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PALMDEV PTY LTD

Geotechnical Investigation

1112-1116 Barrenjoey Road, Palm Beach NSW

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7 December 2021

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Revision	Details	Date	Amended By
	Original	15 July 2021	
1	Fixed typo	7 September 2021	KX
2	Included architectural drawings and additional boreholes	7 December 2021	KX

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1. Introduction

1.1 Background

At the request of Palmdev Pty Ltd (the Client), EI Australia (EI) has carried out a Geotechnical Investigation (GI) for the proposed development at 1112-1116 Barrenjoey Road, Palm Beach NSW (the Site).

This GI report has been prepared to provide advice and recommendations to assist in the preparation of designs for the proposed development. The investigation has been carried out in accordance with the agreed scope of works outlined in EI's proposal referenced P19388.2, dated 11 May 2019, and with the Client's signed authorisation to proceed, dated 2 June 2021.

1.2 Proposed Development

The following documents, supplied by the Client, were used to assist with the preparation of this GI report:

- Architectural drawings prepared by Koichi Takada Architects – Project at 1112-1118 Barrenjoey Road, Palm Beach, Drawing Nos. A0000 to A0003, A0010 to A0013, A0099 to A0105, A0200 to A0203, and A0300 to A0302, Revision A, dated 20 August 2021;
- Geotechnical Investigation Report prepared by Douglas Partners (DP) – Project No. 36684 02, dated October 2009. This investigation was carried out to provide information on subsurface conditions for DA purpose and for the preliminary assessment for site works and design. It comprised a detailed geological inspection of the site, general inspection of slopes and hand augering of one borehole with Dynamic Cone Penetrometer test in the existing carpark. This report was later updated in accordance with the requirements of Pittwater Geotechnical Risk Management Policy (2009); and
- Site survey plan prepared by Beveridge Williams – Project No. 2101343, Drawing Ref. 2101343, Version B, dated 6 September 2021. The datum in the survey plan is in Australian Height Datum (AHD), hence all Reduced Levels (RL) mentioned in this report are henceforth in AHD.

Based on the email correspondence, EI understands that the proposed development involves the demolition of the existing site structures and the construction of a five-storey mixed-use building overlying a single-level basement. The basement level is proposed to have a Finished Floor Level (FFL) of RL -0.40m and -1.24m. A Bulk Excavation Level (BEL) ranging between RL -0.70m and -1.54m is assumed, which includes allowance for the construction of the basement slab. To achieve the BEL, excavation depths varying from 3.80m (towards east of site) to 14.70m (towards west of site) Below Existing Ground Level (BEGL) have been estimated. Locally deeper excavations may be required for footings, lift overrun pits, crane pads, and service trenches.

1.3 Objectives

The objective of the GI was to assess site surface and subsurface conditions at two borehole locations, and to provide preliminary geotechnical advice and recommendations addressing the following:

- Dilapidation Surveys;
- Excavation methodologies and monitoring requirements;

- Groundwater considerations;
- Vibration considerations;
- Excavation support requirements, including preliminary geotechnical design parameters for retaining walls and shoring systems;
- Building foundation options, including;
  - Preliminary design parameters.
  - Earthquake loading factor in accordance with AS1170.4:2007.
- The requirement for additional geotechnical works.

1.4 Scope of Works

The scope of works for the GI included:

- Preparation of a Work Health and Safety Plan;
- Review of relevant geological maps for the project area;
- Site walkover inspection by a Geotechnical Engineer to assess topographical features and site conditions;
- Scanning of proposed borehole locations for buried conductive services using a licensed service locator with reference to Dial Before You Dig (DBYD) plans;
- Auger drilling of BH101M and BH102 (carried out during month of June 2021) by a track-mounted drill rig using solid flight augers equipped with a 'Tungsten-Carbide' (T-C) bit, and hand auger drilling (carried out during month of October 2021) of additional boreholes, BH103 and BH104M. The boreholes were auger drilled to depths as shown in Table1-1 below:

Table 1-1 Augering and Rock Coring Depths

Borehole ID	Augering		Rock Coring	
	Depth (m)	RL (m AHD)	Depth (m)	RL (m AHD)
BH101M	3.23	-0.92	8.80	-6.49
BH102	9.87	-7.37	-	-
BH103	1.00	11.00	13.00	-1.00
BH104M	0.47	11.53	12.57	-0.57

  - Standard Penetration Testing (SPT) was carried out (as per AS 1289.6.3.1-2004), where possible, during auger drilling of the boreholes to assess soil strength/relative densities;
  - Measurements of groundwater seepage/levels, where possible, in the augered sections of the boreholes during and shortly after completion of auger drilling;
  - The strength of the bedrock in the augered sections of the boreholes was assessed by observation of the auger penetration resistance using a T-C drill bit and examination of

the recovered rock cuttings. It should be noted that rock strengths assessed from augered boreholes are approximate and strength variances can be expected;

- The approximate surface levels shown on the borehole logs were interpolated from spot levels shown on the supplied survey plan. Approximate borehole locations are shown on **Figure 2**;

- Continuation of BH101M, BH103 and BH104M using NMLC diamond coring techniques to termination depths shown above in **Table 1-1**. The rock core photographs are presented in **Appendix A**;
- Two Dynamic Cone Penetrometer (DCP) tests (DCP1 and DCP2) were carried out adjacent to BH103 and BH104M to refusal depths of 0.52m (RL 11.48m) and 0.55m BEGL (RL 11.45m), respectively;
- Borehole BH101M and BH104M were converted into groundwater monitoring wells with depths of 7.00m (RL -4.69m) and 11.00m BEGL (RL 1.00m). Data logger was installed in BH101M to allow for long-term groundwater monitoring;
- Borehole BH102 and BH103 were backfilled with drilling spoils and BH102 was capped with concrete upon completion;
- Soil and rock samples were sent to STS Geotechnics Pty Ltd (STS) and SGS Australia (SGS), which are National Australian Testing Authority (NATA) accredited laboratories, for testing and storage and
- Preparation of this GI report.

EI's Geotechnical Engineer was present full-time onsite to set out the borehole locations, direct the testing and sampling, log the subsurface conditions and record groundwater levels.

1.5 Constraints

The GI was limited by the intent of the investigation and the presence of existing site structures. The discussions and advice presented in this report are preliminary and intended to assist in the preparation of initial designs for the proposed development. Further additional investigation in the form of boreholes in the northern side of the site is required following demolition. Further geotechnical inspections should be carried out during construction to confirm the geotechnical and groundwater models, and the preliminary design parameters provided in this report.

2. Site Description

2.1 Site Description and Identification

The site identification details and associated information are presented in **Table 2-1** below while the site locality is shown on **Figure 1.** An aerial photograph of the site is presented in **Plate 1** below.

Table 2-1 Summary of Site Information

Information	Detail
Street Address	1112-1116 Barrenjoey Road, Palm Beach NSW
Lot and Deposited Plan (DP) Identification	Lot 21 in DP 571298
Brief Site Description	At the time of our investigation, the site was occupied by a single-storey commercial building located within the north-western portion of the site, a two-storey residential building located within the north-eastern portion of the site, a carpark located within the south-western portion of the site and a densely vegetated slope of about 30° within the south-eastern portion of the site. The building structures appeared to be in fair condition based on a cursory inspection of the exterior walls. The carpark is retained by a brick retaining wall of 0.5m to 2.0m height to the south and east.
Site Area	The site area is approximately 1362m^2 (based on the provided survey plan referenced above).

Plate 1: Aerial photograph of the site (source: SIX Maps, accessed 30/6/21)

2.2 Local Land Use

The site is situated within an area of commercial and residential use. Current uses on surrounding land at the time of our presence on site are described in **Table 2-2** below. For the sake of this report, the site boundary adjacent to Barrenjoey Road shall be adopted as the western site boundary.

Table 2-2 Summary of Local Land Use

Direction Relative to Site	Land Use Description
North	Property at No. 1120 Barrenjoey Road, a two-level residential building with concrete driveway. The main house has an offset of about 0.5m from the northern site boundary and appeared to be in fair condition. No. 1120 Barrenjoey Road is on a similar elevation to the site. No basements were observed on this site.
East	Properties at No. 21A and 23 Palm Beach Road, two, two-to-three storey residential building with concrete drive way. The two properties are on a higher elevation to the site.
South	Property at No. 1108 Barrenjoey Road, a two-storey commercial building with brick paved driveway and concrete carpark. The driveway abuts the southern boundary of the site. The main house appeared to be in good condition based on inspection of the external walls. No. 1108 Barrenjoey Road is on a similar elevation to the site. No basements were observed on this site.
West	Barrenjoey Road, a two-lane, asphalt paved road. Beyond this is an asphalt paved carpark.

2.3 Regional Setting

The site topography and geological information for the locality is summarised in **Table 2-3** below**.**

Table 2-3 Topographic and Geological Information

Attribute	Description
Topography	The site is located on the high east side of the road with steeply (18° to 20°) west dipping topography with site levels varying from R.L. 14.0m at the south-eastern site corner to R.L. 2.3m at the south-western site corner.
Regional Geology	Information on regional sub-surface conditions, referenced from the Department of Mineral Resources Geological Map Sydney 1:100,000 Geological Series Sheet 9130 (DMR 1983) indicates the site to be underlain by Newport Formation (Rnn) and Garie Formation, which consists of interbedded laminite, shale, and quartz, to lithic-quartz sandstone, and minor red claystone.

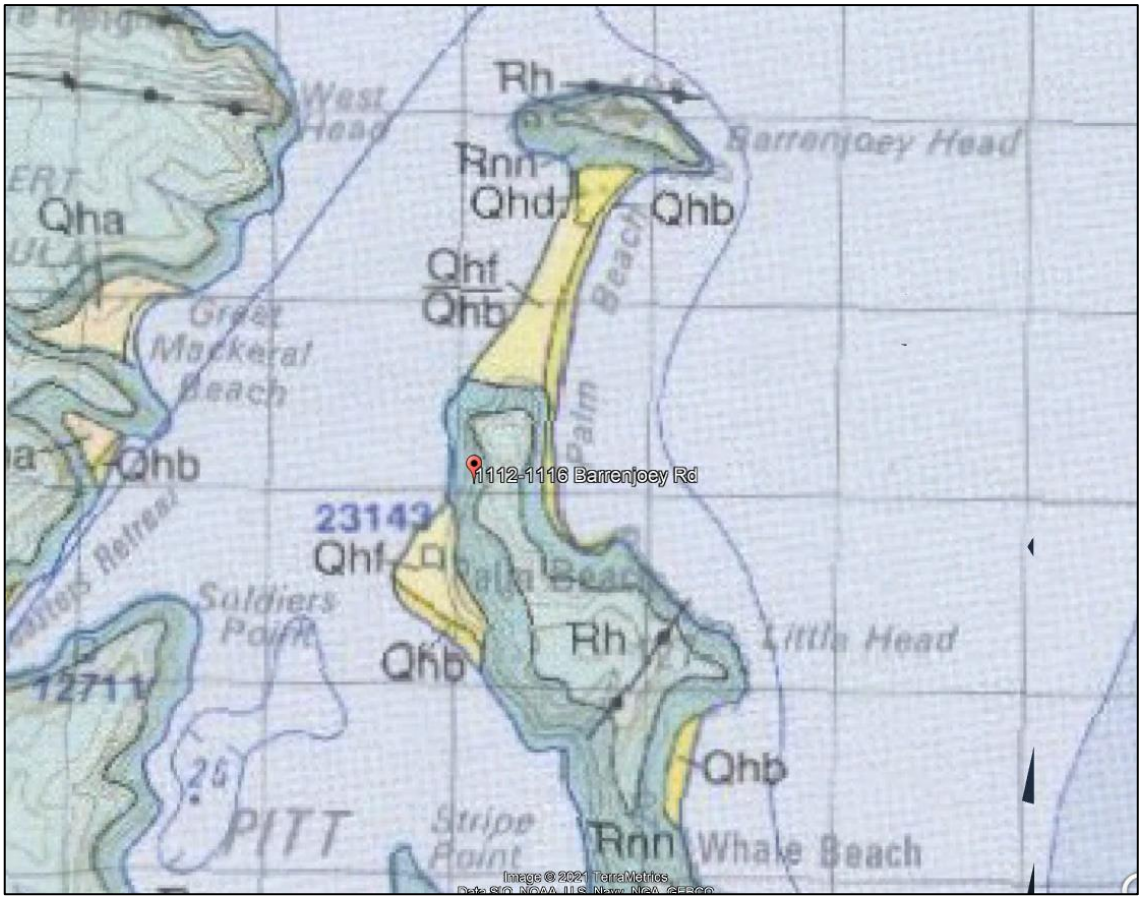


Plate 2: Excerpt of geological map showing location of site.

3. Investigation Results

3.1 Stratigraphy

For the development of a site-specific geotechnical model, the stratigraphy observed in the GI has been grouped into three geotechnical units. A summary of the subsurface conditions across the site, interpreted from the assessment results, is presented in **Table 3-1** below. More detailed descriptions of subsurface conditions at each borehole location are available on the borehole logs presented in **Appendix A**. The details of the methods of soil and rock classifications, explanatory notes and abbreviations adopted on the borehole logs are also presented in **Appendix A.**

Table 3-1 Summary of Subsurface Conditions

Unit	Material[2]	Depth to Top of Unit (m BEGL)[1]	RL of Top of Unit (m AHD)[1]	Observed Thickness (m)	Comments
1	**Fill**	Surface to 0.13	2.31 to 12.00	0.3 to 1.00	Concrete pavements of 130mm thickness observed in BH102 only. Low plasticity sandy clay fill observed in BH101M. Silty sand fill observed in BH102, BH103 and BH104M. Fill was assessed, based on our observations during drilling to be poorly to moderately compacted;
2a	**Alluvial Soil**	0.30 to 0.50	2.00 to 2.01	2.50 to 2.93	Fine grained, loose, becoming dense with depth silty sand. SPT N values range from 4 to 32;
2b	**Residual Soil**	3.0	-0.5	-[3]	Encountered in BH102 only. High plasticity, very stiff silty clay with trace ironstone gravels. SPT values ranged from 17 to 19;
3	**Very Low to Low Strength Sandstone/ Laminite**	0.47 to 9.87	-7.37 to 11.53	-[4]	Distinctly weathered, very low to low strength sandstone/laminite. Bands of medium strength observed in BH103.

Note 1 Approximate depth and level at the time of our assessment. Depths and levels may vary across the site.
Note 2 For more detailed descriptions of the subsurface conditions, reference should be made to the borehole logs attached to **Appendix A.**
Note 3 Observed up to termination depth in BH102.
Note 4 Observed up to termination depth in BH101M, BH103 and BH104M.

3.2 Groundwater Observations

Groundwater seepage was observed during auger drilling of BH102 at 2.0m depth BEGL (RL 0.5m). Following their completion, a groundwater monitoring well was installed in BH101M and a set of Mini-Diver and Baro-Diver has been installed for long-term groundwater monitoring.

The long-term groundwater monitoring at BH101M during the period of 11 June 2021 to 8 September 2021 showed fairly consistent groundwater levels with minimal fluctuation between RL 1.38m to RL 1.08m.

Water circulation due to coring within the borehole prevented further observations of groundwater levels within cored boreholes. We note that the groundwater levels may not have become evident or stabilised in the augered boreholes within the limited observation period.

3.3 Test Results

Two soil samples were selected for laboratory testing to assess the following:

- Soil aggressivity (pH, chloride and sulfate content and electrical conductivity).

A summary of the soil test results is provided in **Table 3-2** below. Laboratory test certificates are presented in **Appendix B**.

Table 3-2 Summary of Soil Laboratory Test Results

Test/ Sample ID		BH101M_0.5-0..95	BH102_3.0-3.45
Unit		2a	2b
Material Description [1]		Silty SAND	Silty CLAY
Aggressivity	Chloride Cl (ppm)	18	110
	Sulfate SO_4 (ppm)	22	63
	pH	5.7	4.8
	Electrical Conductivity (µS/cm)	27	130
	Moisture Content (%)	9.2	34.3

Note 1 More detailed descriptions of the subsurface conditions at each borehole location are available on the borehole logs presented in **Appendix A**.

The assessment indicated high permeability soil was present above the groundwater table. In accordance with Tables 6.4.2(C) and 6.5.2(C) of AS 2159:2009 'Piling – Design and Installation', the results of the pH, chloride and sulfate content and electrical conductivity of the soil provided the following exposure classifications:

- 'Moderate' to 'Mild' for buried concrete structural elements; and
- 'Mild' to 'Non-Aggressive' for buried steel structural elements.

27 selected rock core samples were tested by STS to estimate the Point Load Strength Index (Is_{50}) values to assist with rock strength assessment. The results of the testing are summarised on the attached borehole logs.

The point load strength index tests correlated reasonably well with our field assessments of rock strength. The approximate Unconfined Compressive Strength (UCS) of the rock core, estimated from correlations with the point load strength index test results, varied from 0.1 MPa to 12.8 MPa.

4. Recommendations

4.1 Geotechnical Issues

Based on the results of the assessment, we consider the following to be the main geotechnical issues for the proposed development:

- Presence of loose sands;
- Basement excavation and retention to limit lateral deflections and ground loss as a result of excavations, resulting in damage to nearby structures;
- Highly variable subsurface conditions;
- Rock excavation;
- Groundwater within the depth of the excavation;
- Existing footings of neighbouring properties; and
- Foundation design for building loads.

4.2 Dilapidation Surveys

Prior to excavation and construction, we recommend that detailed dilapidation surveys be carried out on all structures and infrastructures surrounding the site that falls within the zone of influence of the excavation to allow assessment of the recommended vibration limits and protect the client against spurious claims of damage. The zone of influence of the excavation is defined by a distance back from the excavation perimeter of twice the total depth of the excavation. The reports would provide a record of existing conditions prior to commencement of the work. A copy of each report should be provided to the adjoining property owner who should be asked to confirm that it represents a fair assessment of existing conditions. The reports should be carefully reviewed prior to demolition and construction.

4.3 Demolition Considerations

Care should be taken during demolition, particularly the concrete pavement, to avoid damaging neighbouring structures and infrastructures. Demolition of concrete slabs, pavement and floor slabs may require breaking into smaller size prior to disposal offsite. We recommend that saw cut slots be provided near adjoining buildings to reduce the risk of vibrations being transferred to nearby structures and infrastructures. If possible, the concrete slabs should be removed using hydraulic equipment rather than impact hammers.

4.4 Excavation Methodology

4.4.1 Excavation Assessment

Prior to any excavation commencing, we recommend that reference be made to the Safe Work Australia Excavation Work Code of Practice, dated January 2020.

EI assumes that the proposed development will require an excavation depth of about 3.0m BEGL. Locally deeper excavations for footings, service trenches, crane pads and lifts overrun pits may be required.

Based on the borehole logs, the proposed basement excavations will therefore extend through Unit 1 and 2 and likely Unit 3 towards east of the site and all Units towards west of site as

outlined in **Table 3-1** above. As such, an engineered retention system must be installed prior to excavation commencing. Additional geotechnical investigation in the form of cored boreholes is recommended due to highly variable subsurface conditions of the site.

Units 1 and 2 could be excavated using buckets of conventional earthmoving Hydraulic Excavators, particularly if fitted with 'Tiger Teeth'. Excavation of Unit 3 (where encountered) may present hard or heavy ripping, or "hard rock" excavation conditions. Ripping would require a high capacity and heavy bulldozer for effective production. Wear and tear should also be allowed for. The use of a smaller size bulldozer will result in lower productivity and higher wear and tear, and this should be allowed for. Alternatively, hydraulic rock breakers, rock saws, ripping hooks or rotary grinders could be used, though productivity would be lower and equipment wear increased, and this should be allowed for.

The primary issues associated with the excavation will be controlling the groundwater and provide adequate support to adjoining structures/infrastructures. Groundwater is expected to be encountered during excavation. Therefore, to allow for the construction of the basement slab, lift pits and service trenches in 'dry' condition, temporary dewatering will be required. In this regards, it is anticipated that the groundwater table will be maintained at a depth of about 1 m below the bulk excavation level and potentially deeper around lift pits or working platforms (if required).

Dewatering has the potential to cause some drawdown and ground settlement below the adjoining sites; the extent of the drawdown depends upon the depth to which the cut-off system is installed and the pumping operations. Outlets into the stormwater system will require Council approval.

Should rock hammers be used for the excavation of the bedrock, excavation should commence away from the adjoining structures and the transmitted vibrations monitored to assess how close the hammer can operate to the adjoining structures while maintaining transmitted vibrations within acceptable limits. To fall within these limits, we recommend that the size of rock hammers do not exceed a medium sized rock hammer, say 900 kg, such as a Krupp 580, and be trialled prior to use. The transmitted vibrations from rock hammers should be measured to determine how close each individual hammer can operate to the adjoining buildings.

The vibration measurements can be carried out using either an attended or an unattended vibration monitoring system. An unattended vibration monitoring system must be fitted with an alarm in the form of a strobe light or siren or alerts sent directly to the site supervisor to make the plant operator aware immediately when the vibration limit is exceeded. The vibration monitor must be set to trigger the alarm when the overall Peak Particle Velocity (PPV) exceeds set limits outlined by a vibration monitoring plan. Reference should be made to **Appendix C** for a guide to acceptable limits of transmitted vibrations.

If it is found that the transmitted vibrations by the use of rock hammers are unacceptable, then it would be necessary to change to a smaller excavator with a smaller rock hammer, or to a rotary grinder, rock saws, jackhammers, ripping hooks, chemical rock splitting and milling machines. Although these are likely to be less productive, they would reduce or possibly eliminate risks of damage to adjoining properties through vibration effects transmitted via the ground. Such equipment would also be required for detailed excavation, such as footings or service trenches, and for trimming of faces. Final trimming of faces may also be completed using a grinder attachment rather than a rock breaker in order to assist in limiting vibrations. The use of rotary grinders generally generates dust and this may be supressed by spraying with water.

To assist in reducing vibrations and over-break of the sandstone, we recommend that initial saw cutting of the excavation perimeters through the bedrock may be provided using rock saw attachments fitted to the excavator. Rock sawing of the excavation perimeter has several advantages as it often reduces the need for rock bolting as the cut faces generally remain more

stable and require a lower level of rock support than hammer cut excavations, ground vibrations from rock saws are minimal and the saw cuts will provide a slight increase in buffer distance for use of rock hammers. However, the effectiveness of such approach must be confirmed by the results of vibration monitoring.

Groundwater seepage monitoring should be carried out during bulk excavation works and prior to finalising the design of a pump out facility. Outlets into the stormwater system will require Council approval.

Furthermore, any existing buried services, which run below the site, will require diversion prior to the commencement of excavation or alternatively be temporarily supported during excavation, subject to permission or other instructions from the relevant service authorities. Enquiries should also be made for further information and details, such as invert levels, on the buried services.

4.4.2 Excavation Monitoring

Consideration should be made to the impact of the proposed development upon neighbouring structures, roadways and services. Basement excavation retention systems should be designed so as to limit lateral deflections.

Contractors should also consider the following limits associated with carrying out excavation and construction activities:

- Limit lateral deflection of temporary or permanent retaining structures;
- Limit vertical settlements of ground surface at common property boundaries and services easement; and
- Limit Peak Particle Velocities (PPV) from vibrations, caused by construction equipment or excavation, experienced by any nearby structures and services.

Monitoring of deflections of retaining structures and surface settlements should be carried out by a registered surveyor at agreed points along the excavation boundaries and along existing building foundations / services / pavements and other structures located within or near the zone of influence of the excavation. Owners of existing services adjacent to the site should be consulted to assess appropriate deflection limits for their infrastructures. Measurements should be taken in the following sequence:

- Before commencing installation of retaining structures where appropriate to determine the baseline readings. Two independent sets of measurements must be taken confirming measurement consistency;
- After installation of the retaining structures, but before commencement of excavation;
- After excavation to a depth of 1.5m;
- After excavation to the base of the excavation;
- After de-stressing and removal of any rows of supports or anchors; and
- One month after completion of the permanent retaining structure or after three consecutive measurements not less than a week apart showing no further movements, whichever is the latter.

4.5 Groundwater Considerations

Groundwater was observed in all monitoring wells as detailed in **Section 3-2**, all of which is shallower than the excavation depth of 3.0m.

Due to the topography of the bedrock profile any groundwater inflows into the excavation should not have an adverse impact on the proposed development or on the neighbouring sites and should be manageable. However, we expect that some groundwater inflows into the excavation along the soil/rock interface and through any defects within the sandstone bedrock (such as jointing, and bedding planes, etc.) particularly following a period of heavy rainfall. The initial flows into the excavation may be locally high, but would be expected to decrease considerably with time as the bedding seams/joints are drained. We recommend that monitoring of seepage be implemented during the excavation works to confirm the capacity of the drainage system.

We expect that any seepage that does occur will be able to be controlled by a conventional sump and pump system. We recommend that a sump-and-pump system be used both during construction and for permanent groundwater control below the basement floor slab.

In the long term, drainage should be provided behind all basement retaining walls, around the perimeter of the basement and below the basement slab. The completed excavation should be inspected by the hydraulic engineer to confirm that adequate drainage has been allowed for. Drainage should be connected to the sump-and-pump system and discharging into the stormwater system. The permanent groundwater control system should take into account any possible soluble substances in the groundwater which may dictate whether or not groundwater can be pumped into the stormwater system.

The design of drainage and pump systems should take the above issues into account along with careful ongoing inspections and maintenance programs.

4.6 Excavation Retention

4.6.1 Support Systems

From a geotechnical perspective, it is critical to maintain the stability of all adjacent structures and infrastructures during demolition, excavation and construction works.

Based on the provided architectural plans, the proposed basement outline abuts the western site boundary and has a minimum setback of approximately 3.00m from the northern, eastern and southern boundaries. Based on the depth of the excavation, the encountered subsurface conditions and limited setbacks, temporary batters are not recommended for this site. Unsupported vertical cuts of the soil are not recommended for this site as these carry the risk of potential slumping/collapse especially after a period of wet weather. Slumping/Collapse of the material may result in injury to personnel and/or damage to nearby structures/infrastructures and equipment.

Where space for temporary batters is not available, a suitable retention system will be required for the support of the entire depth of the excavation. For this site, we consider that a cantilevered contiguous pile wall with mass concrete in between the piles installed to below BEL and into Unit 3 or better to be the most suitable. Mass concrete must be installed progressively as excavation proceeds.

Only grout injected CFA piles should be used for this site for contiguous piles. Due to the collapsible nature of the sandy soils and the presence of groundwater, bored piers are not recommended for this site. The proposed pile locations should take into account the presence of the neighbouring anchors and/or the presence of buried services. Further advice should be sought from prospective piling contractors who should be provided with a copy of this report.

The retention system will need to be installed to depths which satisfy stability, piping, founding and groundwater cut-off considerations. Anchors/props and shotcrete must be installed progressively as excavation proceeds.

Working platforms may also be required. We can complete the design of the working platform, if commissioned to do so.

4.6.2 Geotechnical Hazard Risk Zone

Please note that with reference to Pittwater Council's LEP 2014 Geotechnical Risk Management Map (GTH_015), the site is classified as being within the H1 (highest category) landslip hazard zone therefore the site requires a Geotechnical Landslip Risk Assessment to be conducted. An excerpt of the geotechnical hazard map is shown below in **Plate 3**:

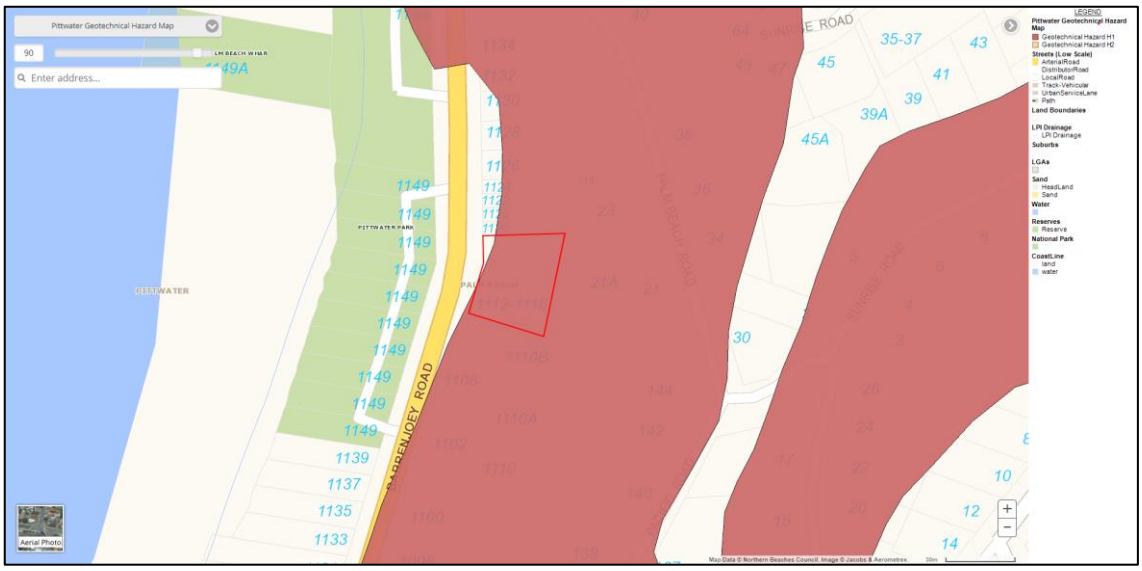


Plate 3: Site location over geotechnical hazard map (Pittwater LEP 2014)

4.6.3 Slope Stability & Risk Assessment:

As per EI's proposal P19388.2, dated 11 May 2019, slope stability and risk assessment was not part of the agreed scope of work for this project, therefore a risk assessment for the proposed development was not carried out. However DP (October 2009) carried out a risk assessment for the previously proposed development at this site and identified the following risks for property, summarised in **Table 4-1** below.

Table 4-1 Property Risk Assessment for Proposed Development (based on DP Report)

Hazard	Likelihood	Consequences	Risk
Rapid and significant erosion/slumping of slope on the eastern side of the development as a result of water flows from upslope	Unlikely for properly graded and drained surface runoff control measures and appropriately designed and constructed retaining walls	Minor	Low
Rapid collapse of proposed retaining walls	Rare – for engineer designed, inspected and constructed wall	Major	Low
Minor creep effects on landscaping walls	Possible	Insignificant	Very Low
Major rapid soil mass movement and impact to building	Rare for a site with engineer designed retaining structures and no features (cliff lines undercuts or floaters) observed suggesting	Medium	Low

Hazard	Likelihood	Consequences	Risk
	incipient instability		

A quantitative assessment of risk of loss of life (person most at risk) related to the identified slope instability hazards has been calculated as varying from 1 x 10^{-6} to 1 x 10^{-8}. It is concluded that as per requirements of Geotechnical Risk Management Policy 2007, the proposed development will achieve the "Acceptable Risk Management" criteria for both property and life under current and foreseeable conditions and that the site is suitable for the proposed development.

It is recommended that site inspections during and after completion of construction works should be carried out to ensure that there is no ensuing risk of slope instability.

4.6.4 Excavation adjacent to RMS Assets

Reference should be made to the RMS Geotechnical Technical Direction (GTD) 2020/001 dated 2 July 2020, with regards to excavation/shoring adjacent to Barrenjoey Road. This document outlines requirements for excavations adjacent to RMS infrastructure and includes the level of geotechnical investigation required, dilapidation surveying, instrumentation and monitoring during construction, trigger levels and contingency plans.

Instrumentation (e.g. inclinometers) and monitoring is typically required where the excavation exceeds 3 m in height (for cantilevered shoring walls) or 6 m in height (for anchored or propped shoring walls). A geotechnical monitoring plan may be required by RMS prior to construction for this site.

As the site of the proposed development lies adjacent to both RMS assets, the asset owner may require further assessment of the potential impact of the proposed development on their assets. In order to assess the latter, a 2D numerical model using a commercially available computer program, such as WALLAP and/or PLAXIS, will be required. This model will enable the assessment of the potential impact of the proposed development on the RMS assets and predict the likely movements in the shoring wall. EI can provide such a service if commissioned to do so.

4.6.5 Retaining Wall Design Parameters

The following parameters may be used for static design of temporary and permanent retaining walls at the subject site:

- Conventional free-standing cantilever walls which support areas where movement is of little concern (i.e. where only gardens or open areas are to be retained), may be designed using a triangular lateral earth pressure distribution and an 'active' earth pressure coefficient, K_a, as shown in **Table 4-1**;
- Cantilevered walls, where the tops of which are restrained by the floor slabs of the permanent structure or which support movement sensitive elements, should be designed using a triangular lateral earth pressure distribution and an 'at rest' earth pressure coefficient, K_o, as shown in **Table 4-1** below;
- All surcharge loading affecting the walls (including from construction equipment, construction loads, adjacent high level footings, etc.) should be adopted in the retaining wall design as an additional surcharge using an 'at rest' earth pressure coefficient, Ko;

- The retaining walls should be designed as drained and measures are to be taken to provide complete and permanent drainage behind the walls. Strip drains protected with a non-woven geotextile fabric should be used behind the shotcrete infill panels for soldier pile walls. Alternatively, for the contiguous pile walls, weepholes comprising 20mm diameter, slotted PVC pipes installed into holes or gaps between adjacent piles at 1.2m centres (horizontal and vertical), may be used. The embedded pipes must, however, be wrapped with a non-woven geotextile fabric (such as Bidim A34) to act as a filter against subsoil erosion;
- For piles embedded into Unit 3 or better, the allowable lateral toe resistance values outlined in **Table 4-1** below may be adopted. These values assume excavation is not carried out within the zone of influence of the wall toe and the rock does not contain adverse defects etc. The upper 0.3m depth of the socket should not be taken into account to allow for tolerance and disturbance effects during excavation.

Table 4-2 Geotechnical Design Parameters

Material [1]		Unit 1 Fill	Unit 2a Alluvial Soil	Unit 2b Residual Soil	Unit 3 Very Low to Low Strength Sandstone/ Laminite
RL of Top of Unit (m AHD) [2]		2.31 to 2.37	2.0 to 2.01	-0.5	-0.92
Bulk Unit Weight (kN/m^3)		17	17	17	22
Friction Angle, ϕ' (°)		25	25	25	34
Earth Pressure Coefficients	At rest, K_o [3]	0.58	0.58	0.58	-
	Active, K_a [3]	0.41	0.41	0.41	-
	Passive, K_p [3]	-	-	2.46	-
Allowable Bearing Pressure (kPa) [5]		-	-	-	700
Allowable Shaft Adhesion (kPa) [4, 5]	in Compression	-	-	-	70
	in Uplift	-	-	-	35
Allowable Toe Resistance (kPa)		-	-	-	-
Allowable Bond Stress (kPa)		-	-	-	35
Earthquake Site Risk Classification		▪ AS 1170.4:2007 indicates an earthquake subsoil class of Class C_e.(Shallow Soil) ▪ AS 1170.4:2007 indicates that the hazard factor (z) for Sydney is 0.08.			

Notes:

1 More detailed descriptions of subsurface conditions are available on the borehole logs presented in **Appendix A.**
2 Approximate levels of top of unit at the time of our investigation. Levels may vary across the site.
3 Earth pressures are provided on the assumption that the ground behind the retaining walls is horizontal.
4 Side adhesion values given assume there is intimate contact between the pile and foundation material and should achieve a clean socket roughness category R2 or better. Design engineer to check both 'piston pull-out' and 'cone liftout' mechanics in accordance with AS4678-2002 Earth Retaining Structures.
5 To adopt these parameters we have assumed that:
- Footings have a nominal socket of at least 0.3m, into the relevant founding material;
- For piles, there is intimate contact between the pile and foundation material (a clean socket roughness category of R2 or better);
- Potential soil and groundwater aggressivity will be considered in the design of piles and footings;
- Piles should be drilled in the presence of a Geotechnical Engineer prior to pile construction to verify that ground conditions meet design assumptions. Where groundwater ingress is encountered during pile excavation, concrete is to be placed as soon as possible upon completion of pile excavation. Pile excavations should be pumped dry of water prior to pouring concrete, or alternatively a tremmie system could be used;
- The bases of all pile, pad and strip footing excavations are cleaned of loose and softened material and water is pumped out prior to placement of concrete;
- The concrete is poured on the same day as drilling, inspection and cleaning.
- The allowable bearing pressures given above are based on serviceability criteria of settlements at the footing base/pile toe of less than or equal to 1% of the minimum footing dimension (or pile diameter).

4.7 Foundations

The most competent foundation stratum at the site is the weathered sandstone and in view of the moderate depths to the bedrock, we recommend that building is supported on shallow or pile footings (depending on the footprint of proposed basement and subsurface conditions) founded into weathered bedrock. However, the option of high level footings founded in the residual clay is also provided. Since this investigation revealed that the site subsurface condition is highly variable, additional geotechnical investigation in the form of cored boreholes is recommended.

4.7.1 Shallow Footings in Rock

Following basement excavation to RL -0.70 to -1.54m, we expect Unit 3 material to be exposed at BEL.

It is recommended that all footings for the building be founded within the sandstone bedrock of similar strength of at least Unit 3 or better to provide uniform support and reduce the potential for differential settlements.

Pad or strip footings founded within Unit 3 may be preliminarily designed for an allowable bearing capacity of 700kPa, based on serviceability.

Geotechnical inspections of foundations are recommended to determine that the required bearing capacity has been achieved and to determine any variations that may occur between the boreholes and inspected locations.

4.7.2 Pile Footings

Alternatively, the proposed development may be supported on deep foundations, such as piles, founded into sandstone bedrock.

For piles founded into weathered sandstone bedrock, these must be embedded a minimum of 0.5m into sandstone, and can be designed for a maximum allowable bearing pressure of 700kPa. The allowable shaft adhesion in sandstone bedrock may be designed as 10% of the allowable bearing pressure (or 5% for uplift) for the socket length in excess of 0.5m.

At least the initial drilling of piles should be completed in the presence of a geotechnical engineer to verify that ground conditions meet design assumptions.

Where groundwater ingress is encountered during pile excavation, concrete is to be placed as soon as possible upon completion of pile excavation. Pile excavations should be pumped dry of water prior to pouring concrete, or alternatively a tremmie system could be used. Concrete must be poured on the same day as drilling, inspection and drilling.

The aggressivity of natural soils and groundwater (if encountered) should be taken into consideration in the design.

4.8 Basement Floor Slab

Following bulk excavations for the proposed basement, sandstone bedrock is expected to be exposed at the basement floor BEL however it depends on the actual footprint of the proposed development.

Additional geotechnical investigation will be required to confirm the depth and conditions of the bedrock once the architectural drawings showing the actual footprint of the proposed development are available.

Following the removal of all loose and softened materials, we recommend that underfloor drainage be provided and should comprise a strong, durable, single sized washed aggregate such as 'blue metal gravel'. Joints in the concrete floor slab should be designed to accommodate shear forces but not bending moments by using dowelled and keyed joints. The basement floor slab should be isolated from columns. The completed excavation should be inspected by the hydraulic engineer to confirm the extent of the drainage required.

In addition, a system of sub-soil drains comprising a durable single sized aggregate with perforated drains/pipes leading to sumps should be provided. The basement floor slab should be isolated from columns.

Permission may need to be obtained from the NSW Department of Primary Industries (DPI) and possibly Council for any permanent discharge of seepage into the drainage system. Given the subsurface conditions, we expect that seepage volumes would be low and within the DPI limits. However, if permission for discharge is not obtained, the basement may need to be designed as a tanked basement.

4.9 Existing Fill

Based on the investigation results, the site is covered by a layer of fill between 0.3m and 0.5m deep. Based on observation, it appears that it has generally been poorly to moderately compacted. However, the SPT tests do not give a precise determination of in-situ densities, since they are affected by friction during driving, the presence of gravel, and the changes in moisture content. Based on available information, the fill on site is not considered to be 'controlled fill'. AS2870 defines 'controlled' fill as material that has been placed and compacted in layers by compaction equipment within a defined moisture range, to a defined density requirement, and placed in accordance with AS3798.

5. Further Geotechnical Inputs

Below is a summary of the previously recommended additional work that needs to be carried out:

- Additional Geotechnical Investigation in the form of two to three cored boreholes following demolition to confirm the depth and quality of Unit 3 sandstone bedrock or better within the northern side of the site;
- Aggressivity testing for buried concrete and steel structures;
- Dilapidation surveys;
- Landslide risk assessment after confirming the actual extent of the proposed development ;
- Design of working platforms (if required) for construction plant by an experienced and qualified geotechnical engineer;
- Classification of all excavated material transported off site;
- Witnessing installation of support measures and proof-testing of anchors (if required);
- Geotechnical inspections of all new footings/piles by an experienced geotechnical professional before concrete or steel are placed to verify their bearing capacity and the in-situ nature of the founding strata; and
- Ongoing monitoring of groundwater inflows into the bulk excavation.

We recommend that a meeting be held after initial structural design has been completed to confirm that our recommendations have been correctly interpreted. We also recommend a meeting at the commencement of construction to discuss the primary geotechnical issues and inspection requirements.

6. Statement of Limitations

This report has been prepared for the exclusive use of William Allen and Palmdev Pty Ltd who is the only intended beneficiary of EI's work. The scope of the assessment carried out for the purpose of this report is limited to those agreed with William Allen and Palmdev Pty Ltd

No other party should rely on the document without the prior written consent of EI, and EI undertakes no duty, or accepts any responsibility or liability, to any third party who purports to rely upon this document without EI's approval.

EI has used a degree of care and skill ordinarily exercised in similar investigations by reputable members of the geotechnical industry in Australia as at the date of this document. No other warranty, expressed or implied, is made or intended. Each section of this report must be read in conjunction with the whole of this report, including its appendices and attachments.

The conclusions presented in this report are based on a limited investigation of conditions, with specific sampling and test locations chosen to be as representative as possible under the given circumstances.

EI's professional opinions are reasonable and based on its professional judgment, experience, training and results from analytical data. EI may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified by EI.

EI's professional opinions contained in this document are subject to modification if additional information is obtained through further investigation, observations, or validation testing and analysis during construction. In some cases, further testing and analysis may be required, which may result in a further report with different conclusions.

We draw your attention to the document "Important Information", which is included in **Appendix D** of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by EI, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Should you have any queries regarding this report, please do not hesitate to contact EI.

References

AS1289.6.3.1:2004, *Methods of Testing Soils for Engineering Purposes,* Standards Australia.

AS1726:2017, *Geotechnical Site Investigations*, Standards Australia.

AS2159:2009, *Piling – Design and Installation*, Standards Australia.

AS3600:2009, *Concrete Structures,* Standards Australia

Safe Work Australia Excavation Work Code of Practice, dated January 2020 – WorkCover NSW

NSW Department of Finance and Service, Spatial Information Viewer, maps.six.nsw.gov.au.

NSW Department of Mineral Resources (1983) Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1). Geological Survey of New South Wales, Department of Mineral Resources.

Abbreviations

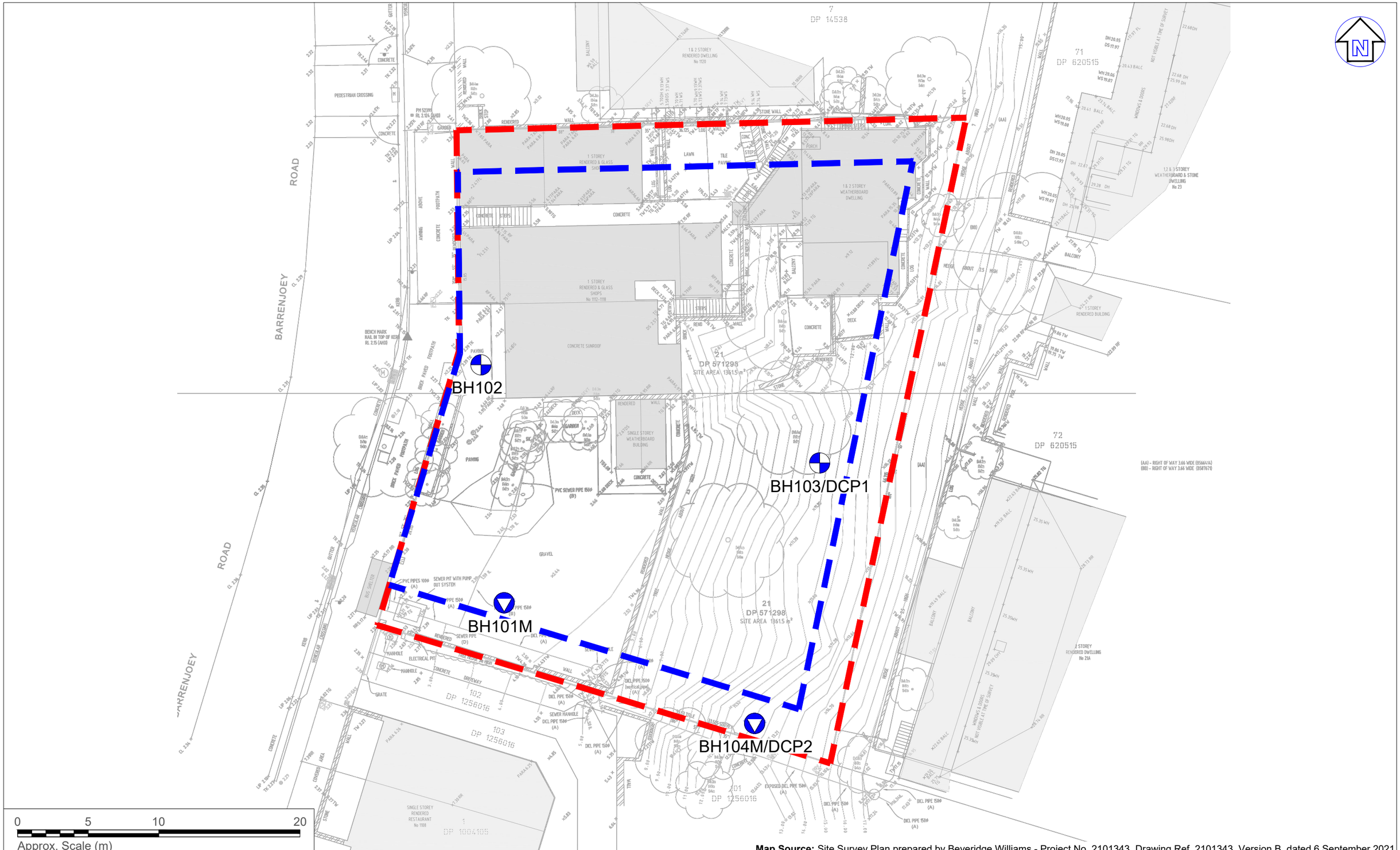
AHD	Australian Height Datum
AS	Australian Standard
BEL	Bulk Excavation Level
BEGL	Below Existing Ground Level
BH	Borehole
DBYD	Dial Before You Dig
DP	Deposited Plan
EI	EI Australia
GI	Geotechnical Investigation
NATA	National Association of Testing Authorities, Australia
RL	Reduced Level
SPT	Standard Penetration Test
T-C	Tungsten-Carbide
UCS	Unconfined Compressive Strength

Figures

eiaustralia Practical Solutions for Built Environments Suite 6.01, 55 Miller Street, PYRMONT 2009 Ph (02) 9516 0722 Fax (02) 9518 5088	Drawn:	T.M.	**Palmdev Pty Ltd** Geotechnical Investigation 1112-1116 Barrenjoey Road, Palm Beach NSW Site Locality Plan
	Approved:	K.X.	
	Date:	28-06-21	
	Scale:	Not To Scale	

Figure: 1

Project: E25203.G03



Map Source: Site Survey Plan prepared by Beveridge Williams - Project No. 2101343, Drawing Ref. 2101343, Version B, dated 6 September 2021

LEGEND (Note: All locations are approximate)

- Site boundary
- Proposed basement boundary
- Location of Geotechnical Borehole/DCP Test
- Location of Geotechnical Borehole/Monitoring Well/DCP Test

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Drawn:	P.M./J.W.
Approved:	S.R
Date:	15/12/2021

Palmdev Pty Ltd
Geotechnical Investigation
1112-1116 Barrenjoey Road, Palm Beach NSW
Borehole Location Plan

Figure: 2

Project: E25203.G03_Rev2

Appendix A – Borehole Logs And Explanatory Notes

BOREHOLE LOG

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BH NO. BH101M

Project	Proposed Development	**Sheet**	1 of 2
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	11/06/2021
Position	Refer to Figure 2	**Date Completed**	11/06/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 11/06/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/07/2021

Drilling Contactor	BG Drilling	**Surface RL**	≈2.31 m AHD
Drill Rig	CE180	**Inclination**	-90°

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	-	GWNE	0	2.31				-	FILL: Sandy CLAY; low plasticity, dark brown.	M (<PL)	-	FILL
				0.30								
				2.01	BH101M_0.50-0.95 SPT 0.50-0.95 m 3,2,3 N=5			SM	Silty SAND; fine grained, brown.		L	RESIDUAL SOIL
			1									
				1.50								
				0.81	BH101M_1.50-1.95 SPT 1.50-1.95 m 6,13,19 N=32				From 1.5 m, pale grey.	M	D	
			2									
			3	*3.23*	BH101M_3.00-3.28 SPT 3.00-3.28 m 10,18/130mm HB				Continued as Cored Borehole			
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

CORED BOREHOLE LOG

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BH NO. BH101M

Project	Proposed Development	**Sheet**	2 OF 2
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	11/06/2021
Position	Refer to Figure 2	**Date Completed**	11/06/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 11/06/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/07/2021

Drilling Contactor	BG Drilling	**Surface RL**	≈2.31 m AHD
Drill Rig	CE180	**Inclination**	-90°

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	Average Defect Spacing (mm) (30, 100, 300, 1000, 3000)
				0							
				1							
				2							
				3	*3.23*		Continuation from non-cored borehole				
NMLC	90-100% RETURN	100	93	4	-0.92		SANDSTONE; fine grained, brown-pale grey, thinly bedded.	DW			
				5						4.73: JT, 50 - 60°, CN, PR, RF	
		100	60	6	*5.82* -3.51		From 5.82 m, grey.			5.54-5.61: XWS, 70 mm 6.27-6.29: XWS, 20 mm 6.43-6.46: XWS, 30 mm 6.54-6.60: XWS, 60 mm	
		100	81	7							
				8	*8.80*					8.27-8.29: XWS, 20 mm	
				9	-6.49		Hole Terminated at 8.80 m Target Depth Reached.				
				10							

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

MONITORING WELL LOG

MW NO. BH101M

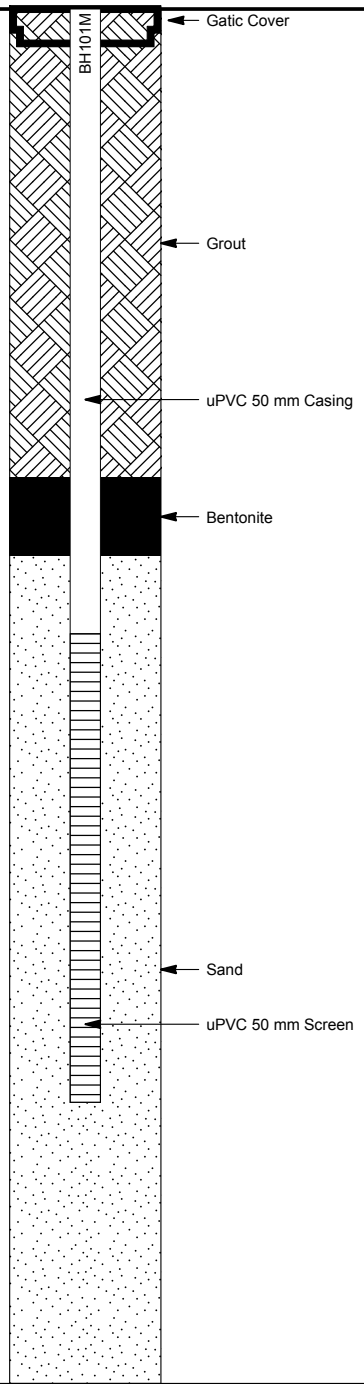
Project	Proposed Development	**Sheet**	1 of 2
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	11/06/2021
Position	Refer to Figure 2	**Date Completed**	11/06/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 11/06/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/07/2021

Drilling Contactor	BG Drilling	**Surface RL**	≈2.31 m AHD
Drill Rig	CE180	**Inclination**	-90°

METHOD	WATER	DEPTH (m)	RL (m AHD)	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION
AD/T	GWNE	0	2		FILL: Sandy CLAY; low plasticity, dark brown.
		1	1		Silty SAND; fine grained, brown.
		2	0		From 1.5 m, pale grey.
		3	-1		SANDSTONE; fine grained, brown-pale grey, thinly bedded.
NMLC	90-100% RETURN	4	-2		
		5	-3		
		6	-4		From 5.82 m, grey.
		7	-5		
		8	-6		
		9	-7		Hole Terminated at 8.80 m Target Depth Reached.

PIEZOMETER CONSTRUCTION DETAILS

ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date Static Water Level
BH101M	Standpipe		7.00 m -4.69 m	



This well log should be read in conjunction with EI Australia's accompanying standard notes.

CORE PHOTOGRAPH OF BOREHOLE: BH101M

Project	Proposed Development			**Depth Range**	3.23m to8.80m BEGL		
Location	1112-1116 Barrenjoey Road, Palm Beach NSW			**Contractor**	BG Drilling		
Position	See Figure 2	**Surface RL**	≈ 2.31 m	**Drill Rig**	CE180		
Job No.	E25203.G03	**Inclination**	-90°	**Logged**	KX	**Date**	11 / 06 / 2021
Client	Palmdev Pty Ltd	**Box**	1-2 of 2	**Checked**	SR	**Date**	14 / 07 / 2021

BOREHOLE LOG

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BH NO. BH102

Project	Proposed Development	**Sheet**	1 of 1
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	11/06/2021
Position	Refer to Figure 2	**Date Completed**	11/06/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 11/06/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/07/2021

Drilling Contactor	BG Drilling	**Surface RL**	≈2.50 m AHD
Drill Rig	CE180	**Inclination**	-90°

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
DT			0	*0.13*				-	CONCRETE; 130 mm thick.	-	-	PAVEMENT
				2.37				-	FILL: Silty SAND; fine grained, dark brown.	M	-	FILL
				0.50								
				2.00	BH102_0.50-0.95 SPT 0.50-0.95 m 4,3,3 N=6			SM	Silty SAND; fine grained, brown.			RESIDUAL SOIL
			1							M		
					BH102_1.50-1.95 SPT 1.50-1.95 m 2,2,2 N=4						L	
		▽	2							W		
				3.00								
			3	-0.50	BH102_3.00-3.45 SPT 3.00-3.45 m 5,9,10 N=19			CH	Silty CLAY; high plasticity, pale grey.			
			4									
				4.50								
AD/T	-			-2.00	BH102_4.50-4.95 SPT 4.50-4.95 m 8,7,10 N=17				From 4.5 m, pale grey to red-brown.			
			5									
				6.00								
			6	-3.50	BH102_6.00-6.40 SPT 6.00-6.40 m 2,10,20/100mm HB				From 6.0 m, pale grey.	M (<PL)	VSt	
			7									
			8									
			9									
				9.87					Hole Terminated at 9.87 m T/C Bit Refusal.			
			10									

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

BOREHOLE LOG

BH NO. BH103

Project	Proposed Development	**Sheet**	1 of 3
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Drilling Contactor	TightSite	**Surface RL**	≈12.00 m AHD
Drill Rig	Hand Portable	**Inclination**	-90°

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA WB	-	GWNE	0	12.00	DS 0.25-0.35 m			-	FILL: Silty SAND; fine grained, brown, trace rootlets, medium to coarse angular to sub-angular gravels.	D	-	FILL
			1	*1.00*					Continued as Cored Borehole			
			2									
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

CORED BOREHOLE LOG

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BH NO. BH103

Project	Proposed Development	**Sheet**	2 OF 3
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Drilling Contactor	TightSite	**Surface RL**	≈12.00 m AHD
Drill Rig	Hand Portable	**Inclination**	-90°

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	Average Defect Spacing (mm) (30, 100, 300, 1000, 3000)
				0							
				1	*1.00*		Continuation from non-cored borehole				
NMLC	80-90% RETURN	100	59	1	11.00		LAMINITE; SANDSTONE and CLAYSTONE; sandstone is fine grained, red-brown, orange-brown, pale brown and pale grey, thinly bedded.	XW			
		100	15	2				DW		2.55-2.58: XWS, 30 mm 2.70-2.80: XWZ, 100 mm 2.85: JT, 70°, CN, UN, RF	
		100	35	3						3.12: JT, 70 - 80°, CN, UN, RF 3.67: JT, 60 - 70°, CN, PR, RF	
		100	34	4						4.05-4.33: SZ, 280 mm 4.70-4.86: XWZ, 160 mm	
		100	37	5						4.95-5.11: XWZ, 160 mm 5.20-5.27: XWS, 70 mm 5.32-5.36: XWS, 40 mm 5.56-5.62: XWS, 60 mm 5.76-5.79: XWS, 30 mm	
		100	46	6						6.00-6.40: XWZ, 400 mm 6.67-6.77: XWS, 100 mm	
				7	*7.16*					7.08-7.12: XWS, 40 mm	
					4.84		LAMINITE; SANDSTONE and SHALE; sandstone is fine grained, grey and brown, with pale grey laminations, thinly bedded.				
		100	16	8						7.82: JT, 40 - 50°, CN, PR, RF	
				9						9.64-9.68: XWS, 40 mm	
				10						9.90-10.08: CS, 90 mm	

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

CORED BOREHOLE LOG

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Practical Solutions for Built Environments

BH NO. BH103

Project	Proposed Development	**Sheet**	3 OF 3
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Drilling Contactor	TightSite	**Surface RL**	≈12.00 m AHD
Drill Rig	Hand Portable	**Inclination**	-90°

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	Average Defect Spacing (mm) (30, 100, 300, 1000, 3000)
NMLC	80-90% RETURN	100	87	10			LAMINITE; SANDSTONE and SHALE; sandstone is fine grained, grey and brown, with pale grey laminations, thinly bedded.	DW			
		100	63	11							
				12							
				13	*13.00* -1.00		Hole Terminated at 13.00 m Target Depth Reached.				
				14							
				15							
				16							
				17							
				18							
				19							
				20							

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

CORE PHOTOGRAPH OF BOREHOLE: BH103

Project	Proposed Development			**Depth Range**	1.00m to9.00m BEGL		
Location	1112-1116 Barrenjoey Road, Palm Beach NSW			**Contractor**	TightSite		
Position	Refer to Figure 2	**Surface RL**	≈ 12.0 m	**Drill Rig**	Hand Portable		
Job No.	E25203.G03	**Inclination**	-90°	**Logged**	KX	**Date**	27 / 10 / 2021
Client	Palmdev Pty Ltd	**Box**	1-2 of 3	**Checked**	....	**Date**	….

CORE PHOTOGRAPH OF BOREHOLE: BH103

Project	Proposed Development			**Depth Range**	9.00m to13.00m BEGL		
Location	1112-1116 Barrenjoey Road, Palm Beach NSW			**Contractor**	TightSite		
Position	Refer to Figure 2	**Surface RL**	≈ 12.0 m	**Drill Rig**	Hand Portable		
Job No.	E25203.G03	**Inclination**	-90°	**Logged**	KX	**Date**	27 / 10 / 2021
Client	Palmdev Pty Ltd	**Box**	3 of 3	**Checked**	....	**Date**	….

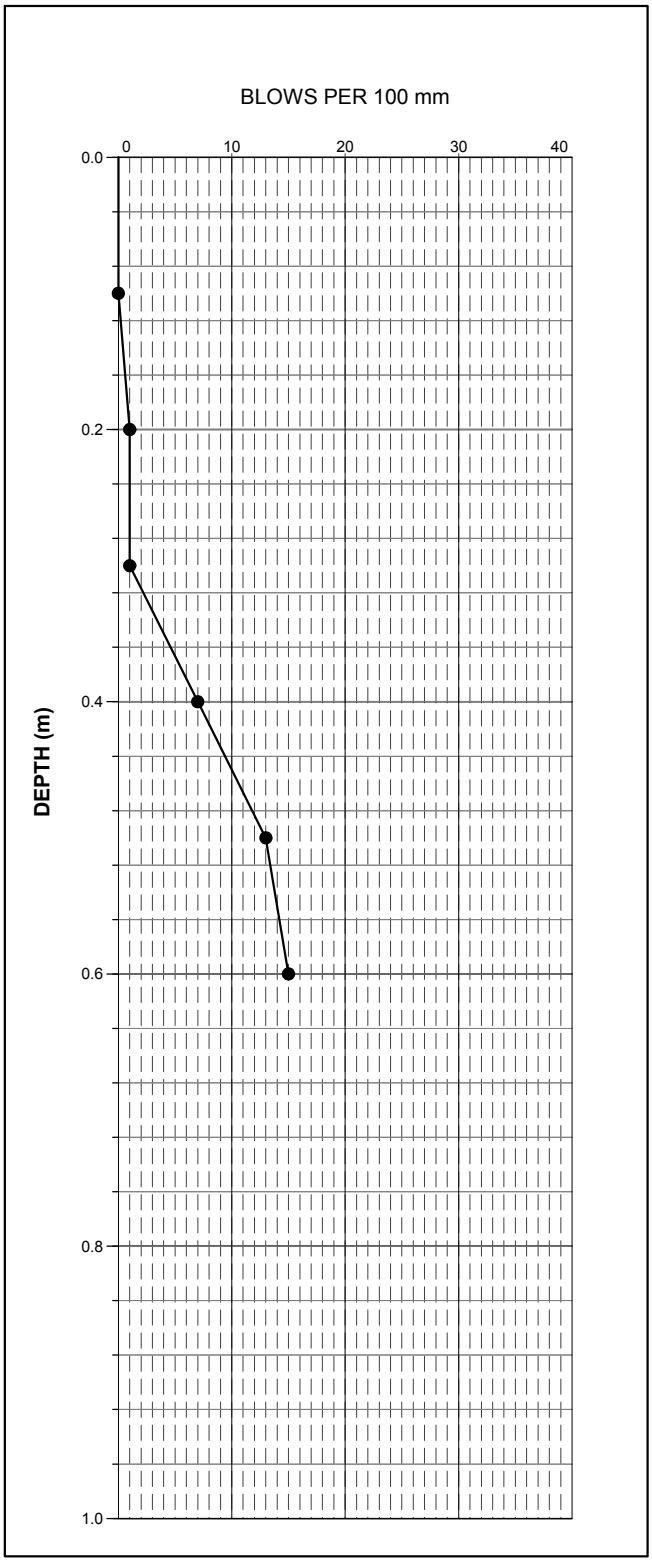
DYNAMIC CONE PENETROMETER TEST RESULTS

DCP NO. DCP1

Project	Proposed Development	**Sheet**	1 of 1
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Inclination -90°

DEPTH (m)	NO OF BLOWS PER 100 mm
0.00-0.10	0
0.10-0.20	1
0.20-0.30	1
0.30-0.40	7
0.40-0.50	13
0.50-0.52	15/20mm HB



Termination Remark
DCP Refused at 0.52 m depth.
HB Hammer Bounced

Final Depth (m)	0.52

This DCP log should be read in conjunction with EI Australia's accompanying standard notes.

BOREHOLE LOG

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BH NO. BH104M

Project	Proposed Development	**Sheet**	1 of 3
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Drilling Contactor	TightSite	**Surface RL**	≈12.00 m AHD
Drill Rig	Hand Portable	**Inclination**	-90°

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY REL. DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	-	GWNE	0	12.00 ***0.47***	1 DS 0.20-0.30 m			-	FILL: Silty SAND; fine grained, brown, trace rootlets, medium to coarse, angular to sub-angular gravels.	D	-	FILL
									Continued as Cored Borehole			
			1									
			2									
			3									
			4									
			5									
			6									
			7									
			8									
			9									
			10									

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

CORED BOREHOLE LOG

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BH NO. BH104M

Project	Proposed Development	**Sheet**	2 OF 3
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Drilling Contactor	TightSite	**Surface RL**	≈12.00 m AHD
Drill Rig	Hand Portable	**Inclination**	-90°

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	Average Defect Spacing (mm) (30, 100, 300, 1000, 3000)
				0							
					0.47		Continuation from non-cored borehole				
NMLC	80-90% RETURN	100	64		11.53		LAMINITE; SANDSTONE and CLAYSTONE; sandstone is fine grained, red-brown, orange-brown, pale brown and pale grey, thinly bedded.	XW			
				1							
		100	85	2							
				3							
		100	37	4							
					4.65						
		100	57	5	7.35		LAMINITE; SANDSTONE and SHALE; sandstone is fine grained, grey and brown, with pale grey laminations, thinly bedded.	DW			
				6						6.36: JT, 70 - 80°, Fe SN, PR, RF	
		100	70	7							
				8						8.49-8.53: CS, 40 mm	
		100	67	9						9.30-9.40: CZ, 100 mm	
		100	80	10							

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

CORED BOREHOLE LOG

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BH NO. BH104M

Project	Proposed Development	**Sheet**	3 OF 3
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Drilling Contactor	TightSite	**Surface RL**	≈12.00 m AHD
Drill Rig	Hand Portable	**Inclination**	-90°

Drilling						Field Material Description				Defect Information	
METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	*DEPTH* RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DESCRIPTION & Additional Observations	Average Defect Spacing (mm) (30, 100, 300, 1000, 3000)
NMLC	80-90% RETURN	100	80	10			LAMINITE; SANDSTONE and SHALE; sandstone is fine grained, grey and brown, with pale grey laminations, thinly bedded.	DW		10.43: JT, 45°, CN, UN, RF	
		100	23	11				FR			
				12							
					12.57 -0.57		Hole Terminated at 12.57 m Target Depth Reached.				
				13							
				14							
				15							
				16							
				17							
				18							
				19							
				20							

This borehole log should be read in conjunction with EI Australia's accompanying standard notes.

CORE PHOTOGRAPH OF BOREHOLE: BH104M

Project	Proposed Development			**Depth Range**	0.47m to10.00m BEGL		
Location	1112-1116 Barrenjoey Road, Palm Beach NSW			**Contractor**	TightSite		
Position	Refer to Figure 2	**Surface RL**	≈ 12.0 m	**Drill Rig**	Hand Portable		
Job No.	E25203.G03	**Inclination**	-90°	**Logged**	KX	**Date**	27 / 10 / 2021
Client	Palmdev Pty Ltd	**Box**	1-2 of 3	**Checked**	....	**Date**	….

CORE PHOTOGRAPH OF BOREHOLE: BH104M

Project	Proposed Development			**Depth Range**	10.0m to12.57m BEGL		
Location	1112-1116 Barrenjoey Road, Palm Beach NSW			**Contractor**	TightSite		
Position	Refer to Figure 2	**Surface RL**	≈ 12.0 m	**Drill Rig**	Hand Portable		
Job No.	E25203.G03	**Inclination**	-90°	**Logged**	KX	**Date**	27 / 10 / 2021
Client	Palmdev Pty Ltd	**Box**	3 of 3	**Checked**	....	**Date**	….

MONITORING WELL LOG

MW NO. BH104M

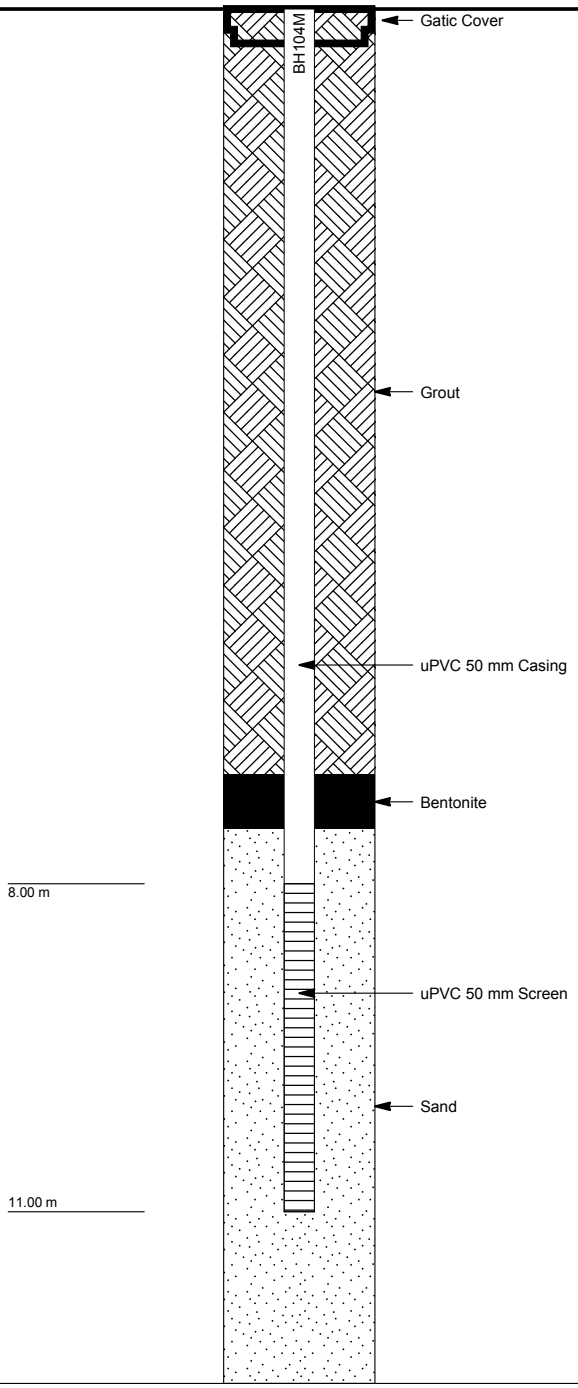
Project	Proposed Development	**Sheet**	1 of 2
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Drilling Contactor	TightSite	**Surface RL**	≈12.00 m AHD
Drill Rig	Hand Portable	**Inclination**	-90°

METHOD	WATER	DEPTH (m)	RL (m AHD)	GRAPHIC LOG	SOIL/ROCK MATERIAL DESCRIPTION
HA	GWNE	0	12		FILL: Silty SAND; fine grained, brown, trace rootlets, medium to coarse, angular to sub-angular gravels.
					LAMINITE; SANDSTONE and CLAYSTONE; sandstone is fine grained, red-brown, orange-brown, pale brown and pale grey, thinly bedded.
		2	10		
		4	8		
NMLC	80-90% RETURN				LAMINITE; SANDSTONE and SHALE; sandstone is fine grained, grey and brown, with pale grey laminations, thinly bedded.
		6	6		
		8	4		
		10	2		
		12	0		
					Hole Terminated at 12.57 m Target Depth Reached.

PIEZOMETER CONSTRUCTION DETAILS

ID	Type	Stick Up & RL	Tip Depth & RL	Installation Date Static Water Level
BH104M	Standpipe		11.00 m 1.00 m	



This well log should be read in conjunction with EI Australia's accompanying standard notes.

DYNAMIC CONE PENETROMETER TEST RESULTS

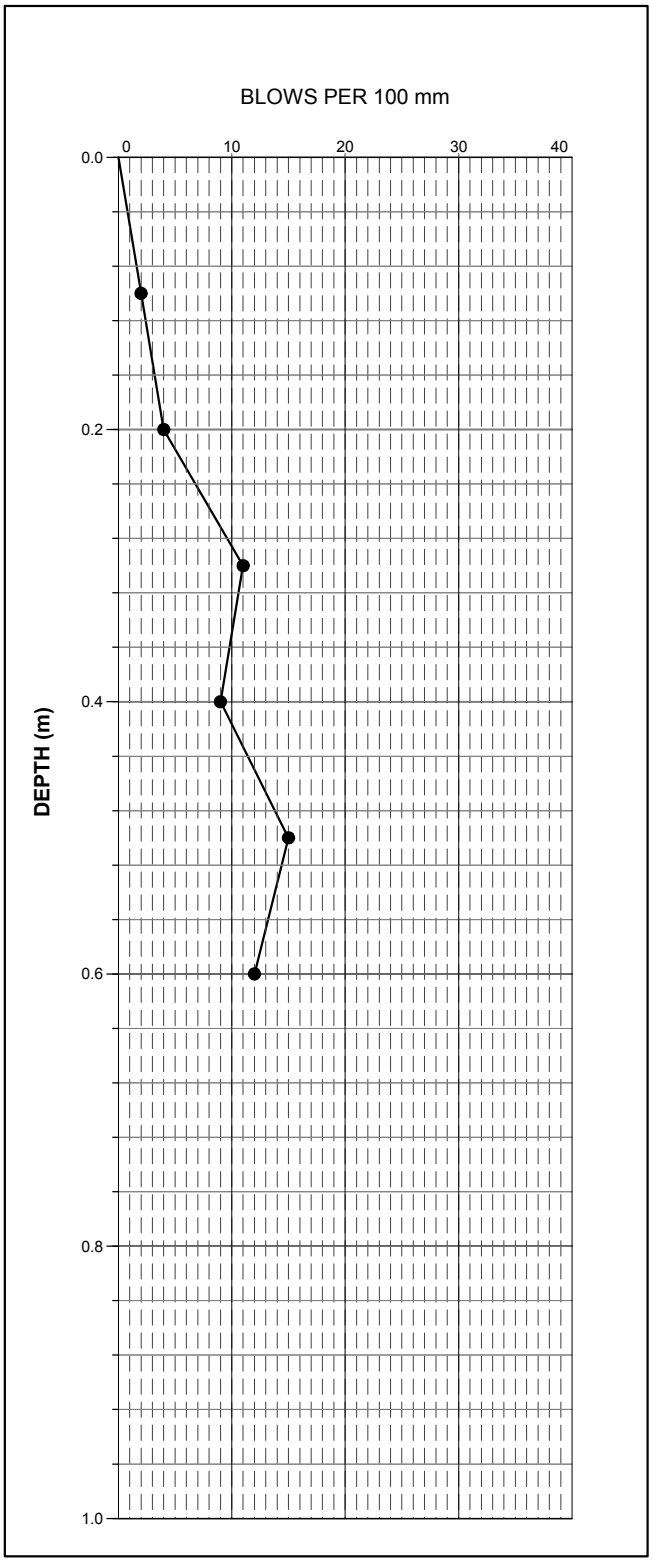
DCP NO. DCP2

Project	Proposed Development	**Sheet**	1 of 1
Location	1112-1116 Barrenjoey Road, Palm Beach NSW	**Date Started**	27/10/2021
Position	Refer to Figure 2	**Date Completed**	27/10/2021
Job No.	E25203.G03	**Logged By** KX	**Date** 27/10/2021
Client	Palmdev Pty Ltd	**Reviewed By** SR	**Date** 14/12/2021

Drilling Contractor

Drill Rig **Inclination** -90°

DEPTH (m)	NO OF BLOWS PER 100 mm
0.00-0.10	2
0.10-0.20	4
0.20-0.30	11
0.30-0.40	9
0.40-0.50	15
0.50-0.55	12/50mm HB



Termination Remark
DCP Refused at 0.55 m depth.
HB Hammer Bounced

Final Depth (m)	0.55

This DCP log should be read in conjunction with EI Australia's accompanying standard notes.

EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT LOGS

DRILLING/EXCAVATION METHOD

HA	Hand Auger	**ADH**	Hollow Auger	**NQ**	Diamond Core - 47 mm
DT	Diatube Coring	**RT**	Rotary Tricone bit	**NMLC**	Diamond Core - 52 mm
NDD	Non-destructive digging	**RAB**	Rotary Air Blast	**HQ**	Diamond Core - 63 mm
AD*	Auger Drilling	**RC**	Reverse Circulation	**HMLC**	Diamond Core - 63 mm
***V**	V-Bit	**PT**	Push Tube	**EX**	Tracked Hydraulic Excavator
***T**	TC-Bit, e.g. AD/T	**WB**	Washbore	**HAND**	Excavated by Hand Methods

PENETRATION RESISTANCE

L	**Low Resistance**	Rapid penetration/ excavation possible with little effort from equipment used.
M	**Medium Resistance**	Penetration/ excavation possible at an acceptable rate with moderate effort from equipment used.
H	**High Resistance**	Penetration/ excavation is possible but at a slow rate and requires significant effort from equipment used.
R	**Refusal/Practical Refusal**	No further progress possible without risk of damage or unacceptable wear to equipment used.

These assessments are subjective and are dependent on many factors, including equipment power and weight, condition of excavation or drilling tools and experience of the operator.

WATER

Standing Water Level — **Partial water loss**

Water Seepage — **Complete Water Loss**

GWNO	GROUNDWATER NOT OBSERVED - Observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave-in of the borehole/ test pit.
GWNE	GROUNDWATER NOT ENCOUNTERED - Borehole/ test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/ test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following a 150mm seating drive
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported, N is not reported
RW	Penetration occurred under the rod weight only, N<1
HW	Penetration occurred under the hammer and rod weight only, N<1
HB	Hammer double bouncing on anvil, N is not reported
Sampling	
DS	Disturbed Sample
ES	Sample for environmental testing
BDS	Bulk disturbed Sample
GS	Gas Sample
WS	Water Sample
U50	Thin walled tube sample - number indicates nominal sample diameter in millimetres
Testing	
FP	Field Permeability test over section noted
FVS	Field Vane Shear test expressed as uncorrected shear strength (sv= peak value, sr= residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket Penetrometer test expressed as instrument reading in kPa
WPT	Water Pressure tests
DCP	Dynamic Cone Penetrometer test
CPT	Static Cone Penetration test
CPTu	Static Cone Penetration test with pore pressure (u) measurement

GEOLOGICAL BOUNDARIES

———— = Observed Boundary (position known)

– – – – – – – – – – = Observed Boundary (position approximate)

– –?– –?– –?– – = Boundary (interpreted or inferred)

ROCK CORE RECOVERY

TCR=Total Core Recovery (%)

$$= \frac{\textit{Length of core recovered}}{\textit{Length of core run}} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum \textit{Axial lengths of core} > 100mm}{\textit{Length of core run}} \times 100$$

METHOD OF SOIL DESCRIPTION USED ON BOREHOLE AND TEST PIT LOGS

	FILL		ORGANIC SOILS (OL, OH or Pt)		CLAY (CL, CI or CH)
	COUBLES or BOULDERS		SILT (ML or MH)		SAND (SP or SW)
	GRAVEL (GP or GW)	Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay			

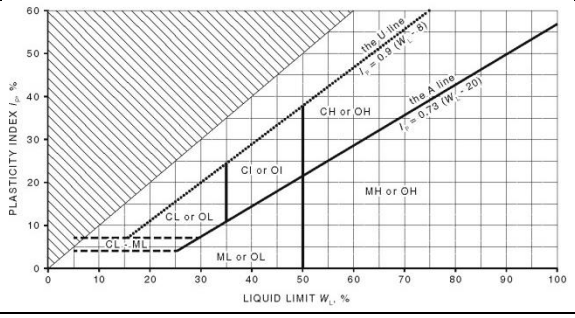
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS 1726:2017, Section 6.1 – Soil description and classification.

PARTICLE SIZE CHARACTERISTICS

Fraction	Components	Sub Division	Size mm
Oversize	BOULDERS		>200
	COBBLES		63 to 200
Coarse grained soil	GRAVEL	Coarse	19 to 63
		Medium	6.7 to 19
		Fine	2.36 to 6.7
	SAND	Coarse	0.6 to 2.36
		Medium	0.21 to 0.6
		Fine	0.075 to 0.21
Fine grained soil	SILT		0.002 to 0.075
	CLAY		<0.002

PLASTICITY PROPERTIES



GROUP SYMBOLS

Major Divisions		Symbol	Description
COARSE GRAINED SOILS More than 65% of soil excluding oversize fraction is greater than 0.075mm	GRAVEL More than 50% of coarse fraction is >2.36mm	GW	Well graded gravel and gravel-sand mixtures, little or no fines, no dry strength.
		GP	Poorly graded gravel and gravel-sand mixtures, little or no fines, no dry strength.
		GM	Silty gravel, gravel-sand-silt mixtures, zero to medium dry strength.
		GC	Clayey gravel, gravel-sand-clay mixtures, medium to high dry strength.
	SAND More than 50% of coarse fraction is <2.36 mm	SW	Well graded sand and gravelly sand, little or no fines, no dry strength.
		SP	Poorly graded sand and gravelly sand, little or no fines, no dry strength.
		SM	Silty sand, sand-silt mixtures, zero to medium dry strength.
		SC	Clayey sand, sandy-clay mixtures, medium to high dry strength.
FINE GRAINED SOILS More than 35% of soil excluding oversized fraction is less than 0.075mm	Liquid Limit less < 50%	ML	Inorganic silts of low plasticity, very fine sands, rock flour, silty or clayey fine sands, zero to medium dry strength.
		CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, medium to high dry strength.
		OL	Organic silts and organic silty clays of low plasticity, low to medium dry strength.
	Liquid Limit > than 50%	MH	Inorganic silts of high plasticity, high to very high dry strength.
		CH	Inorganic clays of high plasticity, high to very high dry strength.
		OH	Organic clays of medium to high plasticity, medium to high dry strength.
Highly Organic soil		PT	Peat muck and other highly organic soils.

MOISTURE CONDITION

Symbol	Term	Description
D	Dry	Non- cohesive and free-running.
M	Moist	Soils feel cool, darkened in colour. Soil tends to stick together.
W	Wet	Soils feel cool, darkened in colour. Soil tends to stick together, free water forms when handling.

Moisture content of cohesive soils shall be described in relation to plastic limit (PL) or liquid limit (LL) for soils with higher moisture content as follows: Moist, dry of plastic limit (w < PL); Moist, near plastic limit (w ≈ PL); Moist, wet of plastic limit (w < PL); Wet, near liquid limit (w ≈ LL), Wet, wet of liquid limit (w > LL),

CONSISTENCY

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N" #
VS	Very Soft	≤ 12	≤ 2
S	Soft	>12 to ≤ 25	>2 to ≤ 4
F	Firm	>25 to ≤ 50	>4 to 8
St	Stiff	>50 to ≤ 100	>8 to 15
VSt	Very Stiff	>100 to ≤ 200	>15 to 30
H	Hard	>200	>30
Fr	Friable	-	

DENSITY

Symbol	Term	Density Index %	SPT "N" #
VL	Very Loose	≤ 15	0 to 4
L	Loose	>15 to ≤ 35	4 to 10
MD	Medium Dense	>35 to ≤ 65	10 to 30
D	Dense	>65 to ≤ 85	30 to 50
VD	Very Dense	>85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.
SPT correlations are not stated in AS1726:2017, and may be subject to corrections for overburden pressure, moisture content of the soil, and equipment type.

MINOR COMPONENTS

Term	Assessment Guide	Proportion by Mass
Add 'Trace'	Presence just detectable by feel or eye but soil properties little or no different to general properties of primary component	Coarse grained soils: ≤ 5% Fine grained soil: ≤ 15%
Add 'With'	Presence easily detectable by feel or eye but soil properties little or no different to general properties of primary component	Coarse grained soils: 5 - 12% Fine grained soil: 15 - 30%
Prefix soil name	Presence easily detectable by feel or eye in conjunction with the general properties of primary component	Coarse grained soils: >12% Fine grained soil: >30%

TERMS FOR ROCK MATERIAL STRENGTH AND WEATHERING

CLASSIFICATION AND INFERRED STRATIGRAPHY

Rock is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS1726 – 2017, Section 6.2 – Rock identification, description and classification.

ROCK MATERIAL STRENGTH CLASSIFICATION

Symbol	Term	Point Load Index, $Is_{(50)}$ (MPa) #	Field Guide
VL	Very Low	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30 mm can be broken by finger pressure.
L	Low	0.1 to 0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
M	Medium	0.3 to 1	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
H	High	1 to 3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow; rock rings under hammer.
VH	Very High	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
EH	Extremely High	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

 # Rock Strength Test Results

▼ Point Load Strength Index, $Is_{(50)}$, Axial test (MPa)

● Point Load Strength Index, $Is_{(50)}$, Diametral test (MPa)

Relationship between rock strength test result ($Is_{(50)}$) and unconfined compressive strength (UCS) will vary with rock type and strength, and should be determined on a site-specific basis. However UCS is typically 20 x $Is_{(50)}$.

ROCK MATERIAL WEATHERING CLASSIFICATION

Symbol		Term	Field Guide
RS		Residual Soil	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
XW		Extremely Weathered	Rock is weathered to such an extent that it has soil properties - i.e. it either disintegrates or can be remoulded, in water.
DW	HW	Distinctly Weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores. In some environments it is convenient to subdivide into Highly Weathered and Moderately Weathered, with the degree of alteration typically less for MW.
	MW		
SW		Slightly Weathered	Rock slightly discoloured but shows little or no change of strength relative to fresh rock.
FR		Fresh	Rock shows no sign of decomposition or staining.

ABBREVIATIONS AND DESCRIPTIONS FOR ROCK MATERIAL AND DEFECTS

CLASSIFICATION AND INFERRED STRATIGRAPHY
Rock is broadly classified and described in Borehole and Test Pit Logs using the preferred method given in AS1726 – 2017, Section 6.2 – Rock identification, description and classification.

DETAILED ROCK DEFECT SPACING

Defect Spacing

Spacing/width (mm)	Descriptor	Symbol
<20	Extremely Close	EC
20-60	Very Close	VC
60-200	Close	C
200-600	Medium	M
600-2000	Wide	W
2000-6000	Very Wide	VW

Bedding Thickness (Stratification)

Term	Spacing (mm)
Thinly laminated	<6
Laminated	6 – 20
Very thinly bedded	20 – 60
Thinly bedded	60 – 200
Medium bedded	200 – 600
Thickly bedded	600 – 2,000
Very thickly bedded	> 2,000

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT TYPES

Defect Type	Abbr.	Description
Joint	JT	Surface of a fracture or parting, formed without displacement, across which the rock has little or no tensile strength. May be closed or filled by air, water or soil or rock substance, which acts as cement.
Bedding Parting	BP	Surface of fracture or parting, across which the rock has little or no tensile strength, parallel or sub-parallel to layering/ bedding. Bedding refers to the layering or stratification of a rock, indicating orientation during deposition, resulting in planar anisotropy in the rock material.
Contact	CO	The surface between two types or ages of rock.
Sheared Surface	SSU	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.
Sheared Seam/ Zone (Fault)	SS/SZ	Seam or zone with roughly parallel almost planar boundaries of rock substance cut by closely spaced (often <50 mm) parallel and usually smooth or slickensided joints or cleavage planes.
Crushed Seam/ Zone (Fault)	CS/CZ	Seam or zone composed of disoriented usually angular fragments of the host rock substance, with roughly parallel near-planar boundaries. The brecciated fragments may be of clay, silt, sand or gravel sizes or mixtures of these.
Extremely Weathered Seam/ Zone	XWS/XWZ	Seam of soil substance, often with gradational boundaries, formed by weathering of the rock material in places.
Infilled Seam	IS	Seam of soil substance, usually clay or clayey, with very distinct roughly parallel boundaries, formed by soil migrating into joint or open cavity.
Vein	VN	Distinct sheet-like body of minerals crystallised within rock through typically open-space filling or crack-seal growth.

NOTE: Defects size of <100mm SS, CS and XWS. Defects size of >100mm SZ, CZ and XWZ.

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT SHAPE AND ROUGHNESS

Shape	Abbr.	Description	Roughness	Abbr.	Description
Planar	PR	Consistent orientation	Polished	POL	Shiny smooth surface
Curved	CU	Gradual change in orientation	Slickensided	SL	Grooved or striated surface, usually polished
Undulating	UN	Wavy surface	Smooth	SM	Smooth to touch. Few or no surface irregularities
Stepped	ST	One or more well defined steps	Rough	RO	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper
Irregular	IR	Many sharp changes in orientation	Very Rough	VR	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper

Orientation: **Vertical Boreholes –** The dip (inclination from horizontal) of the defect.
Inclined Boreholes – The inclination is measured as the acute angle to the core axis.

ABBREVIATIONS AND DESCRIPTIONS FOR DEFECT COATING

Coating	Abbr.	Description
Clean	CN	No visible coating or infilling
Stain	SN	No visible coating but surfaces are discoloured by staining, often limonite (orange-brown)
Veneer	VNR	A visible coating of soil or mineral substance, usually too thin to measure (< 1 mm); may be patchy

DEFECT APERTURE

Aperture	Abbr.	Description
Closed	CL	Closed.
Open	OP	Without any infill material.
Infilled	-	Soil or rock i.e. clay, silt, talc, pyrite, quartz, etc.

Appendix B – Laboratory Certificates

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

STS Geotechnics Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 | Email: enquiries@stsgeo.com.au

Point Load Strength Index Report

Project: E25203.G03, 1112-1116 Barrenjoey Rd, Palm Beach — Project No.: 31264/5259D-L

Client: EI Australia — Report No.: 21/1884

Address: Suite 6.01, 55 Miller Street, Pyrmont NSW — Report Date: 22/06/2021

Test Method: AS 4133.4.1 — Page: 1 OF 1

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 11/06/2021

Borehole No. 101M

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
3.30	A	**0.052**	TS	3	M
4.39	A	**0.062**	TS	3	M
5.28	A	**0.086**	TS	3	M
5.84	A	**0.110**	TS	3	M
6.34	A	**0.085**	TS	3	M
7.40	A	**0.130**	TS	3	M
8.34	A	**0.089**	TS	3	M

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken:

Borehole No.

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture

FAILURE TYPE	TEST TYPE	MOISTURE CONDITION	ROCK TYPE
1= FRACTURE THROUGH BEDDING OR WEAK PLANE	A= AXIAL	W= WET	SS= SANDSTONE
2= FRACTURE ALONG BEDDING	D= DIAMETRAL	M= MOIST	ST= SILTSTONE
3= FRACTURE THROUGH ROCK MASS	I= IRREGULAR	D= DRY	SH= SHALE
4= FRACTURE INFLUENCED BY NATURAL DEFECT OR DRILLING	C= CUBE		YS= CLAYSTONE
5= PARTIAL FRACTURE OR CHIP (INVALID RESULT)			IG= IGNEOUS

Remarks:

Approved Signatory.....

Technician: FV

Orlando Mendoza - Laboratory Manager

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

STS Geotechnics Pty Ltd
14/1 Cowpasture Place, Wetherill Park NSW 2164
Phone: (02)9756 2166 | Email: enquiries@stsgeo.com.au

Point Load Strength Index Report

Project: E25203.G03: 1112 - 1116 Barrenjoey Road, Palm Beach
Project No.: 31380/5855D-L

Client: EI Australia Pty Ltd
Report No.: 21/3558

Address: Suite 6.01, 55 Miller Street, Pyrmont NSW 2009
Report Date: 30/11/2021

Test Method: AS4133.4.1
Page: 1 of 1

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 27/10/21

Borehole No. 103

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
1.47	A	**0.023**	SS	3	W
2.40	A	**0.400**	SS	3	M
3.78	A	**0.039**	TS	3	W
4.53	A	**0.750**	SS	3	W
6.49	A	**0.640**	SS	3	M
7.44	A	**0.073**	SS	3	M
9.22	A	**0.180**	SS	3	M
10.34	A	**0.120**	SS	3	M
11.43	A	**0.290**	SS	3	M
12.43	A	**0.200**	SH	3	M

Sampling Procedure: Samples Supplied By Client (Not covered under NATA Scope of Accreditation)

Date Samples Drilled / Taken: 27/10/21

Borehole No. 104

Depth	Test Type	Is(50) (Mpa)	Rock Type	Failure Type	Moisture
1.27	A	**0.024**	SS	3	M
2.38	A	**0.020**	SS	3	M
4.65	A	**0.057**	SS	3	M
5.79	A	**0.120**	SS	3	M
7.44	A	**0.160**	SS	3	M
8.71	A	**0.063**	SS	3	M
9.67	A	**0.260**	SS	3	M
10.38	A	**0.330**	SS	3	M
11.51	A	**0.340**	SS	3	M
12.43	A	**0.200**	SS	3	M

FAILURE TYPE
1= FRACTURE THROUGH BEDDING OR WEAK PLANE
2= FRACTURE ALONG BEDDING
3= FRACTURE THROUGH ROCK MASS
4= FRACTURE INFLUENCED BY NATURAL DEFECT OR DRILLING
5= PARTIAL FRACTURE OR CHIP (INVALID RESULT)

TEST TYPE
A= AXIAL
D= DIAMETRAL
I= IRREGULAR
C= CUBE

MOISTURE CONDITION
W= WET
M= MOIST
D= DRY

ROCK TYPE
SS= SANDSTONE
ST= SILTSTONE
SH= SHALE
YS= CLAYSTONE
IG= IGNEOUS

Remarks:

Approved Signatory..... .....

Technician: FV

Orlando Mendoza - Laboratory Manager

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS

Contact	Kaiyu Xu
Client	EI AUSTRALIA
Address	SUITE 6.01 55 MILLER STREET PYRMONT NSW 2009
Telephone	61 2 9516 0722
Facsimile	(Not specified)
Email	kaiyu.xu@eiaustralia.com.au
Project	**E25203.G03 1112-1116 Barrenjoey Rd, Palm**
Order Number	**E25203.G03**
Samples	2

LABORATORY DETAILS

Manager	Huong Crawford
Laboratory	SGS Alexandria Environmental
Address	Unit 16, 33 Maddox St Alexandria NSW 2015
Telephone	+61 2 8594 0400
Facsimile	+61 2 8594 0499
Email	au.environmental.sydney@sgs.com
SGS Reference	**SE220690 R0**
Date Received	15/6/2021
Date Reported	22/6/2021

COMMENTS

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

SIGNATORIES

Dong LIANG
Metals/Inorganics Team Leader

Shane MCDERMOTT
Inorganic/Metals Chemist

Soluble Anions (1:5) in Soil/Solids by Ion Chromatography [AN245] Tested: 17/6/2021

PARAMETER	UOM	LOR	BH101M 0.5-0.95m SOIL - 11/6/2021 SE220690.001	BH102 3.0-3.45m SOIL - 11/6/2021 SE220690.002
Chloride	mg/kg	0.25	**18**	**110**
Sulfate	mg/kg	5	**22**	**63**

pH in soil (1:5) [AN101] Tested: 17/6/2021

PARAMETER	UOM	LOR	BH101M 0.5-0.95m SOIL - 11/6/2021 SE220690.001	BH102 3.0-3.45m SOIL - 11/6/2021 SE220690.002
pH	pH Units	0.1	**5.7**	**4.8**

Conductivity and TDS by Calculation - Soil [AN106] Tested: 17/6/2021

PARAMETER	UOM	LOR	BH101M 0.5-0.95m SOIL - 11/6/2021 SE220690.001	BH102 3.0-3.45m SOIL - 11/6/2021 SE220690.002
Conductivity of Extract (1:5 dry sample basis)	µS/cm	1	**27**	**130**

Moisture Content [AN002] Tested: 21/6/2021

PARAMETER	UOM	LOR	BH101M 0.5-0.95m SOIL - 11/6/2021 SE220690.001	BH102 3.0-3.45m SOIL - 11/6/2021 SE220690.002
% Moisture	%w/w	1	**9.2**	**34.3**

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode and is calibrated against 3 buffers purchased commercially. For soils, sediments and sludges, an extract with water (or 0.01M CaCl2) is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos /cm or µS/cm @ 25°C. For soils, an extract of as received sample with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2510 B.
AN245	Anions by Ion Chromatography: A water sample is injected into an eluent stream that passes through the ion chromatographic system where the anions of interest ie Br, Cl, NO2, NO3 and SO4 are separated on their relative affinities for the active sites on the column packing material. Changes to the conductivity and the UV-visible absorbance of the eluent enable identification and quantitation of the anions based on their retention time and peak height or area. APHA 4110 B

FOOTNOTES

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

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

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

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

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

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

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

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

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety.

Appendix C – Vibration Limits

German Standard DIN 4150 – Part 3: 1999 provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally considered to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) directions, in the plane of the uppermost floor), are summarised in **Table A** below.

It should be noted that peak vibration velocities higher than the minimum figures in **Table A** for low frequencies may be quite 'safe', depending on the frequency content of the vibration and the actual conditions of the structures.

It should also be noted that these levels are 'safe limits', up to which no damage due to vibration effects has been observed for the particular class of building. 'Damage' is defined by DIN 4150 to include even minor non-structural cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. Should damage be observed at vibration levels lower than the 'safe limits', then it may be attributed to other causes. DIN 4150 also states that when vibration levels higher than the 'safe limits' are present, it does not necessarily follow that damage will occur. Values given are only a broad guide.

Table A DIN 4150 – Structural Damage – Safe Limits for Building Vibration

Group	Type of Structure	Peak Vibration Velocity (mm/s)			
		At Foundation Level at a Frequency of:			Plane of Floor of Uppermost Storey
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 and 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note: For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column should be used.

Appendix D – Important Information

Important Information

SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client And EI Australia ("EI"). The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

RELIANCE ON DATA

EI has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. EI has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, EI will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to EI.

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. EI should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that EI be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

REPRODUCTION OF REPORTS

 Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimize the likelihood of misinterpretation from logs.

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party. EI assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of EI or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

EI will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.