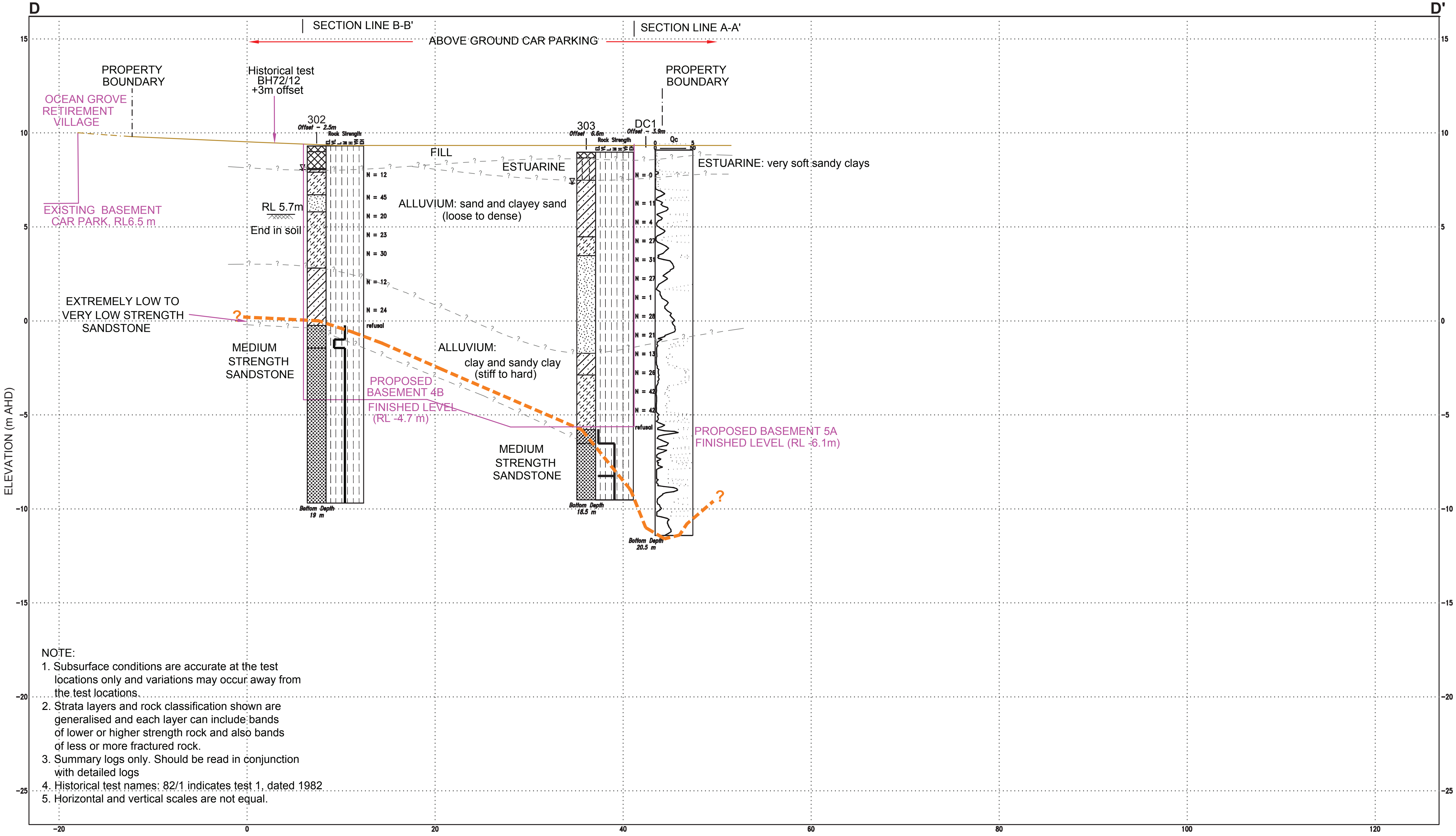
Horizontal Scale (metres)
Vertical Exaggeration = 2.0

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Dee Why RSL
OFFICE: Sydney
DRAWN BY: HDS
SCALE: 1:400 (H) 1:200 (V) @ A3
DATE: 2.03.2018

TITLE: **Geotechnical Cross-Section C-C'**
Proposed Car Park Upgrade
932 Pittwater Road, Dee Why

PROJECT No: 84926.03
DRAWING No: 5
REVISION: 2



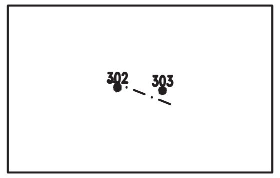
NOTE:
1. Subsurface conditions are accurate at the test locations only and variations may occur away from the test locations.
2. Strata layers and rock classification shown are generalised and each layer can include bands of lower or higher strength rock and also bands of less or more fractured rock.
3. Summary logs only. Should be read in conjunction with detailed logs
4. Historical test names: 82/1 indicates test 1, dated 1982
5. Horizontal and vertical scales are not equal.

LEGEND

■ Asphaltic Concrete
▩ Filling
░ Sand
▨ Sandy Clay
▨ Clayey Sand
▩ Sandstone coarse grained
▨ Silty Clay

TESTS / OTHER
N - Standard penetration test value
▽ - Water level

SITE MAP



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Horizontal Scale (metres)
Vertical Exaggeration = 2.0

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Dee Why RSL
OFFICE: Sydney
DRAWN BY: HDS
SCALE: 1:400 (H) 1:200 (V) @ A3
DATE: 09.03.2018

TITLE: **Geotechnical Cross-Section D-D'**
Proposed Car Park Upgrade
932 Pittwater Road, Dee Why

PROJECT No: 84926.03
DRAWING No: 6
REVISION: 5

Appendix C

Results of Field Work

Sampling Methods

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Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Soil Descriptions

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Description and Classification Methods

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

Soil Types

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

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

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

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

The proportions of secondary constituents of soils are described as:

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

Definitions of grading terms used are:

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

Cohesive Soils

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

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

Cohesionless Soils

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

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

Soil Descriptions

Soil Origin

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

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

Transported soils may be further subdivided into:

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

Rock Descriptions

Rock Strength

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

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

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

Degree of Fracturing

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

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

Rock Descriptions

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Symbols & Abbreviations

Douglas Partners

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
▽	Water level

Sampling and Testing

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

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

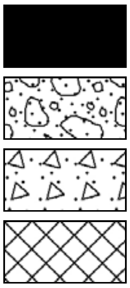
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

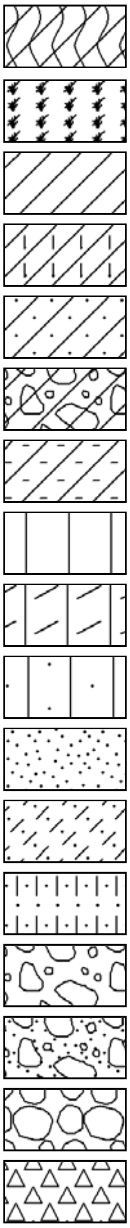
Graphic Symbols for Soil and Rock

General



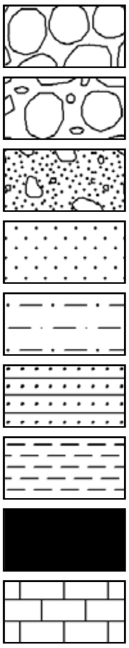
Asphalt
Road base
Concrete
Filling

Soils



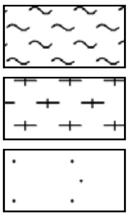
Topsoil
Peat
Clay
Silty clay
Sandy clay
Gravelly clay
Shaly clay
Silt
Clayey silt
Sandy silt
Sand
Clayey sand
Silty sand
Gravel
Sandy gravel
Cobbles, boulders
Talus

Sedimentary Rocks



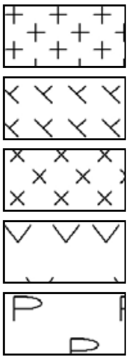
Boulder conglomerate
Conglomerate
Conglomeratic sandstone
Sandstone
Siltstone
Laminite
Mudstone, claystone, shale
Coal
Limestone

Metamorphic Rocks



Slate, phyllite, schist
Gneiss
Quartzite

Igneous Rocks



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

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.4 AHD^
EASTING: 341620
NORTHING: 6264116
DIP/AZIMUTH: 90°/--

BORE No: 201
PROJECT No: 84926.03
DATE: 4/3/2016
SHEET 1 OF 3

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01 0.05 0.10 0.50 1.00)	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	0.01	ASPHALTIC CONCRETE										
	0.11	FILLING - dark grey, gravel (5mm - 15mm) and sand filling with some asphalt										
	0.61	FILLING - brown sand and some sandstone gravel filling and traces of slag, damp										
		FILLING - well compacted, brown-grey sand filling with some gravel and tree roots, traces of clay, damp							S			4,6,6 N = 12
	1.61	FILLING - dark grey-grey, sand filling with traces of silt, wet (possibly natural?)				▼						
	2.4	SAND - medium dense, brown-grey, medium sand with traces of silt										
	2.7	SANDY CLAY - stiff, grey, sandy clay, wet							S			9,9,10 N = 19
									S			4,5,7 N = 12
	5.5	CLAYEY SAND - medium dense, grey to dark grey, fine to medium clayey sand							S			7,7,9 N = 16
									S			10,11,13 N = 24

RIG: **DRILLER:** GM **LOGGED:** AT **CASING:** HW to 11.0m; HQ to 17.65m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary (mud) to 17.65m; NMLC-Coring to 22.0m

WATER OBSERVATIONS: Free groundwater observed at 2.2m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.

SAMPLING & IN SITU TESTING LEGEND

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

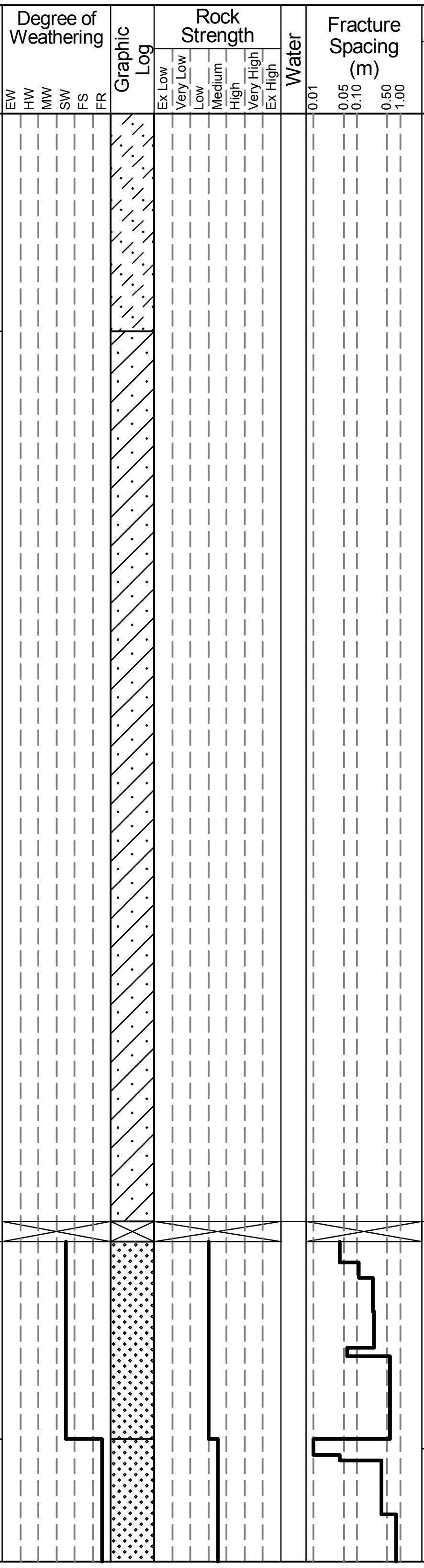
Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.4 AHD^
EASTING: 341620
NORTHING: 6264116
DIP/AZIMUTH: 90°/--

BORE No: 201
PROJECT No: 84926.03
DATE: 4/3/2016
SHEET 2 OF 3



Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	CLAYEY SAND - medium dense, grey to dark grey, fine to medium clayey sand *(continued)*					
11.5	SANDY CLAY - very stiff, grey, sandy clay with significant ironstaining		S			7,10,11 N = 21
			S			5,9,7 N = 16
		Note: Unless otherwise stated, discontinuities are B (0°- 5°), rough, clay veneer	S			25/30mm refusal
17.65 17.79		17.65m: CORE LOSS: 140mm				
17.79	SANDSTONE - low to medium strength, slightly weathered, fractured and slightly fractured, pale grey, medium grained sandstone	17.93m: J85°, pl, ro, cly vn	C	95	78	PL(A) = 0.3 PL(A) = 0.3
19.15	SANDSTONE - medium strength, fresh, slightly fractured, pale grey, medium grained sandstone	19.15m: Cs, 20mm 19.22m: Cs, 40mm				PL(A) = 0.4

RL scale: -1, -2, -3, -4, -5, -6, -7, -8, -9, -10
Depth scale: 11, 12, 13, 14, 15, 16, 17, 18, 19

RIG: **DRILLER:** GM **LOGGED:** AT **CASING:** HW to 11.0m; HQ to 17.65m
TYPE OF BORING: Solid flight auger to 2.5m; Rotary (mud) to 17.65m; NMLC-Coring to 22.0m
WATER OBSERVATIONS: Free groundwater observed at 2.2m whilst augering
REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.

SAMPLING & IN SITU TESTING LEGEND

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

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Geotechnics / Environment / Groundwater

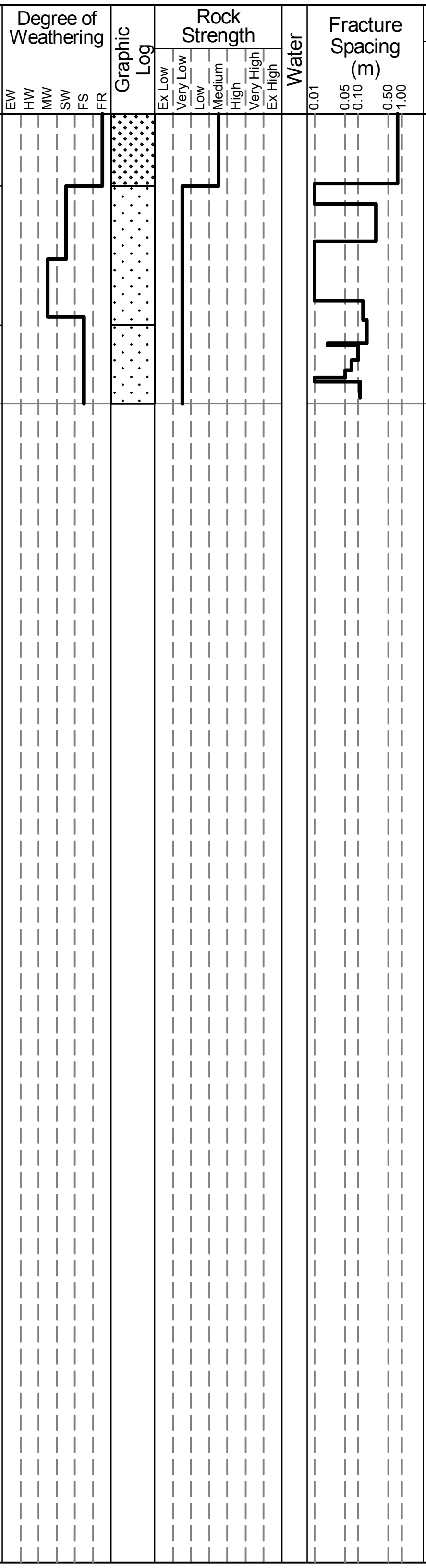
BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.4 AHD^
EASTING: 341620
NORTHING: 6264116
DIP/AZIMUTH: 90°/--

BORE No: 201
PROJECT No: 84926.03
DATE: 4/3/2016
SHEET 3 OF 3

RL	Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
-11		SANDSTONE - medium strength, fresh, slightly fractured, pale grey, medium grained sandstone *(continued)*		C	95	78	
	20.5	SANDSTONE - very low strength, slightly to moderately weathered, fractured, light brown, fine to medium grained sandstone	20.48m: Cs, 140mm 20.88m: J90°, pl, ro, cly co	C	100	0	PL(A) = 0.1
-12	21.46	SANDSTONE - very low strength, fresh stained, fractured, grey, fine to medium grained sandstone	21.58m: Cs, 20mm 21.77m: J70°, pl, ro, cly co				PL(A) = 0.1
	22.0	Bore discontinued at 22.0m					



Depth scale (m): 21, 22, 23, 24, 25, 26, 27, 28, 29
RL scale: -11, -12, -13, -14, -15, -16, -17, -18, -19, -20

RIG: **DRILLER:** GM **LOGGED:** AT **CASING:** HW to 11.0m; HQ to 17.65m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary (mud) to 17.65m; NMLC-Coring to 22.0m

WATER OBSERVATIONS: Free groundwater observed at 2.2m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.

SAMPLING & IN SITU TESTING LEGEND

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

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RSL CLUB CAR PARK – DEE WHY

BORE 201 PROJECT 84926.01 MAR 2016

17.65 – 22.0m

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.8 AHD^
EASTING: 341577
NORTHING: 6264117
DIP/AZIMUTH: 90°/--

BORE No: 202
PROJECT No: 84926.03
DATE: 4/3/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Degree of Weathering (EW HW MW SW FS FR)	Graphic Log	Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High)	Water	Fracture Spacing (m) (0.01 0.05 0.10 0.50 1.00)	Discontinuities (B - Bedding J - Joint S - Shear F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	0.1	ASPHALTIC CONCRETE							A/E			
	0.24	ROADBASE GRAVEL							A/E			
	0.4	FILLING - brown, sand and crushed sandstone filling, damp										
	0.75	SANDSTONE? - very low strength, light grey-brown, medium grained sandstone										
		Bore discontinued at 0.75m										

RIG:
DRILLER: GM
LOGGED: SI
CASING: Uncased

TYPE OF BORING: Solid flight auger (TC-bit) to 0.75m

WATER OBSERVATIONS: No free groundwater observed whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.

SAMPLING & IN SITU TESTING LEGEND

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

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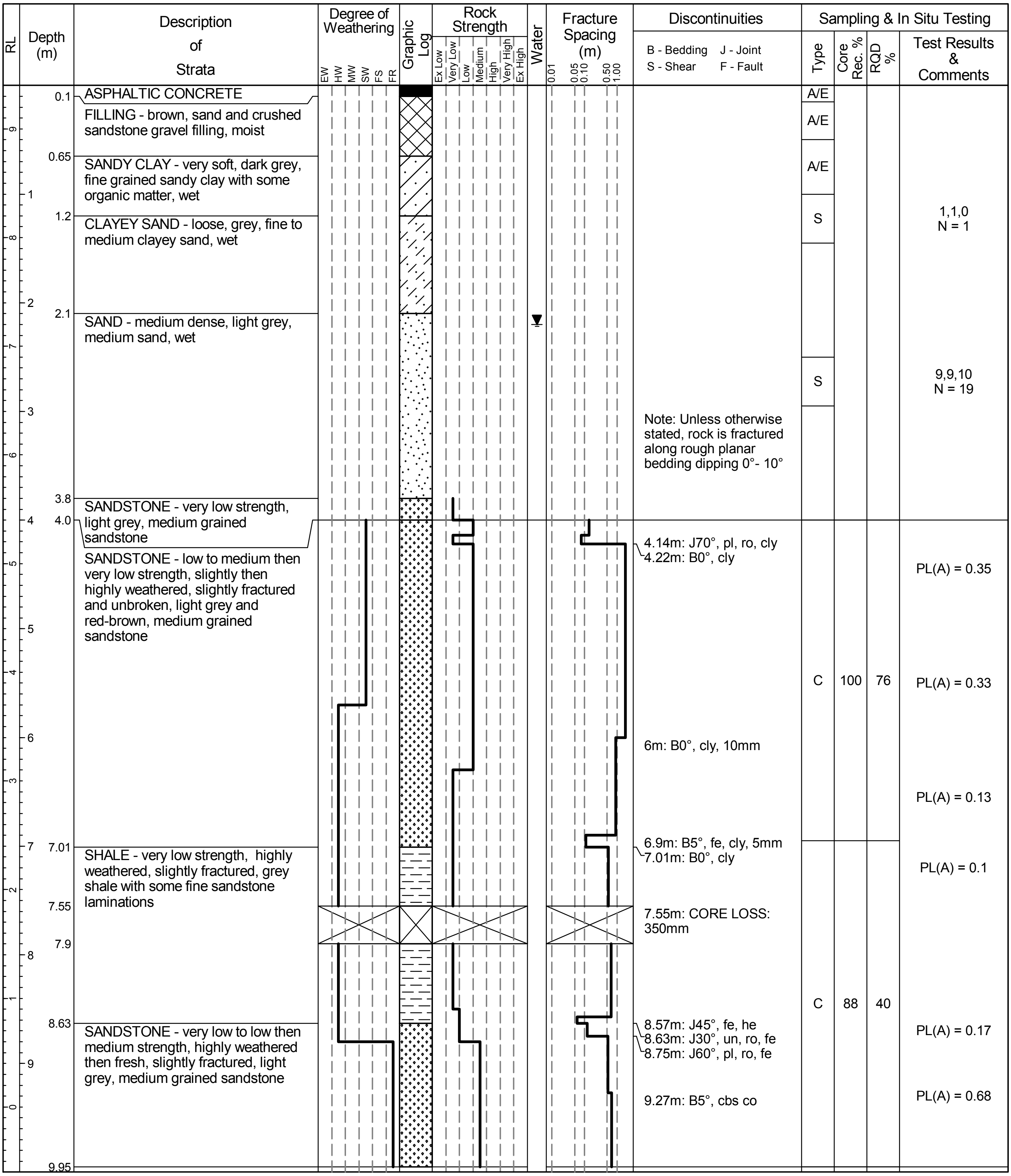
BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.4 AHD^
EASTING: 341628
NORTHING: 6264183
DIP/AZIMUTH: 90°/--

BORE No: 203
PROJECT No: 84926.03
DATE: 3/3/2016
SHEET 1 OF 1



Depth (m)	Description of Strata
0.1	ASPHALTIC CONCRETE
	FILLING - brown, sand and crushed sandstone gravel filling, moist
0.65	SANDY CLAY - very soft, dark grey, fine grained sandy clay with some organic matter, wet
1.2	CLAYEY SAND - loose, grey, fine to medium clayey sand, wet
2.1	SAND - medium dense, light grey, medium sand, wet
3.8	SANDSTONE - very low strength, light grey, medium grained sandstone
4.0	SANDSTONE - low to medium then very low strength, slightly then highly weathered, slightly fractured and unbroken, light grey and red-brown, medium grained sandstone
7.01	SHALE - very low strength, highly weathered, slightly fractured, grey shale with some fine sandstone laminations
7.55	
7.9	
8.63	SANDSTONE - very low to low then medium strength, highly weathered then fresh, slightly fractured, light grey, medium grained sandstone
9.95	

Discontinuities
B - Bedding J - Joint S - Shear F - Fault
Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°
4.14m: J70°, pl, ro, cly
4.22m: B0°, cly
6m: B0°, cly, 10mm
6.9m: B5°, fe, cly, 5mm
7.01m: B0°, cly
7.55m: CORE LOSS: 350mm
8.57m: J45°, fe, he
8.63m: J30°, un, ro, fe
8.75m: J60°, pl, ro, fe
9.27m: B5°, cbs co

Type	Core Rec. %	RQD %	Test Results & Comments
A/E			
A/E			
A/E			
S			1,1,0 N = 1
S			9,9,10 N = 19
C	100	76	PL(A) = 0.35 PL(A) = 0.33 PL(A) = 0.13
C	88	40	PL(A) = 0.1 PL(A) = 0.17 PL(A) = 0.68

Bore discontinued at 9.95m

RIG: Bobcat **DRILLER:** GM **LOGGED:** SI **CASING:** HW to 2.5m;

TYPE OF BORING: Solid flight auger (TC-bit) to 2.5m; Rotary (mud) to 4.0m; NMLC-Coring to 9.95m

WATER OBSERVATIONS: Free groundwater observed at 2.2m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.

SAMPLING & IN SITU TESTING LEGEND

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

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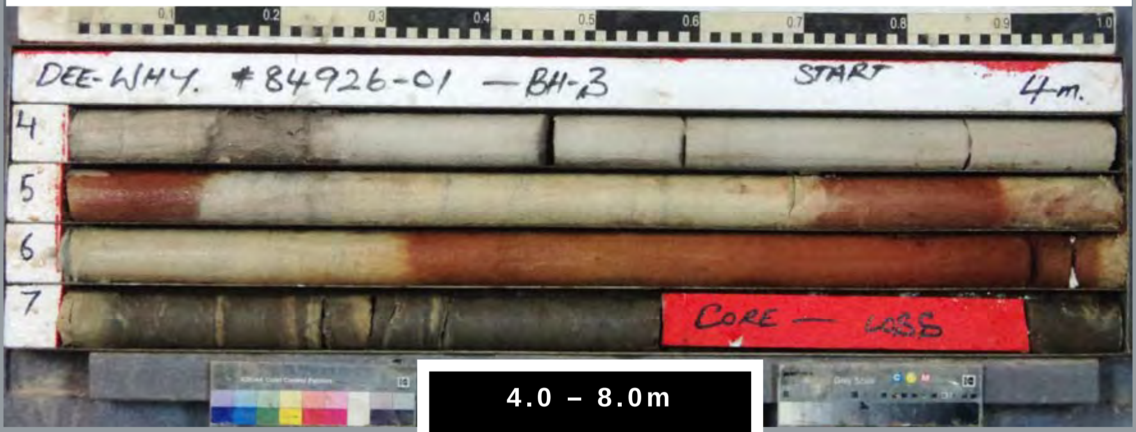
RSL CLUB CAR PARK – DEE WHY

BORE 203 PROJECT 84926.01 MAR 2016



4.0 – 8.0m

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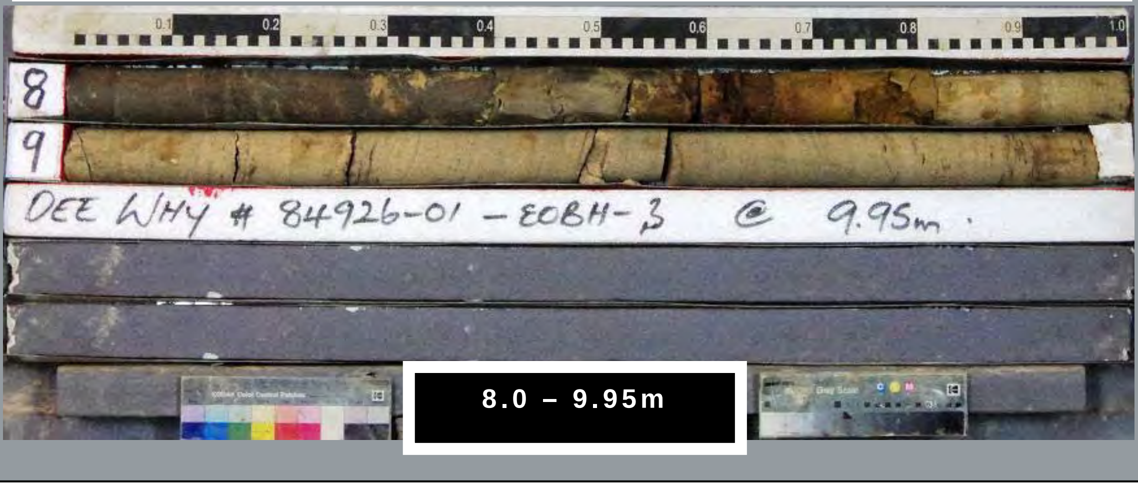
RSL CLUB CAR PARK – DEE WHY

BORE 203 PROJECT 84926.01 MAR 2016



8.0 – 9.95m

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 8.6 AHD^
EASTING: 341647
NORTHING: 6264176
DIP/AZIMUTH: 90°/--

BORE No: 204
PROJECT No: 84926.03
DATE: 9/3/2016
SHEET 1 OF 2

Depth (m)	Description of Strata	Water	Sampling Type	Test Results & Comments
	FILLING - light grey-brown, sand filling with some crushed sandstone and brick fragments		A A	
0.6	SANDY CLAY - very soft, grey, fine sandy clay, wet		A S	2,1,1 N = 2
1.8	CLAYEY SAND - medium dense, brown, medium clayey sand, wet	▼	S	2,8,18 N = 26
3.5	SAND - dense, light grey, medium sand with some clay, moist		S	18,18,18 N = 36
5.0	CLAYEY SAND - medium dense, grey, medium grained clayey sand with some peaty clay		S S	5,5,5 N = 10 5,9,6 N = 15
9.4	SAND - medium dense, light grey, fine to medium sand, moist			
10.0				

Column headings: RL; Depth (m); Description of Strata; Degree of Weathering (EW, HW, MW, SW, FS, FR); Graphic Log; Rock Strength (Ex Low, Very Low, Low, Medium, High, Very High, Ex High); Water; Fracture Spacing (m) (0.01, 0.05, 0.10, 0.50, 1.00); Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault); Sampling & In Situ Testing (Type, Core Rec. %, RQD %, Test Results & Comments)

RIG: Bobcat **DRILLER:** GM **LOGGED:** SI **CASING:** HW to 7.5m

TYPE OF BORING: Solid flight auger (TC-bit) to 2.5m; Rotary to 10.2m

WATER OBSERVATIONS: Free groundwater observed at 2.3m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 8.6 AHD^
EASTING: 341647
NORTHING: 6264176
DIP/AZIMUTH: 90°/--

BORE No: 204
PROJECT No: 84926.03
DATE: 9/3/2016
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low, Very Low, Low, Medium, High, Very High, Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
	10.2	SAND - medium dense, light grey, fine to medium sand, moist (continued)		∴								
		Bore discontinued at 10.2m on sandstone										
-2												
	11											
-3												
	12											
-4												
	13											
-5												
	14											
-6												
	15											
-7												
	16											
-8												
	17											
-9												
	18											
-10												
	19											
-11												

RIG: Bobcat **DRILLER:** GM **LOGGED:** SI **CASING:** HW to 7.5m
TYPE OF BORING: Solid flight auger (TC-bit) to 2.5m; Rotary to 10.2m
WATER OBSERVATIONS: Free groundwater observed at 2.3m whilst augering
REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
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BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.2 AHD^
EASTING: 341609
NORTHING: 6264142
DIP/AZIMUTH: 90°/--

BORE No: 205
PROJECT No: 84926.03
DATE: 8/3/2016
SHEET 1 OF 2

Depth (m)	Description of Strata	Water
0.2	ROADBASE GRAVEL	
0.52	FILLING - red-brown, sand and crushed sandstone filling	
1.6	CLAYEY SAND - medium dense, grey, fine to medium clayey sand, moist	
3.6	SAND - medium dense then dense, light grey, medium sand with some clay, wet	▼
4.9	CLAYEY SAND - dense, grey, fine to medium clayey sand, moist	
8.0	SANDY CLAY - very stiff, light grey, fine sandy clay, moist	
8.15	SANDSTONE - very low strength, light grey, medium grained sandstone	
	SANDSTONE - medium strength, moderately to slightly weathered then fresh, unbroken, brown then light grey, medium grained sandstone	

Discontinuities: B - Bedding J - Joint S - Shear F - Fault

Type	Core Rec. %	RQD %	Test Results & Comments
A/E			
A/E			
A/E			
S			5,9,6 N = 15
S			12,20,18 N = 38
S			7,14,18 N = 32
S			3,5,15 N = 20
C	100	100	PL(A) = 0.39 PL(A) = 0.45

RIG: Bobcat **DRILLER:** GM **LOGGED:** SI **CASING:** HW to 6.5m; HQ to 10.75m

TYPE OF BORING: Solid flight auger (TC-bit) to 3.15m; Rotary (mud) to 10.8m; NMLC-Coring to 11.05m

WATER OBSERVATIONS: Free groundwater observed at 2.3m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.
Standpipe installed to 9.0m (screen 6.0-9.0m; gravel 5.5-9.0m; bentonite 4.5-5.5m; backfill to GL with gatic cover)

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.2 AHD^
EASTING: 341609
NORTHING: 6264142
DIP/AZIMUTH: 90°/--

BORE No: 205
PROJECT No: 84926.03
DATE: 8/3/2016
SHEET 2 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low, Very Low, Low, Medium, High, Very High, Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
-1		SANDSTONE - medium strength, moderately to slightly weathered then fresh, unbroken, brown then light grey, medium grained sandstone *(continued)*							C	100	100	PL(A) = 0.71
	11 11.05											PL(A) = 0.63
-2		Bore discontinued at 11.05m										
	12											
-3												
	13											
-4												
	14											
-5												
	15											
-6												
	16											
-7												
	17											
-8												
	18											
-9												
	19											
-10												

RIG: Bobcat **DRILLER:** GM **LOGGED:** SI **CASING:** HW to 6.5m; HQ to 10.75m
TYPE OF BORING: Solid flight auger (TC-bit) to 3.15m; Rotary (mud) to 10.8m; NMLC-Coring to 11.05m
WATER OBSERVATIONS: Free groundwater observed at 2.3m whilst augering
REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16.
Standpipe installed to 9.0m (screen 6.0-9.0m; gravel 5.5-9.0m; bentonite 4.5-5.5m; backfill to GL with gatic cover)

SAMPLING & IN SITU TESTING LEGEND

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

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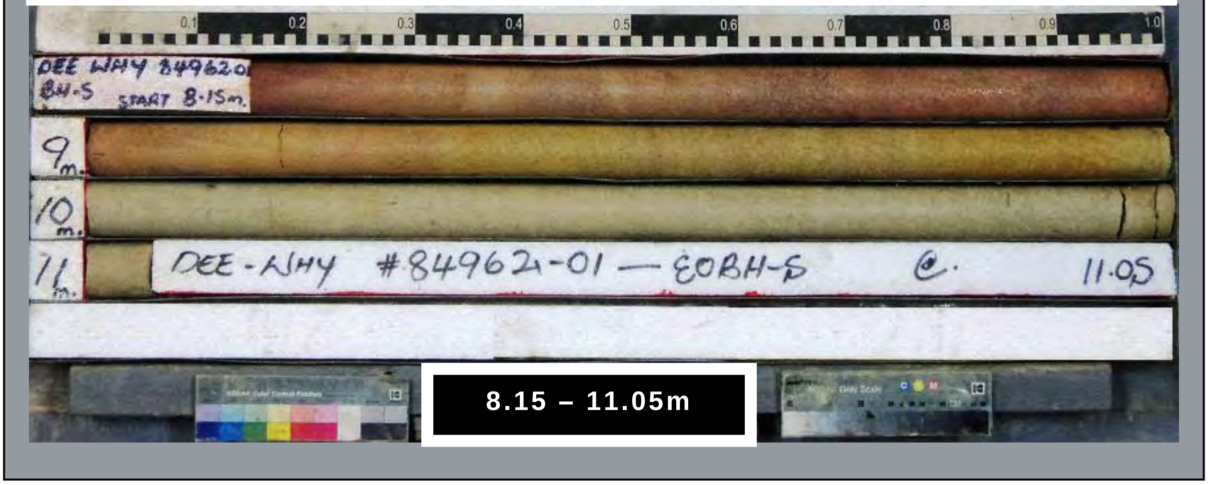
RSL CLUB CAR PARK – DEE WHY

BORE 205 **PROJECT 84926.01** **MAR 2016**



8.15 – 11.05m

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.7 AHD^
EASTING: 341586
NORTHING: 6264117
DIP/AZIMUTH: 90°/--

BORE No: 301
PROJECT No: 84926.03
DATE: 11, 14 & 15/11/2016
SHEET 1 OF 2

Depth (m)	Description of Strata	Water	Type	Test Results & Comments
0.03	ASPHALTIC CONCRETE		A/E	
0.3	FILLING - grey and dark grey, sandy basalt and sandstone gravel filling with some silt, humid (roadbase)		A/E	
0.85	FILLING - orange-brown, medium to coarse sand filling with some silt and fine to medium sandstone gravel, trace brick fragments, humid		A/E	
		▼	S	10,15,22 N = 37
	SAND - dense, grey, medium sand with some clay, moist, sulphurous odour 1.3m: becoming yellow-brown and wet		A A	
2.3	SANDY CLAY - very stiff, grey sandy clay, wet		S	8,12,8 N = 20
3.5	CLAYEY SAND - loose then medium dense, clayey medium sand		S	11,4,2 N = 6
	4.5m: with some grey organic clay lenses (sulphurous odour)		S	1,4,8 N = 12
5.7	SAND - medium dense then very dense, light grey, medium to coarse sand with some fine quartz gravel		S	10,11,13 N = 24
			S	23,25/120mm refusal
7.0	SANDY CLAY - stiff, grey and orange-brown mottled sandy clay		S	4,6,7 N = 13
			S	5,7,8 N = 15

Discontinuities: B - Bedding J - Joint S - Shear F - Fault

RIG: Bobcat **DRILLER:** GM **LOGGED:** MP/SI **CASING:** HW to 2.5m; HQ to 16.0m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary (washbore) 2.5-12.2m, 14.5-16.0m; NMLC-Coring 12.2-14.5m, 16.0-19.0m

WATER OBSERVATIONS: Free groundwater observed at 1.3m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16. Borehole drilled from upper level of carpark. Standpipe installed to 18.75 m (screen 0.75-18.75m; gravel 0.3-18.75m; bentonite plug 0.0-0.3m; gatic cover at surface).

SAMPLING & IN SITU TESTING LEGEND

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

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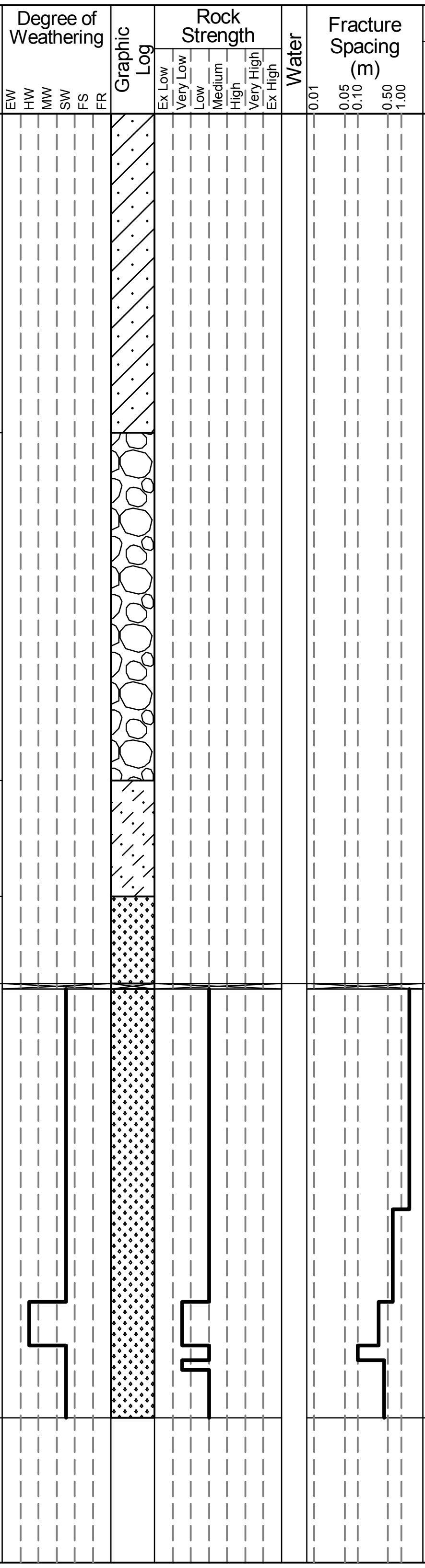
BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.7 AHD^
EASTING: 341586
NORTHING: 6264117
DIP/AZIMUTH: 90°/--

BORE No: 301
PROJECT No: 84926.03
DATE: 11, 14 & 15/11/2016
SHEET 2 OF 2

Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	SANDY CLAY - stiff, grey and orange-brown mottled sandy clay *(continued)*		S			3,6,7 N = 13
			S			6,8,25 N = 33
	11.9m: becoming red					
12.2	BOULDERS - red-brown and brown, iron cemented, medium grained sandstone boulders with sand					
14.6	CLAYEY SAND - medium dense, yellow-brown clayey sand		S			18,12,9 N = 21
15.4	SANDSTONE - low to very low strength, moderately weathered, light grey and red-brown, medium grained sandstone	Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°				
16.0 16.04	SANDSTONE - low to medium strength, slightly weathered, slightly fractured, light grey-brown medium grained sandstone	16m: CORE LOSS: 40mm	C	99	89	PL(A) = 0.3
		17.56m: J25°, pl, ro, cln				PL(A) = 0.3
		18.2-18.5m: Ds				
		18.6-18.67m: Ds				PL(A) = 0.3
19.0	Bore discontinued at 19.0m - target depth reached					



RIG: Bobcat **DRILLER:** GM **LOGGED:** MP/SI **CASING:** HW to 2.5m; HQ to 16.0m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary (washbore) 2.5-12.2m, 14.5-16.0m; NMLC-Coring 12.2-14.5m, 16.0-19.0m

WATER OBSERVATIONS: Free groundwater observed at 1.3m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16. Borehole drilled from upper level of carpark. Standpipe installed to 18.75 m (screen 0.75-18.75m; gravel 0.3-18.75m; bentonite plug 0.0-0.3m; gatic cover at surface).

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BORE 301 PROJECT 84926.03 November 2016

16.0 – 19.0m

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.3 AHD^
EASTING: 341597
NORTHING: 6264134
DIP/AZIMUTH: 90°/--

BORE No: 302
PROJECT No: 84926.03
DATE: 16/11/2016
SHEET 1 OF 2

Depth (m)	Description of Strata	Water	Type	Core Rec. %	RQD %	Test Results & Comments
0.01	ASPHALTIC CONCRETE		A/E			
0.3	FILLING - dark grey sandy basalt gravel filling with some silt, humid (roadbase)		A/E			
	FILLING - orange-brown, medium to coarse sand filling, trace silt, fine to medium sandstone gravel and basalt gravel, humid					
1.2 1.25	SAND - medium dense, grey medium sand with some clay, moist	▼	A/E S			8,8,4 N = 12
1.4	SANDY CLAY - very stiff, dark grey sandy clay, trace organic matter (slightly peaty and sulphurous odour)		A			
	CLAYEY SAND - medium dense, light grey fine to coarse clayey sand with some subrounded river gravel		A			
2.6	SAND - dense, light grey medium to coarse sand, trace clay		S			10,15,30 N = 45
3.5	CLAYEY SAND - medium dense, light grey, medium to coarse clayey sand		S			4,8,12 N = 20
			S			10,11,12 N = 23
	5.5m: becoming dense		S			11,18,12 N = 30
6.5	SANDY CLAY - stiff, light grey fine to medium sandy clay		S			3,5,7 N = 12
	7.5m: becoming red-brown					
	8.5m: very stiff and light grey		S			6,11,13 N = 24
9.55	SANDSTONE - continued next page		S C	 100	 85	6/0mm refusal PL(A) = 0.5

Degree of Weathering: EW HW MW SW FS FR
Rock Strength: Ex Low, Very Low, Low, Medium, High, Very High, Ex High
Fracture Spacing (m): 0.01 0.05 0.10 0.50 1.00
Discontinuities: B - Bedding J - Joint S - Shear F - Fault

Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°

RIG: Bobcat **DRILLER:** GM **LOGGED:** VK/SI **CASING:** HW to 5.7m; HQ to 9.55m
TYPE OF BORING: Solid flight auger to 2.5m; Rotary (washbore) drilling to 9.55m; NMLC-Coring to 19.0m
WATER OBSERVATIONS: Free groundwater observed at 1.3m whilst augering
REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16. Borehole drilled from upper level of carpark

SAMPLING & IN SITU TESTING LEGEND

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

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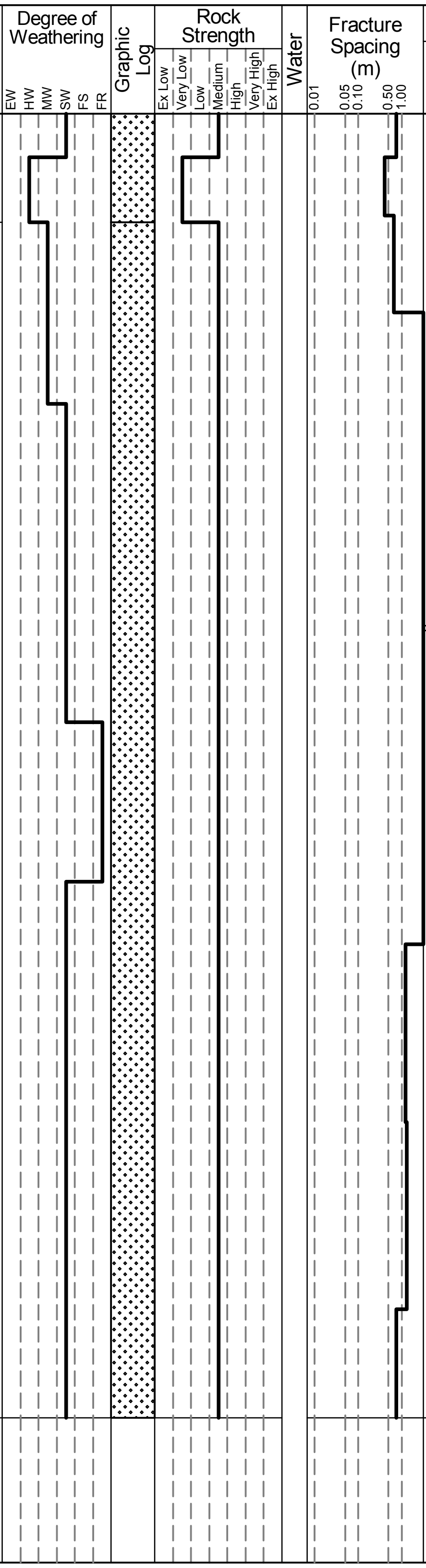
BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.3 AHD^
EASTING: 341597
NORTHING: 6264134
DIP/AZIMUTH: 90°/--

BORE No: 302
PROJECT No: 84926.03
DATE: 16/11/2016
SHEET 2 OF 2



RL	Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
-1		SANDSTONE - medium then very low strength, slightly then highly weathered, slightly fractured, light brown then red-brown, medium grained sandstone *(continued)*	10.3m: B0°, fe, cly 10.7-10.75m: Ds	C	100	85	PL(A) = 0.1
-2	10.75 11	SANDSTONE - medium strength, slightly weathered and fresh, slightly fractured and unbroken, light brown and red-brown medium grained sandstone	11.37m: B0°, fe				PL(A) = 0.7
-3	12			C	100	100	PL(A) = 0.7
-4	13						PL(A) = 1.1
-5	14						PL(A) = 0.9
-6	15			C	100	100	
-7	16		15.73m: J50°, un, ro, fe				PL(A) = 0.8 PL(A) = 0.8
-8	17		16.96m: J45°, pl, ro, fe				PL(A) = 0.7
-9	18		18.25m: J45°- 80°, cu, ro, cln	C	100	100	PL(A) = 0.8
-10	19 19.0	Bore discontinued at 19.0m - target depth reached					

RIG: Bobcat **DRILLER:** GM **LOGGED:** VK/SI **CASING:** HW to 5.7m; HQ to 9.55m

TYPE OF BORING: Solid flight auger to 2.5m; Rotary (washbore) drilling to 9.55m; NMLC-Coring to 19.0m

WATER OBSERVATIONS: Free groundwater observed at 1.3m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16. Borehole drilled from upper level of carpark

SAMPLING & IN SITU TESTING LEGEND

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

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BORE 302 PROJECT 84926.03 November 2016

16.55 – 14.0m

BORE 302 PROJECT 84926.03 November 2016

14.0 – 19.0m

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.0 AHD^
EASTING: 341627
NORTHING: 6264132
DIP/AZIMUTH: 90°/--

BORE No: 303
PROJECT No: 84926.03
DATE: 21/11/2016
SHEET 1 OF 2

RL	Depth (m)	Description of Strata	Degree of Weathering EW HW MW SW FS FR	Graphic Log	Rock Strength Ex Low, Very Low, Low, Medium, High, Very High, Ex High	Water	Fracture Spacing (m) 0.01 0.05 0.10 0.50 1.00	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Sampling & In Situ Testing: Type	Core Rec. %	RQD %	Test Results & Comments
9	0.01	ASPHALT							A/E*			
	0.3	FILLING - orange-brown, fine to coarse sandy clay filling with some angular ironstone gravel							A/E			
		SILTY CLAY - very soft, dark grey silty clay, trace organic material, sulphurous odour (slightly peaty), moist										
8	1								A/E			
		0.85m: increasing proportion of sand (trace)							S			1,0,0 N = 0
	1.5	SANDY CLAY - very soft, light grey, fine to coarse sandy clay, wet				▼			A/E			
7	2	1.7m: saturated										
		2.5m: stiff consistency							S			6,6,5 N = 11
6	3											
		3.5m: soft consistency 3.7m: very stiff, grey fine to coarse sandy clay, trace sub-rounded quartz gravel, moist							S			1,1,3 N = 4
5	4											
	4.5	CLAYEY SAND - medium dense, brown-grey, medium to coarse clayey sand							S			9,12,15 N = 27
4	5											
	5.5	SAND - medium dense to dense, brown-grey, coarse sand, trace clay and some sub-angular quartz gravel							S			11,15,16 N = 31
3	6											
									S			11,14,13 N = 27
2	7											
		7.5-8.0m: very soft, dark grey silty clay (slightly peaty)							S			1,0,1 N = 1
1	8	8.0m: medium dense, brown-grey, coarse sand, trace clay										
									S			15,14,14 N = 28
0	9											
		9.5m: some sub-angular quartz gravel							S			7,9,12 N = 21

RIG: Bobcat **DRILLER:** GM **LOGGED:** VK/SI **CASING:** HW to 3.5m; HQ to 15.5m

TYPE OF BORING: Solid flight auger to 4.5m; Rotary drilling to 15.5m; NMLC-Coring to 18.5m

WATER OBSERVATIONS: Free groundwater observed at 1.7m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16. Borehole drilled from upper level of carpark. *BD1/211116 taken at 0.1m to 0.2m

SAMPLING & IN SITU TESTING LEGEND

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

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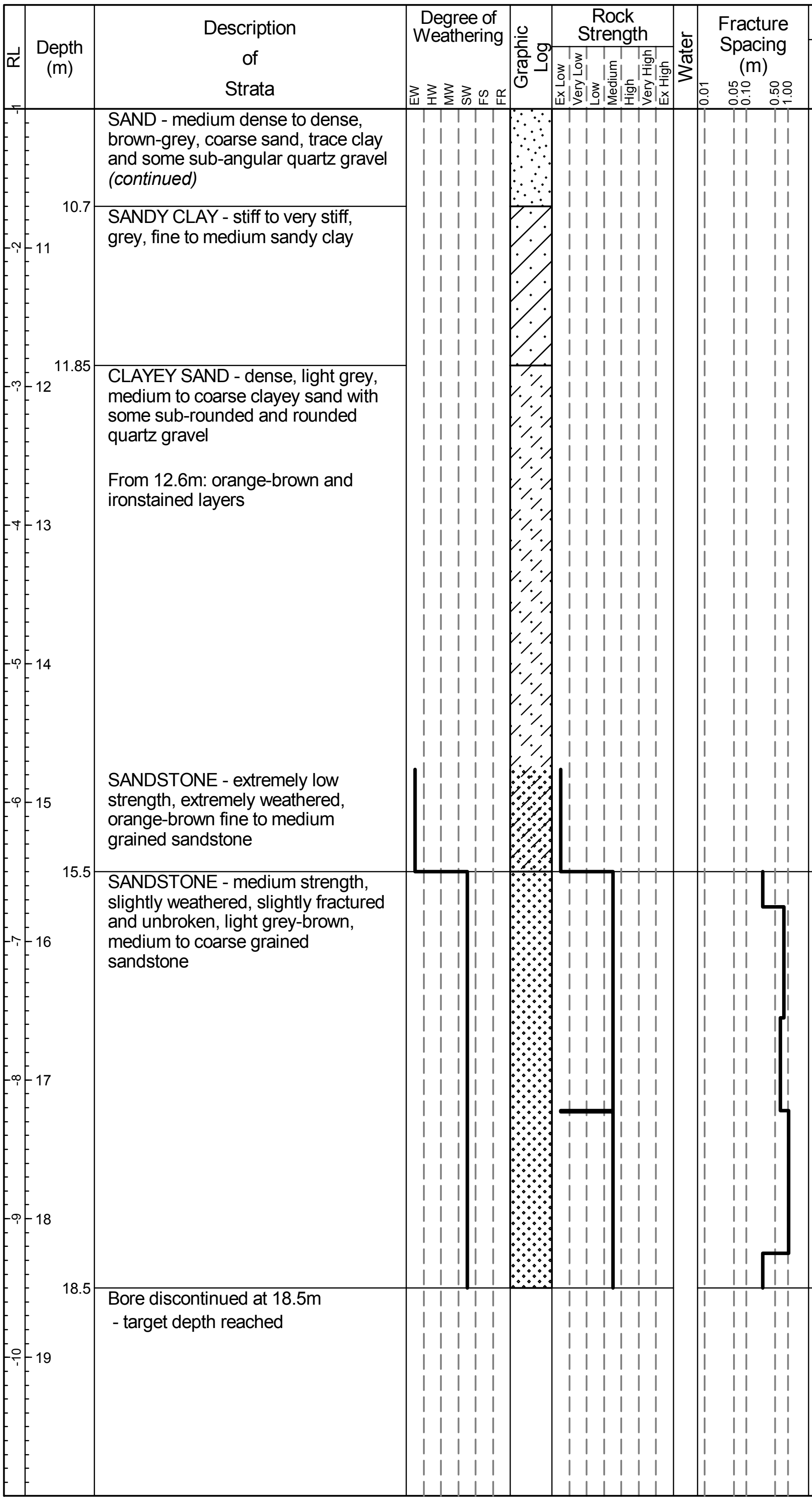
BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 9.0 AHD^
EASTING: 341627
NORTHING: 6264132
DIP/AZIMUTH: 90°/--

BORE No: 303
PROJECT No: 84926.03
DATE: 21/11/2016
SHEET 2 OF 2



Depth (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
	SAND - medium dense to dense, brown-grey, coarse sand, trace clay and some sub-angular quartz gravel *(continued)*					
10.7	SANDY CLAY - stiff to very stiff, grey, fine to medium sandy clay		S			14,9,4 N = 13
			S			5,9,17 N = 26
11.85	CLAYEY SAND - dense, light grey, medium to coarse clayey sand with some sub-rounded and rounded quartz gravel From 12.6m: orange-brown and ironstained layers		S			17,18,24 N = 42
			S			10,21,21 N = 42
		Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°	S			14,36/100mm refusal Bouncing
	SANDSTONE - extremely low strength, extremely weathered, orange-brown fine to medium grained sandstone					
15.5	SANDSTONE - medium strength, slightly weathered, slightly fractured and unbroken, light grey-brown, medium to coarse grained sandstone	15.75m: B10°, cly vn, ti 16.55m: J30°, pl, sm, cly 17.22m: B5°, cly, 5mm 18.25-18.5m: J45° & 85°, st, ro, cln	C	100	99	PL(A) = 0.7 PL(A) = 0.5 PL(A) = 0.5 PL(A) = 0.7
18.5	Bore discontinued at 18.5m - target depth reached					

RIG: Bobcat **DRILLER:** GM **LOGGED:** VK/SI **CASING:** HW to 3.5m; HQ to 15.5m

TYPE OF BORING: Solid flight auger to 4.5m; Rotary drilling to 15.5m; NMLC-Coring to 18.5m

WATER OBSERVATIONS: Free groundwater observed at 1.7m whilst augering

REMARKS: ^Surface level interpolated from LTS Lockley Survey 43018DT dated 24/3/16. Borehole drilled from upper level of carpark. *BD1/211116 taken at 0.1m to 0.2m

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BORE 303 PROJECT 84926.03 November 2016

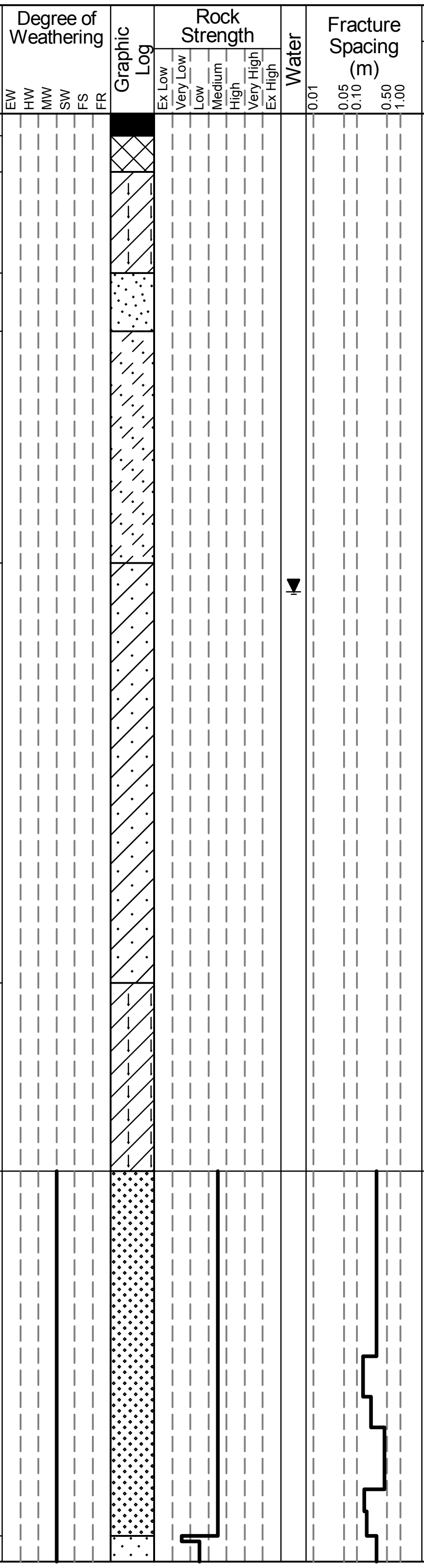
15.5 – 18.5m

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 8.9 AHD^
EASTING: 341634
NORTHING: 6264180
DIP/AZIMUTH: 90°/--

BORE No: 304
PROJECT No: 84926.03
DATE: 17/11/2016
SHEET 1 OF 2



Depth (m)	Description of Strata	Type	Core Rec. %	RQD %	Test Results & Comments	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)
	ASPHALT					
0.15	FILLING - brown sand filling, trace basalt gravel and tile	A* A/E				
0.4	SILTY CLAY - very soft, dark grey silty clay, slightly peaty, trace organic matter, slight sulphurous odour, moist 0.4-0.6m: trace sand	A/E				
1.1	SAND - medium dense, light grey, fine to medium sand, trace clay, wet	S			1,7,8 N = 15	
1.5	CLAYEY SAND - medium dense, light grey, fine to medium clayey sand, slight odour, wet	A/E S			5,4,10 N = 14	
3.1	SANDY CLAY - very soft, light grey sandy clay 3.5m: stiff consistency 4.5m: firm consistency 5.0m: trace red-brown sand	E S S			3,4,5 N = 9 3,3,4 N = 7	
6.0	SILTY CLAY - hard, light grey silty clay 6.5m: some fine to coarse sand and sub-rounded quartz/river gravel	S S			5,13,17 N = 30 7,14,25/50mm refusal bouncing	Note: Unless otherwise stated, rock is fractured along rough planar bedding dipping 0°- 10°
7.3	SANDSTONE - medium strength, moderately to slightly weathered, slightly fractured, light grey-brown medium grained sandstone	C	93	92	PL(A) = 0.8 PL(A) = 0.7 PL(A) = 0.5	8.58m: B10°, cly vn, ti 8.72m: B0°, cly co, 3mm 8.86m: B0°, fe 9.07m: B0°, fe 9.65m: B0°, cly vn, ti 9.82m: J30°, pl, ro, cly, 20mm
9.82	SANDSTONE - see over					

RIG: Bobcat **DRILLER:** GM **LOGGED:** VK/SI **CASING:** HW to 5.5m; HQ to 7.3m

TYPE OF BORING: Solid flight auger to 4.5m; Rotary drilling to 7.3m; NMLC-Coring to 10.0m

WATER OBSERVATIONS: Free groundwater observed at 3.3m (and wet from 1.0m)

REMARKS: ^Level interpolated from LTS Lockley Survey 43018DT. Drilled from upper level of carpark. Standpipe installed to 18.00 m (screen 10.0-18.0m; gravel 9.0-18.0m; bentonite plug 8.0-9.0m; backfill to surface; gatic cover). *BD1/171116 taken at 0.2m to 0.3m.

SAMPLING & IN SITU TESTING LEGEND

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

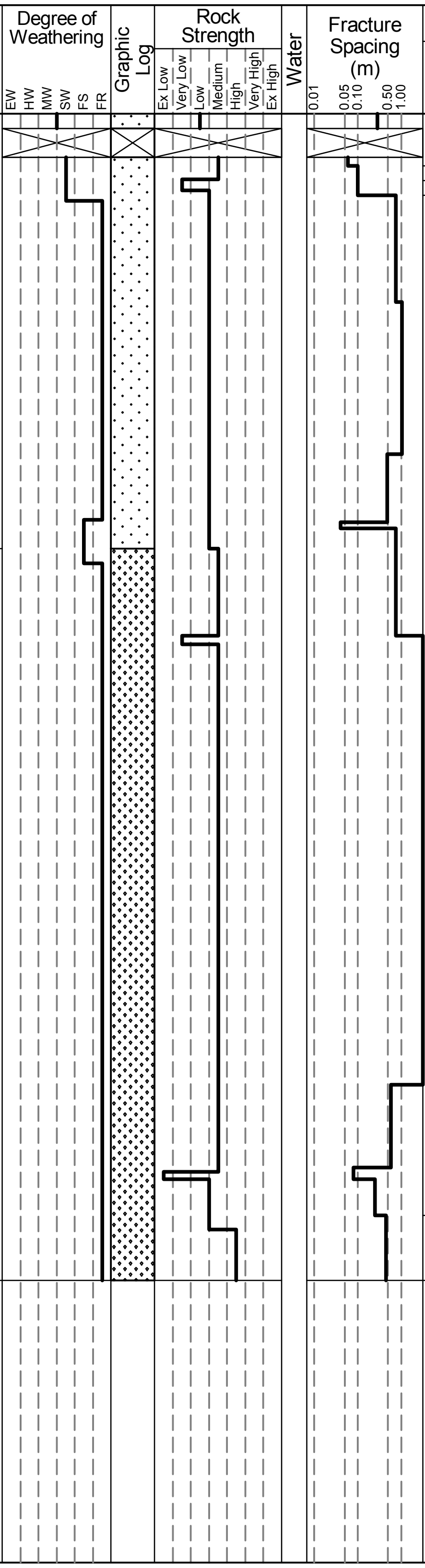
Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Dee Why RSL
PROJECT: Proposed Car Park Upgrade
LOCATION: 932 Pittwater Road, Dee Why

SURFACE LEVEL: 8.9 AHD^
EASTING: 341634
NORTHING: 6264180
DIP/AZIMUTH: 90°/--

BORE No: 304
PROJECT No: 84926.03
DATE: 17/11/2016
SHEET 2 OF 2



RL	Depth (m)	Description of Strata	Discontinuities B - Bedding J - Joint S - Shear F - Fault	Type	Core Rec. %	RQD %	Test Results & Comments
		SANDSTONE - low then low to medium strength, slightly fractured and unbroken, light grey, fine to medium grained sandstone with some very low strength bands *(continued)* 10.46m: carbonaceous shale band	10.1m: CORE LOSS: 200mm	C	93	92	
	10.3		10.36m: B0°, cly co, 5mm 10.46m: J35°, pl, ro, cbs cly, 30mm 10.56m: J45°, pl, sm, cly 11.3m: B0°, cly co, 3mm 12.35m: J20°, pl, ro, cln 12.82 & 12.86m: J (x2) 70°, pl, ro, fe, cly	C	100	95	PL(A) = 0.5 PL(A) = 0.3 PL(A) = 0.3
	13.0	SANDSTONE - medium then high strength, fresh, slightly fractured and unbroken, light grey, medium grained sandstone	13.6-13.66m: Ds	C	100	97	PL(A) = 0.6 PL(A) = 0.8 PL(A) = 0.5
		27.35-17.7m: low to medium strength band	16.7m: B10°, cly vn, ti 17.35m: J70°, pl, ro, cln 17.35-17.38m: Cs 17.6m: B0°, cly co, 2mm	C	100	94	PL(A) = 0.5 PL(A) = 0.3 PL(A) = 1.2
	18.05	Bore discontinued at 18.05m - target depth reached					

RIG: Bobcat **DRILLER:** GM **LOGGED:** VK/SI **CASING:** HW to 5.5m; HQ to 7.3m

TYPE OF BORING: Solid flight auger to 4.5m; Rotary drilling to 7.3m; NMLC-Coring to 10.0m

WATER OBSERVATIONS: Free groundwater observed at 3.3m (and wet from 1.0m)

REMARKS: ^Level interpolated from LTS Lockley Survey 43018DT. Drilled from upper level of carpark. Standpipe installed to 18.00 m (screen 10.0-18.0m; gravel 9.0-18.0m; bentonite plug 8.0-9.0m; backfill to surface; gatic cover). *BD1/171116 taken at 0.2m to 0.3m.

SAMPLING & IN SITU TESTING LEGEND

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

Douglas Partners
Geotechnics / Environment / Groundwater

BORE 304 PROJECT 84926.03 November 2016

7.3 – 12.0m

BORE 304 PROJECT 84926.03 November 2016

12.0 – 17.0m

BORE 304 PROJECT 84926.03 November 2016

17.0 – 18.05m

Permeability Testing - Rising or Falling Head Test Report

Client:	Dee Why RSL	Project No:	84926.03
Project:	Proposed Car Park Upgrade	Test date:	22.11.16 (12.55pm)
Location:	932 Pittwater Road, Dee Why	Tested by:	VK

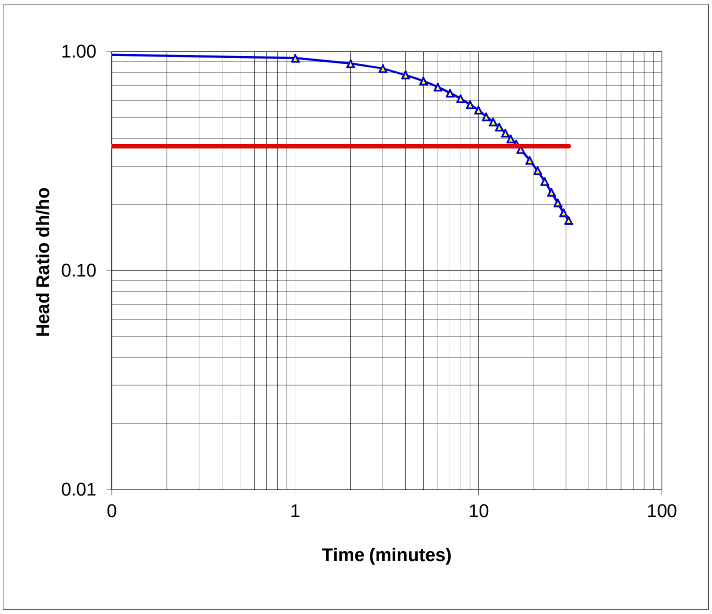
Test Location		**Test No.**	BH205	
Description:	Standpipe in borehole	Easting:	341609	m
Material type:	Sandy Clay and Sandstone (Screen interval: 6-9 m)	Northing	6264142	m
		Surface Level:	9.2	m AHD

Details of Well Installation

Well casing diameter (2r)	76	mm	Depth to water before test	1.21	m
Well screen diameter (2R)	76	mm	Depth to water at start of test	6.69	m
Length of well screen (Le)	3	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	6.69	5.48	1.000
1	6.33	5.12	0.934
2	6.05	4.84	0.883
3	5.8	4.59	0.838
4	5.5	4.29	0.783
5	5.24	4.03	0.735
6	4.99	3.78	0.690
7	4.76	3.55	0.648
8	4.56	3.35	0.611
9	4.35	3.14	0.573
10	4.18	2.97	0.542
11	3.98	2.77	0.505
12	3.83	2.62	0.478
13	3.69	2.48	0.453
14	3.54	2.33	0.425
15	3.4	2.19	0.400
16	3.29	2.08	0.380
17	3.17	1.96	0.358
19	2.96	1.75	0.319
21	2.78	1.57	0.286
23	2.61	1.40	0.255
25	2.46	1.25	0.228
27	2.33	1.12	0.204
29	2.22	1.01	0.184
31	2.14	0.93	0.170
33	2.05	0.84	0.153



To = 16 mins
960 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**1.1E-06**	m/sec
	=	**0.394**	cm/hour

Permeability Testing - Rising or Falling Head Test Report

Client: Dee Why RSL
Project: Proposed Car Park Upgrade
Location: 932 Pittwater Road, Dee Why

Project No: 84926.03
Test date: 24.11.16 (11.43 am)
Tested by: VK

Test Location
Description: Standpipe in borehole
Material type: Sand, Clay, Sandstone (Screen interval:0.6-18.75 m)

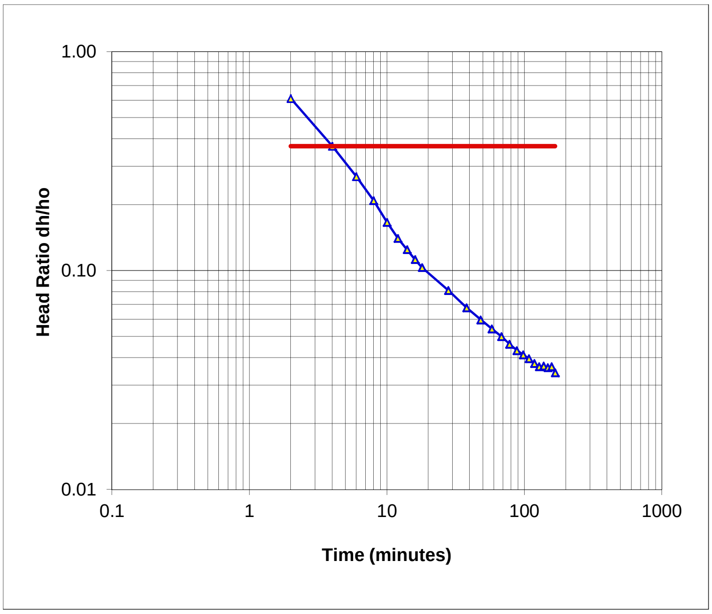
Test No. BH301
Easting: 341586 m
Northing 6264117 m
Surface Level: 9.7 m AHD

Details of Well Installation

Well casing diameter (2r)	76	mm
Well screen diameter (2R)	76	mm
Length of well screen (Le)	3.1	m
Depth to water before test	1.19	m
Depth to water at start of test	4.29	m

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	4.361	3.17	1.023
2	3.083	1.89	0.611
4	2.338	1.15	0.370
6	2.025	0.84	0.269
8	1.838	0.65	0.209
10	1.706	0.52	0.166
12	1.626	0.44	0.141
14	1.577	0.39	0.125
16	1.539	0.35	0.113
18	1.511	0.32	0.104
28	1.442	0.25	0.081
38	1.4	0.21	0.068
48	1.375	0.19	0.060
58	1.358	0.17	0.054
68	1.345	0.16	0.050
78	1.333	0.14	0.046
88	1.324	0.13	0.043
98	1.318	0.13	0.041
108	1.313	0.12	0.040
118	1.307	0.12	0.038
128	1.303	0.11	0.036
138	1.304	0.11	0.037
148	1.302	0.11	0.036
158	1.303	0.11	0.036
167	1.296	0.11	0.034



To = 4 mins
240 secs

Theory: Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**4.3E-06**	m/sec
	=	**1.538**	cm/hour

Permeability Testing - Rising or Falling Head Test Report

Client:	Dee Why RSL	Project No:	84926.03
Project:	Proposed Car Park Upgrade	Test date:	24.11.16 (9.39 am)
Location:	932 Pittwater Road, Dee Why	Tested by:	VK

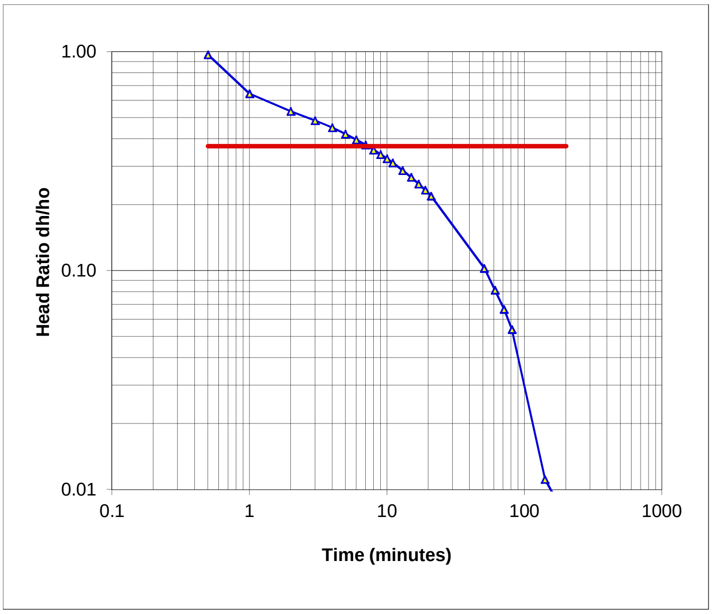
Test Location		**Test No.**	BH304	
Description:	Standpipe in borehole	Easting:	341634	m
Material type:	Sandstone (Screen interval: 10.0-19.0 m)	Northing	6264180	m
		Surface Level:	8.9	m AHD

Details of Well Installation

Well casing diameter (2r)	76	mm	Depth to water before test	0.34	m
Well screen diameter (2R)	76	mm	Depth to water at start of test	3.84	m
Length of well screen (Le)	9	m			

Test Results

Time (min)	Depth (m)	Change in Head: δH (m)	δH/Ho
0	3.84	3.50	1.000
0.5	3.734	3.39	0.970
1	2.589	2.25	0.643
2	2.21	1.87	0.534
3	2.037	1.70	0.485
4	1.913	1.57	0.449
5	1.813	1.47	0.421
6	1.726	1.39	0.396
7	1.652	1.31	0.375
8	1.587	1.25	0.356
9	1.528	1.19	0.339
10	1.477	1.14	0.325
11	1.43	1.09	0.311
13	1.344	1.00	0.287
15	1.274	0.93	0.267
17	1.211	0.87	0.249
19	1.157	0.82	0.233
21	1.107	0.77	0.219
51	0.699	0.36	0.103
61	0.625	0.29	0.081
71	0.573	0.23	0.067
81	0.529	0.19	0.054
141	0.379	0.04	0.011
201	0.314	0.03	0.007



To = 7 mins
420 secs

Theory:

Falling Head Permeability calculated using equation by Hvorslev

$k = [r^2 \ln(Le/R)]/2Le\ To$

where r = radius of casing
R = radius of well screen
Le = length of well screen
To = time taken to rise or fall to 37% of initial change

Hydraulic Conductivity	**k =**	**1.0E-06**	m/sec
	=	**0.376**	cm/hour

Appendix D

Laboratory Results

12 Ashley Street, Chatswood, NSW 2067
tel: +61 2 9910 6200

email: sydney@envirolab.com.au
envirolab.com.au

Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 157839

Client:

Douglas Partners Pty Ltd
96 Hermitage Rd
West Ryde
NSW 2114

Attention: Veronica Ku, Huw Smith

Sample log in details:

Your Reference:	**84926.03, Dee Why**
No. of samples:	10 Soils
Date samples received / completed instructions received	23/11/16 / 23/11/16

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.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by: / Issue Date:	30/11/16 / 30/11/16
Date of Preliminary Report:	Not Issued

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Accredited for compliance with ISO/IEC 17025 - Testing **Tests not covered by NATA are denoted with *.**

Results Approved By:

David Springer
General Manager

vTRH(C6-C10)/BTEXN in Soil					
Our Reference:	UNITS	157839-1	157839-2	157839-3	157839-4
Your Reference	-------------	BH303	BH303	TS	TB
Depth	------------	0.1-0.2	0.4-0.5	-	-
Type of sample		Soil	Soil	Soil	Soil
Date Sampled		21/11/2016	21/11/2016	-	-
Date extracted	-	25/11/2016	25/11/2016	25/11/2016	25/11/2016
Date analysed	-	28/11/2016	28/11/2016	28/11/2016	28/11/2016
TRHC$_6$ - C$_9$	mg/kg	<25	<25	[NA]	[NA]
TRHC$_6$ - C$_{10}$	mg/kg	<25	<25	[NA]	[NA]
vTPH C$_6$ - C$_{10}$ less BTEX (F1)	mg/kg	<25	<25	[NA]	[NA]
Benzene	mg/kg	<0.2	<0.2	98%	<0.2
Toluene	mg/kg	<0.5	<0.5	98%	<0.5
Ethylbenzene	mg/kg	<1	<1	97%	<1
m+p-xylene	mg/kg	<2	<2	99%	<2
o-Xylene	mg/kg	<1	<1	98%	<1
naphthalene	mg/kg	<1	<1	[NA]	[NA]
Surrogate aaa-Trifluorotoluene	%	85	81	87	94

svTRH (C10-C40) in Soil			
Our Reference:	UNITS	157839-1	157839-2
Your Reference	------------- -	BH303	BH303
Depth	------------	0.1-0.2	0.4-0.5
Type of sample		Soil	Soil
Date Sampled		21/11/2016	21/11/2016
Date extracted	-	24/11/2016	24/11/2016
Date analysed	-	25/11/2016	25/11/2016
TRHC $_{10}$ - C $_{14}$	mg/kg	<50	<50
TRHC $_{15}$ - C $_{28}$	mg/kg	<100	<100
TRHC $_{29}$ - C $_{36}$	mg/kg	<100	<100
TRH>C $_{10}$-C $_{16}$	mg/kg	<50	<50
TRH>C $_{10}$ - C $_{16}$ less Naphthalene (F2)	mg/kg	<50	<50
TRH>C $_{16}$-C $_{34}$	mg/kg	<100	<100
TRH>C $_{34}$-C $_{40}$	mg/kg	<100	<100
Surrogate o-Terphenyl	%	87	107

PAHs in Soil			
Our Reference:	UNITS	157839-1	157839-2
Your Reference	------------- -	BH303	BH303
Depth	------------	0.1-0.2	0.4-0.5
Type of sample		Soil	Soil
Date Sampled		21/11/2016	21/11/2016
Date extracted	-	24/11/2016	24/11/2016
Date analysed	-	28/11/2016	28/11/2016
Naphthalene	mg/kg	<0.1	<0.1
Acenaphthylene	mg/kg	<0.1	<0.1
Acenaphthene	mg/kg	<0.1	<0.1
Fluorene	mg/kg	<0.1	<0.1
Phenanthrene	mg/kg	0.5	<0.1
Anthracene	mg/kg	0.1	<0.1
Fluoranthene	mg/kg	0.7	<0.1
Pyrene	mg/kg	0.7	<0.1
Benzo(a)anthracene	mg/kg	0.2	<0.1
Chrysene	mg/kg	0.3	<0.1
Benzo(b,j+k)fluoranthene	mg/kg	0.4	<0.2
Benzo(a)pyrene	mg/kg	0.2	<0.05
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	<0.1
Dibenzo(a,h)anthracene	mg/kg	<0.1	<0.1
Benzo(g,h,i)perylene	mg/kg	0.1	<0.1
Benzo(a)pyrene TEQ calc (zero)	mg/kg	<0.5	<0.5
Benzo(a)pyrene TEQ calc(half)	mg/kg	<0.5	<0.5
Benzo(a)pyrene TEQ calc(PQL)	mg/kg	<0.5	<0.5
Total +ve PAH's	mg/kg	3.4	NIL (+)VE
Surrogate p-Terphenyl-d14	%	93	92

Organochlorine Pesticides in soil Our Reference: Your Reference Depth Type of sample Date Sampled	UNITS ------------- ------------	157839-1 BH303 0.1-0.2 Soil 21/11/2016	157839-2 BH303 0.4-0.5 Soil 21/11/2016
Date extracted	-	24/11/2016	24/11/2016
Date analysed	-	26/11/2016	26/11/2016
HCB	mg/kg	<0.1	<0.1
alpha-BHC	mg/kg	<0.1	<0.1
gamma-BHC	mg/kg	<0.1	<0.1
beta-BHC	mg/kg	<0.1	<0.1
Heptachlor	mg/kg	<0.1	<0.1
delta-BHC	mg/kg	<0.1	<0.1
Aldrin	mg/kg	<0.1	<0.1
Heptachlor Epoxide	mg/kg	<0.1	<0.1
gamma-Chlordane	mg/kg	<0.1	<0.1
alpha-chlordane	mg/kg	<0.1	<0.1
Endosulfan I	mg/kg	<0.1	<0.1
pp-DDE	mg/kg	<0.1	<0.1
Dieldrin	mg/kg	<0.1	<0.1
Endrin	mg/kg	<0.1	<0.1
pp-DDD	mg/kg	<0.1	<0.1
Endosulfan II	mg/kg	<0.1	<0.1
pp-DDT	mg/kg	<0.1	<0.1
Endrin Aldehyde	mg/kg	<0.1	<0.1
Endosulfan Sulphate	mg/kg	<0.1	<0.1
Methoxychlor	mg/kg	<0.1	<0.1
Surrogate TCMX	%	114	122

Organophosphorus Pesticides			
Our Reference:	UNITS	157839-1	157839-2
Your Reference	------------- -	BH303	BH303
Depth	------------	0.1-0.2	0.4-0.5
Type of sample		Soil	Soil
Date Sampled		21/11/2016	21/11/2016
Date extracted	-	24/11/2016	24/11/2016
Date analysed	-	26/11/2016	26/11/2016
Azinphos-methyl (Guthion)	mg/kg	<0.1	<0.1
Bromophos-ethyl	mg/kg	<0.1	<0.1
Chlorpyriphos	mg/kg	<0.1	<0.1
Chlorpyriphos-methyl	mg/kg	<0.1	<0.1
Diazinon	mg/kg	<0.1	<0.1
Dichlorvos	mg/kg	<0.1	<0.1
Dimethoate	mg/kg	<0.1	<0.1
Ethion	mg/kg	<0.1	<0.1
Fenitrothion	mg/kg	<0.1	<0.1
Malathion	mg/kg	<0.1	<0.1
Parathion	mg/kg	<0.1	<0.1
Ronnel	mg/kg	<0.1	<0.1
Surrogate TCMX	%	114	122

PCBs in Soil			
Our Reference:	UNITS	157839-1	157839-2
Your Reference	------------- -	BH303	BH303
Depth	------------	0.1-0.2	0.4-0.5
Type of sample		Soil	Soil
Date Sampled		21/11/2016	21/11/2016
Date extracted	-	24/11/2016	24/11/2016
Date analysed	-	26/11/2016	26/11/2016
Aroclor 1016	mg/kg	<0.1	<0.1
Aroclor 1221	mg/kg	<0.1	<0.1
Aroclor 1232	mg/kg	<0.1	<0.1
Aroclor 1242	mg/kg	<0.1	<0.1
Aroclor 1248	mg/kg	<0.1	<0.1
Aroclor 1254	mg/kg	<0.1	<0.1
Aroclor 1260	mg/kg	<0.1	<0.1
Surrogate TCLMX	%	114	122

Acid Extractable metals in soil				
Our Reference:	UNITS	157839-1	157839-2	157839-11
Your Reference	-------------	BH303	BH303	BH303 - [TRIPLICATE]
Depth	------------	0.1-0.2	0.4-0.5	0.1-0.2
Type of sample		Soil	Soil	Soil
Date Sampled		21/11/2016	21/11/2016	21/11/2016
Date prepared	-	25/11/2016	25/11/2016	25/11/2016
Date analysed	-	28/11/2016	28/11/2016	28/11/2016
Arsenic	mg/kg	5	<4	<4
Cadmium	mg/kg	<0.4	<0.4	<0.4
Chromium	mg/kg	55	19	58
Copper	mg/kg	3	6	10
Lead	mg/kg	8	95	6
Mercury	mg/kg	<0.1	0.2	<0.1
Nickel	mg/kg	11	3	29
Zinc	mg/kg	14	66	20

Misc Soil - Inorg			
Our Reference:	UNITS	157839-1	157839-2
Your Reference	------------- -	BH303	BH303
Depth	------------	0.1-0.2	0.4-0.5
Type of sample		Soil	Soil
Date Sampled		21/11/2016	21/11/2016
Date prepared	-	24/11/2016	24/11/2016
Date analysed	-	24/11/2016	24/11/2016
Total Phenolics (as Phenol)	mg/kg	<5	<5

Moisture			
Our Reference:	UNITS	157839-1	157839-2
Your Reference	------------- -	BH303	BH303
Depth	------------	0.1-0.2	0.4-0.5
Type of sample		Soil	Soil
Date Sampled		21/11/2016	21/11/2016
Date prepared	-	23/11/2016	23/11/2016
Date analysed	-	24/11/2016	24/11/2016
Moisture	%	11	39

Asbestos ID - soils			
Our Reference:	UNITS	157839-1	157839-2
Your Reference	-------------	BH303	BH303
Depth	------------	0.1-0.2	0.4-0.5
Type of sample		Soil	Soil
Date Sampled		21/11/2016	21/11/2016
Date analysed	-	28/11/2016	28/11/2016
Sample mass tested	g	Approx. 35g	Approx. 25g
Sample Description	-	Red coarse-grained soil & rocks	Brown coarse-grained soil & rocks
Asbestos ID in soil	-	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected	No asbestos detected at reporting limit of 0.1g/kg Organic fibres detected
Trace Analysis	-	No asbestos detected	No asbestos detected

Misc Inorg - Soil					
Our Reference:	UNITS	157839-5	157839-6	157839-7	157839-8
Your Reference	-------------	BH301	BH302	BH303	BH304
Depth	------------	2.95	4.5-4.95	6.5-6.95	6.0-6.45
Type of sample		Soil	Soil	Soil	Soil
Date Sampled		11/11/2016	16/11/2016	21/11/2016	17/11/2016
Date prepared	-	24/11/2016	24/11/2016	24/11/2016	24/11/2016
Date analysed	-	24/11/2016	24/11/2016	24/11/2016	24/11/2016
pH 1:5 soil:water	pH Units	5.4	5.1	5.6	6.0
Electrical Conductivity 1:5 soil:water	µS/cm	27	31	14	15
Chloride, Cl 1:5 soil:water	mg/kg	<10	<10	<10	10
Sulphate, SO4 1:5 soil:water	mg/kg	10	20	<10	<10

Chromium Suite Our Reference:	UNITS	157839-5	157839-9	157839-10
Your Reference	-------------	BH301	BH301	BH301
Depth	------------	2.95	4.7-4.95	7.7-7.95
Type of sample		Soil	Soil	Soil
Date Sampled		11/11/2016	11/11/2016	11/11/2016
Date prepared	-	24/11/2016	24/11/2016	24/11/2016
Date analysed	-	24/11/2016	24/11/2016	24/11/2016
pH_{kcl}	pH units	4.5	4.1	3.9
s-TAA pH 6.5	%w/w S	0.01	0.05	0.04
TAA pH 6.5	moles H^+/t	9	34	24
Chromium Reducible Sulfur	%w/w	0.01	0.02	0.02
a-Chromium Reducible Sulfur	moles H^+/t	10	12	10
S_{HCl}	%w/w S	<0.005	<0.005	<0.005
S_{KCl}	%w/w S	<0.005	<0.005	<0.005
S_{NAS}	%w/w S	<0.005	<0.005	<0.005
ANC_{BT}	% $CaCO_3$	<0.05	<0.05	<0.05
s-ANC_{BT}	%w/w S	<0.05	<0.05	<0.05
s-Net Acidity	%w/w S	0.03	0.07	0.05
a-Net Acidity	moles H^+/t	18	46	34
Liming rate	kg $CaCO_3/t$	1.4	3.5	2.6
a-Net Acidity without ANCE	moles H^+/t	18	46	34
Liming rate without ANCE	kg $CaCO_3/t$	1.4	3.5	2.6

Method ID	Methodology Summary
Org-016	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.
Org-014	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS.
Org-003	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-012	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013. For soil results:- 1. 'TEQ PQL' values are assuming all contributing PAHs reported as <PQL are actually at the PQL. This is the most conservative approach and can give false positive TEQs given that PAHs that contribute to the TEQ calculation may not be present. 2. 'TEQ zero' values are assuming all contributing PAHs reported as <PQL are zero. This is the least conservative approach and is more susceptible to false negative TEQs when PAHs that contribute to the TEQ calculation are present but below PQL. 3. 'TEQ half PQL' values are assuming all contributing PAHs reported as <PQL are half the stipulated PQL. Hence a mid-point between the most and least conservative approaches above. Note, the Total +ve PAHs PQL is reflective of the lowest individual PQL and is therefore" Total +ve PAHs" is simply a sum of the positive individual PAHs.
Org-005	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
Org-008	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC with dual ECD's.
Org-006	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-ECD.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Inorg-031	Total Phenolics by segmented flow analyser (in line distillation with colourimetric finish). Solids are extracted in a caustic media prior to analysis.
Inorg-008	Moisture content determined by heating at 105+/-5 deg C for a minimum of 12 hours.
ASB-001	Asbestos ID - Qualitative identification of asbestos in bulk samples using Polarised Light Microscopy and Dispersion Staining Techniques including Synthetic Mineral Fibre and Organic Fibre as per Australian Standard 4964-2004.
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 25oC in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.
Inorg-068	Chromium Reducible Sulfur - Hydrogen Sulfide is quantified by iodometric titration after distillation to determine potential acidity. Based on Acid Sulfate Soils Laboratory Methods Guidelines, Version 2.1 - June 2004.

Method ID	Methodology Summary

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			25/11/2016	157839-1	25/11/2016 || 25/11/2016	LCS-5	25/11/2016
Date analysed	-			28/11/2016	157839-1	28/11/2016 || 28/11/2016	LCS-5	28/11/2016
TRHC_6 - C_9	mg/kg	25	Org-016	<25	157839-1	<25 || <25	LCS-5	99%
TRHC_6 - C_{10}	mg/kg	25	Org-016	<25	157839-1	<25 || <25	LCS-5	99%
Benzene	mg/kg	0.2	Org-016	<0.2	157839-1	<0.2 || <0.2	LCS-5	104%
Toluene	mg/kg	0.5	Org-016	<0.5	157839-1	<0.5 || <0.5	LCS-5	101%
Ethylbenzene	mg/kg	1	Org-016	<1	157839-1	<1 || <1	LCS-5	97%
m+p-xylene	mg/kg	2	Org-016	<2	157839-1	<2 || <2	LCS-5	97%
o-Xylene	mg/kg	1	Org-016	<1	157839-1	<1 || <1	LCS-5	98%
naphthalene	mg/kg	1	Org-014	<1	157839-1	<1 || <1	[NR]	[NR]
Surrogate aaa-Trifluorotoluene	%		Org-016	97	157839-1	85 || 93 || RPD: 9	LCS-5	93%

QUALITY CONTROL svTRH (C10-C40) in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			25/11/2016	157839-1	24/11/2016 || 24/11/2016	LCS-5	25/11/2016
Date analysed	-			25/11/2016	157839-1	25/11/2016 || 25/11/2016	LCS-5	25/11/2016
TRHC_{10} - C_{14}	mg/kg	50	Org-003	<50	157839-1	<50 || <50	LCS-5	121%
TRHC_{15} - C_{28}	mg/kg	100	Org-003	<100	157839-1	<100 || <100	LCS-5	117%
TRHC_{29} - C_{36}	mg/kg	100	Org-003	<100	157839-1	<100 || <100	LCS-5	92%
TRH>C_{10}-C_{16}	mg/kg	50	Org-003	<50	157839-1	<50 || <50	LCS-5	121%
TRH>C_{16}-C_{34}	mg/kg	100	Org-003	<100	157839-1	<100 || <100	LCS-5	117%
TRH>C_{34}-C_{40}	mg/kg	100	Org-003	<100	157839-1	<100 || <100	LCS-5	92%
Surrogate o-Terphenyl	%		Org-003	90	157839-1	87 || 99 || RPD: 13	LCS-5	97%

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			24/11/2016	157839-1	24/11/2016 || 24/11/2016	LCS-5	24/11/2016
Date analysed	-			28/11/2016	157839-1	28/11/2016 || 28/11/2016	LCS-5	28/11/2016
Naphthalene	mg/kg	0.1	Org-012	<0.1	157839-1	<0.1 || <0.1	LCS-5	103%
Acenaphthylene	mg/kg	0.1	Org-012	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Acenaphthene	mg/kg	0.1	Org-012	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Fluorene	mg/kg	0.1	Org-012	<0.1	157839-1	<0.1 || <0.1	LCS-5	98%
Phenanthrene	mg/kg	0.1	Org-012	<0.1	157839-1	0.5 || 0.6 || RPD: 18	LCS-5	102%
Anthracene	mg/kg	0.1	Org-012	<0.1	157839-1	0.1 || 0.1 || RPD: 0	[NR]	[NR]
Fluoranthene	mg/kg	0.1	Org-012	<0.1	157839-1	0.7 || 0.8 || RPD: 13	LCS-5	95%
Pyrene	mg/kg	0.1	Org-012	<0.1	157839-1	0.7 || 0.7 || RPD: 0	LCS-5	99%
Benzo(a)anthracene	mg/kg	0.1	Org-012	<0.1	157839-1	0.2 || 0.2 || RPD: 0	[NR]	[NR]
Chrysene	mg/kg	0.1	Org-012	<0.1	157839-1	0.3 || 0.2 || RPD: 40	[NR]	[NR]
Benzo(b,j+k) fluoranthene	mg/kg	0.2	Org-012	<0.2	157839-1	0.4 || 0.3 || RPD: 29	[NR]	[NR]

QUALITY CONTROL PAHs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Benzo(a)pyrene	mg/kg	0.05	Org-012	<0.05	157839-1	0.2 || 0.2 || RPD: 0	LCS-5	102%
Indeno(1,2,3-c,d)pyrene	mg/kg	0.1	Org-012	<0.1	157839-1	0.1 || 0.1 || RPD: 0	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	0.1	Org-012	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	0.1	Org-012	<0.1	157839-1	0.1 || 0.2 || RPD: 67	[NR]	[NR]
Surrogate p-Terphenyl-d14	%		Org-012	97	157839-1	93 || 100 || RPD: 7	LCS-5	116%

QUALITY CONTROL Organochlorine Pesticides in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			24/11/2016	157839-1	24/11/2016 || 24/11/2016	LCS-5	24/11/2016
Date analysed	-			26/11/2016	157839-1	26/11/2016 || 26/11/2016	LCS-5	26/11/2016
HCB	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
alpha-BHC	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	88%
gamma-BHC	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
beta-BHC	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	94%
Heptachlor	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	91%
delta-BHC	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Aldrin	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	91%
Heptachlor Epoxide	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	96%
gamma-Chlordane	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
alpha-chlordane	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Endosulfan I	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
pp-DDE	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	95%
Dieldrin	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	102%
Endrin	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	128%
pp-DDD	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	98%
Endosulfan II	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
pp-DDT	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Endrin Aldehyde	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Endosulfan Sulphate	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	LCS-5	82%
Methoxychlor	mg/kg	0.1	Org-005	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Surrogate TCMX	%		Org-005	110	157839-1	114 || 114 || RPD: 0	LCS-5	89%

QUALITY CONTROL Organophosphorus Pesticides	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			24/11/2016	157839-1	24/11/2016 || 24/11/2016	LCS-5	24/11/2016
Date analysed	-			26/11/2016	157839-1	26/11/2016 || 26/11/2016	LCS-5	26/11/2016
Azinphos-methyl (Guthion)	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Bromophos-ethyl	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Chlorpyriphos	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	LCS-5	96%
Chlorpyriphos-methyl	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Diazinon	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Dichlorvos	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	LCS-5	124%
Dimethoate	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Ethion	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	LCS-5	94%
Fenitrothion	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	LCS-5	108%
Malathion	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	LCS-5	93%
Parathion	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	LCS-5	109%
Ronnel	mg/kg	0.1	Org-008	<0.1	157839-1	<0.1 || <0.1	LCS-5	107%
Surrogate TCMX	%		Org-008	110	157839-1	114 || 114 || RPD: 0	LCS-5	109%

QUALITY CONTROL PCBs in Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date extracted	-			24/11/2016	157839-1	24/11/2016 || 24/11/2016	LCS-5	24/11/2016
Date analysed	-			26/11/2016	157839-1	26/11/2016 || 26/11/2016	LCS-5	26/11/2016
Aroclor 1016	mg/kg	0.1	Org-006	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1221	mg/kg	0.1	Org-006	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1232	mg/kg	0.1	Org-006	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1242	mg/kg	0.1	Org-006	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1248	mg/kg	0.1	Org-006	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Aroclor 1254	mg/kg	0.1	Org-006	<0.1	157839-1	<0.1 || <0.1	LCS-5	101%
Aroclor 1260	mg/kg	0.1	Org-006	<0.1	157839-1	<0.1 || <0.1	[NR]	[NR]
Surrogate TCLMX	%		Org-006	110	157839-1	114 || 114 || RPD: 0	LCS-5	109%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base || Duplicate || %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			25/11/2016	157839-1	25/11/2016 || 25/11/2016	LCS-5	25/11/2016
Date analysed	-			28/11/2016	157839-1	28/11/2016 || 28/11/2016	LCS-5	28/11/2016
Arsenic	mg/kg	4	Metals-020	<4	157839-1	5 || 4 || RPD: 22	LCS-5	110%
Cadmium	mg/kg	0.4	Metals-020	<0.4	157839-1	<0.4 || <0.4	LCS-5	99%
Chromium	mg/kg	1	Metals-020	<1	157839-1	55 || 61 || RPD: 10	LCS-5	106%
Copper	mg/kg	1	Metals-020	<1	157839-1	3 || 9 || RPD: 100	LCS-5	107%
Lead	mg/kg	1	Metals-020	<1	157839-1	8 || 7 || RPD: 13	LCS-5	101%
Mercury	mg/kg	0.1	Metals-021	<0.1	157839-1	<0.1 || <0.1	LCS-5	91%
Nickel	mg/kg	1	Metals-020	<1	157839-1	11 || 25 || RPD: 78	LCS-5	95%
Zinc	mg/kg	1	Metals-020	<1	157839-1	14 || 20 || RPD: 35	LCS-5	98%

QUALITY CONTROL Misc Soil - Inorg	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base || Duplicate || %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			24/11/2016	[NT]	[NT]	LCS-1	24/11/2016
Date analysed	-			24/11/2016	[NT]	[NT]	LCS-1	24/11/2016
Total Phenolics (as Phenol)	mg/kg	5	Inorg-031	<5	[NT]	[NT]	LCS-1	94%

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base || Duplicate || %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			24/11/2016	[NT]	[NT]	LCS-5	24/11/2016
Date analysed	-			24/11/2016	[NT]	[NT]	LCS-5	24/11/2016
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-5	101%
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	LCS-5	102%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-5	90%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-5	94%

QUALITY CONTROL Chromium Suite	UNITS	PQL	METHOD	Blank
Date prepared	-			24/11/2016
Date analysed	-			24/11/2016
pH$_{kcl}$	pH units		Inorg-068	[NT]
s-TAA pH 6.5	%w/w S	0.01	Inorg-068	<0.01
TAA pH 6.5	moles H$^+$/t	5	Inorg-068	<5
Chromium Reducible Sulfur	%w/w	0.005	Inorg-068	<0.005

QUALITY CONTROL Chromium Suite	UNITS	PQL	METHOD	Blank
a-Chromium Reducible Sulfur	moles H^+/t	3	Inorg-068	<3
S_{HCl}	%w/w S	0.005	Inorg-068	<0.005
S_{KCl}	%w/w S	0.005	Inorg-068	<0.005
S_{NAS}	%w/w S	0.005	Inorg-068	<0.005
ANC_{BT}	% $CaCO_3$	0.05	Inorg-068	<0.05
s-ANC_{BT}	%w/w S	0.05	Inorg-068	<0.05
s-Net Acidity	%w/w S	0.01	Inorg-068	<0.01
a-Net Acidity	moles H^+/t	10	Inorg-068	<10
Liming rate	kg $CaCO_3$ /t	0.75	Inorg-068	<0.75
a-Net Acidity without ANCE	moles H^+/t	10	Inorg-068	<10
Liming rate without ANCE	kg $CaCO_3$ /t	0.75	Inorg-068	<0.75

QUALITY CONTROL vTRH(C6-C10)/BTEXN in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	157839-2	25/11/2016
Date analysed	-	[NT]	[NT]	157839-2	28/11/2016
TRHC_6 - C_9	mg/kg	[NT]	[NT]	157839-2	98%
TRHC_6 - C_{10}	mg/kg	[NT]	[NT]	157839-2	98%
Benzene	mg/kg	[NT]	[NT]	157839-2	103%
Toluene	mg/kg	[NT]	[NT]	157839-2	97%
Ethylbenzene	mg/kg	[NT]	[NT]	157839-2	97%
m+p-xylene	mg/kg	[NT]	[NT]	157839-2	97%
o-Xylene	mg/kg	[NT]	[NT]	157839-2	99%
naphthalene	mg/kg	[NT]	[NT]	[NR]	[NR]
Surrogate aaa-Trifluorotoluene	%	[NT]	[NT]	157839-2	81%

QUALITY CONTROL svTRH (C10-C40) in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	157839-2	24/11/2016
Date analysed	-	[NT]	[NT]	157839-2	25/11/2016
TRHC_{10} - C_{14}	mg/kg	[NT]	[NT]	157839-2	116%
TRHC_{15} - C_{28}	mg/kg	[NT]	[NT]	157839-2	111%
TRHC_{29} - C_{36}	mg/kg	[NT]	[NT]	157839-2	101%
TRH>C_{10}-C_{16}	mg/kg	[NT]	[NT]	157839-2	116%
TRH>C_{16}-C_{34}	mg/kg	[NT]	[NT]	157839-2	111%
TRH>C_{34}-C_{40}	mg/kg	[NT]	[NT]	157839-2	101%
Surrogate o-Terphenyl	%	[NT]	[NT]	157839-2	107%

QUALITY CONTROL PAHs in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	157839-2	24/11/2016
Date analysed	-	[NT]	[NT]	157839-2	28/11/2016
Naphthalene	mg/kg	[NT]	[NT]	157839-2	101%
Acenaphthylene	mg/kg	[NT]	[NT]	[NR]	[NR]
Acenaphthene	mg/kg	[NT]	[NT]	[NR]	[NR]
Fluorene	mg/kg	[NT]	[NT]	157839-2	92%
Phenanthrene	mg/kg	[NT]	[NT]	157839-2	84%
Anthracene	mg/kg	[NT]	[NT]	[NR]	[NR]
Fluoranthene	mg/kg	[NT]	[NT]	157839-2	81%
Pyrene	mg/kg	[NT]	[NT]	157839-2	90%
Benzo(a)anthracene	mg/kg	[NT]	[NT]	[NR]	[NR]
Chrysene	mg/kg	[NT]	[NT]	[NR]	[NR]
Benzo(b,j+k)fluoranthene	mg/kg	[NT]	[NT]	[NR]	[NR]
Benzo(a)pyrene	mg/kg	[NT]	[NT]	157839-2	109%
Indeno(1,2,3-c,d)pyrene	mg/kg	[NT]	[NT]	[NR]	[NR]
Dibenzo(a,h)anthracene	mg/kg	[NT]	[NT]	[NR]	[NR]
Benzo(g,h,i)perylene	mg/kg	[NT]	[NT]	[NR]	[NR]
Surrogate p-Terphenyl-d14	%	[NT]	[NT]	157839-2	123%

QUALITY CONTROL Organochlorine Pesticides in soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	157839-2	24/11/2016
Date analysed	-	[NT]	[NT]	157839-2	26/11/2016
HCB	mg/kg	[NT]	[NT]	[NR]	[NR]
alpha-BHC	mg/kg	[NT]	[NT]	157839-2	97%
gamma-BHC	mg/kg	[NT]	[NT]	[NR]	[NR]
beta-BHC	mg/kg	[NT]	[NT]	157839-2	106%
Heptachlor	mg/kg	[NT]	[NT]	157839-2	102%
delta-BHC	mg/kg	[NT]	[NT]	[NR]	[NR]
Aldrin	mg/kg	[NT]	[NT]	157839-2	87%
Heptachlor Epoxide	mg/kg	[NT]	[NT]	157839-2	108%
gamma-Chlordane	mg/kg	[NT]	[NT]	[NR]	[NR]
alpha-chlordane	mg/kg	[NT]	[NT]	[NR]	[NR]
Endosulfan I	mg/kg	[NT]	[NT]	[NR]	[NR]
pp-DDE	mg/kg	[NT]	[NT]	157839-2	105%
Dieldrin	mg/kg	[NT]	[NT]	157839-2	111%
Endrin	mg/kg	[NT]	[NT]	157839-2	112%
pp-DDD	mg/kg	[NT]	[NT]	157839-2	108%
Endosulfan II	mg/kg	[NT]	[NT]	[NR]	[NR]
pp-DDT	mg/kg	[NT]	[NT]	[NR]	[NR]
Endrin Aldehyde	mg/kg	[NT]	[NT]	[NR]	[NR]
Endosulfan Sulphate	mg/kg	[NT]	[NT]	157839-2	93%
Methoxychlor	mg/kg	[NT]	[NT]	[NR]	[NR]
Surrogate TCMX	%	[NT]	[NT]	157839-2	102%

QUALITY CONTROL Organophosphorus Pesticides	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	157839-2	24/11/2016
Date analysed	-	[NT]	[NT]	157839-2	26/11/2016
Azinphos-methyl (Guthion)	mg/kg	[NT]	[NT]	[NR]	[NR]
Bromophos-ethyl	mg/kg	[NT]	[NT]	[NR]	[NR]
Chlorpyriphos	mg/kg	[NT]	[NT]	157839-2	107%
Chlorpyriphos-methyl	mg/kg	[NT]	[NT]	[NR]	[NR]
Diazinon	mg/kg	[NT]	[NT]	[NR]	[NR]
Dichlorvos	mg/kg	[NT]	[NT]	157839-2	109%
Dimethoate	mg/kg	[NT]	[NT]	[NR]	[NR]
Ethion	mg/kg	[NT]	[NT]	157839-2	113%
Fenitrothion	mg/kg	[NT]	[NT]	157839-2	106%
Malathion	mg/kg	[NT]	[NT]	157839-2	103%
Parathion	mg/kg	[NT]	[NT]	157839-2	105%
Ronnel	mg/kg	[NT]	[NT]	157839-2	111%
Surrogate TCMX	%	[NT]	[NT]	157839-2	120%

QUALITY CONTROL PCBs in Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date extracted	-	[NT]	[NT]	157839-2	24/11/2016
Date analysed	-	[NT]	[NT]	157839-2	26/11/2016
Aroclor 1016	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1221	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1232	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1242	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1248	mg/kg	[NT]	[NT]	[NR]	[NR]
Aroclor 1254	mg/kg	[NT]	[NT]	157839-2	105%
Aroclor 1260	mg/kg	[NT]	[NT]	[NR]	[NR]
Surrogate TCLMX	%	[NT]	[NT]	157839-2	120%

QUALITY CONTROL Acid Extractable metals in soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	157839-2	25/11/2016
Date analysed	-	[NT]	[NT]	157839-2	28/11/2016
Arsenic	mg/kg	[NT]	[NT]	157839-2	81%
Cadmium	mg/kg	[NT]	[NT]	157839-2	84%
Chromium	mg/kg	[NT]	[NT]	157839-2	94%
Copper	mg/kg	[NT]	[NT]	157839-2	88%
Lead	mg/kg	[NT]	[NT]	157839-2	80%
Mercury	mg/kg	[NT]	[NT]	157839-2	78%
Nickel	mg/kg	[NT]	[NT]	157839-2	81%
Zinc	mg/kg	[NT]	[NT]	157839-2	#

QUALITY CONTROL Misc Inorg - Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	157839-5	24/11/2016 || 24/11/2016
Date analysed	-	157839-5	24/11/2016 || 24/11/2016
pH 1:5 soil:water	pH Units	157839-5	5.4 || 5.4 || RPD: 0
Electrical Conductivity 1:5 soil:water	µS/cm	157839-5	27 || 23 || RPD: 16
Chloride, Cl 1:5 soil:water	mg/kg	157839-5	<10 || <10
Sulphate, SO4 1:5 soil:water	mg/kg	157839-5	10 || 10 || RPD: 0

QUALITY CONTROL Chromium Suite	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD
Date prepared	-	157839-5	24/11/2016 || 24/11/2016
Date analysed	-	157839-5	24/11/2016 || 24/11/2016
pH_{kcl}	pH units	157839-5	4.5 || 4.6 || RPD: 2
s-TAA pH 6.5	%w/w S	157839-5	0.01 || 0.01 || RPD: 0
TAA pH 6.5	moles H^+/t	157839-5	9 || 9 || RPD: 0
Chromium Reducible Sulfur	% w / w	157839-5	0.01 || 0.02 || RPD: 67
a-Chromium Reducible Sulfur	moles H^+/t	157839-5	10 || 11 || RPD: 10
S_{HCl}	%w/w S	157839-5	<0.005 || <0.005
S_{KCl}	%w/w S	157839-5	<0.005 || <0.005
S_{NAS}	%w/w S	157839-5	<0.005 || <0.005
ANC_{BT}	% $CaCO_3$	157839-5	<0.05 || <0.05
s-ANC_{BT}	%w/w S	157839-5	<0.05 || <0.05
s-Net Acidity	%w/w S	157839-5	0.03 || 0.03 || RPD: 0
a-Net Acidity	moles H^+/t	157839-5	18 || 19 || RPD: 5
Liming rate	kg $CaCO_3$ /t	157839-5	1.4 || 1.4 || RPD: 0
a-Net Acidity without ANCE	moles H^+/t	157839-5	18 || 19 || RPD: 5
Liming rate without ANCE	kg $CaCO_3$ /t	157839-5	1.4 || 1.4 || RPD: 0

QUALITY CONTROL Misc Inorg - Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	157839-6	24/11/2016
Date analysed	-	[NT]	[NT]	157839-6	24/11/2016
pH 1:5 soil:water	pH Units	[NT]	[NT]	[NR]	[NR]
Electrical Conductivity 1:5 soil:water	µS/cm	[NT]	[NT]	[NR]	[NR]
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]	157839-6	88%
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]	157839-6	119%

QUALITY CONTROL Chromium Suite	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	LCS-1	24/11/2016
Date analysed	-	[NT]	[NT]	LCS-1	24/11/2016
pH $_{kcl}$	pH units	[NT]	[NT]	LCS-1	97%
s-TAA pH 6.5	%w/w S	[NT]	[NT]	[NR]	[NR]
TAA pH 6.5	moles H^+/t	[NT]	[NT]	LCS-1	120%
Chromium Reducible Sulfur	% w / w	[NT]	[NT]	LCS-1	85%
a-Chromium Reducible Sulfur	moles H^+/t	[NT]	[NT]	[NR]	[NR]
S_{HCl}	%w/w S	[NT]	[NT]	[NR]	[NR]
S_{KCl}	%w/w S	[NT]	[NT]	[NR]	[NR]
S_{NAS}	%w/w S	[NT]	[NT]	[NR]	[NR]
ANC_{BT}	% $CaCO_3$	[NT]	[NT]	[NR]	[NR]
s-ANC_{BT}	%w/w S	[NT]	[NT]	[NR]	[NR]
s-Net Acidity	%w/w S	[NT]	[NT]	[NR]	[NR]
a-Net Acidity	moles H^+/t	[NT]	[NT]	[NR]	[NR]
Liming rate	kg $CaCO_3$ /t	[NT]	[NT]	[NR]	[NR]
a-Net Acidity without ANCE	moles H^+/t	[NT]	[NT]	[NR]	[NR]
Liming rate without ANCE	kg $CaCO_3$ /t	[NT]	[NT]	[NR]	[NR]

Report Comments:

Asbestos: A portion of the supplied sample was sub-sampled for asbestos analysis according to Envirolab procedures. We cannot guarantee that this sub-sample is indicative of the entire sample. Envirolab recommends supplying 40-50g of sample in its own container.
Note: Samples 157839-1, 2 were sub-sampled from jars provided by the client.

Acid Extractable Metals in Soil: The laboratory RPD acceptance criteria has been exceeded for 157839-1 for Cu and Ni. Therefore a triplicate result has been issued as laboratory sample number 157839-11.

METALS_S: # Percent recovery is not possible to report due to the inhomogeneous nature of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

Asbestos ID was analysed by Approved Identifier:	Lucy Zhu
Asbestos ID was authorised by Approved Signatory:	Paul Ching

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NR: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

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.

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

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

SAMPLE RECEIPT ADVICE

Client Details	
Client	Douglas Partners Pty Ltd
Attention	Veronica Ku, Huw Smith

Sample Login Details	
Your Reference	84926.03, Dee Why
Envirolab Reference	**157839**
Date Sample Received	23/11/2016
Date Instructions Received	23/11/2016
Date Results Expected to be Reported	**30/11/2016**

Sample Condition	
Samples received in appropriate condition for analysis	YES
No. of Samples Provided	10 Soils
Turnaround Time Requested	Standard
Temperature on receipt (°C)	16.8
Cooling Method	Ice Pack
Sampling Date Provided	YES

Comments
Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples

Please direct any queries to:

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

Sample and Testing Details on following page

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

Sample Id	*vTRH(C6-C10)/BTEXN in Soil*	*svTRH (C10-C40) in Soil*	*PAHs in Soil*	*Organochlorine Pesticides in soil*	*Organophosphorus Pesticides*	*PCBs in Soil*	*Acid Extractable metals in soil*	*Total Phenolics (as Phenol)*	*Asbestos ID - soils*	*Chloride, Cl 1:5 soil:water*	*Electrical Conductivity 1:5 soil:water*	*pH 1:5 soil:water*	*Sulphate, SO4 1:5 soil:water*	*Chromium Suite*
BH303-0.1-0.2	✓	✓	✓	✓	✓	✓	✓	✓	✓					
BH303-0.4-0.5	✓	✓	✓	✓	✓	✓	✓	✓	✓					
TS	✓													
TB	✓													
BH301-2.95										✓	✓	✓	✓	✓
BH302-4.5-4.95										✓	✓	✓	✓	
BH303-6.5-6.95										✓	✓	✓	✓	
BH304-6.0-6.45										✓	✓	✓	✓	
BH301-4.7-4.95														✓
BH301-7.7-7.95														✓

Appendix E

GHD Pty Ltd Review Letter
DP Response Letter

Appendix F

Report on Preliminary Shoring Wall Analysis

Appendix G

Groundwater Analysis and Preliminary Modelling