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REPORT ON GEOTECHNICAL SITE INVESTIGATION

for

PROPOSED NEW DEVELOPMENT

at

38 PARK STREET & 1795-1797 & 1793 PITTWATER ROAD, MONA VALE, NSW

Prepared For

Mona Vale 3 Pty Ltd & 1793 Pittwater Road Pty Ltd

Project No.: 2019-132.1
September 2020

Document Revision Record

Issue No	Date	Details of Revisions
0	7th September 2020	Original issue

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER
FORM NO. 1 – To be submitted with Development Application

Development Application for ______________________________	
	Name of Applicant
Address of site	38 Park Street & 1795-1797 & 1793 Pittwater Road, Mona Vale, NSW

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

I, ***__Troy Crozier___________*** *on behalf of* ***___Crozier Geotechnical Consultants*** _on this the _7th September 2020___ certify that I am a ~~geotechnical engineer or~~ engineering geologist ~~or coastal engineer~~ as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above ~~organisation/~~company to issue this document and to certify that the ~~organisation/~~company has a current professional indemnity policy of at least $2million.

I:

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

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

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

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

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

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

Geotechnical Report Details:

Report Title: Geotechnical Investigation for Proposed New Development

Report Date: 7th September 2020 **Project No.:** 2019-132.1

Author: Jun Yan
Author's Company/Organisation: Crozier Geotechnical Consultants

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

Architectural drawing by Gartner Trovato Architects, Project No. 1835, Drawing No. DA02 to DA05,
DA07 and DA08, Revision: B, Dated: 3rd September 2019
Architectural drawings by Gartner Trovato Architects, Project No.: 2015, Drawing No.: DA02 to
DA05, DA10, Revision: C, Dated: 29th July 2020.
Survey Plan by DP Surveying, Reference: 3190, Dated: 16th January 2019

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

Signature ....

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

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

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

Company... **Crozier Geotechnical Consultants**

REGISTERED PROFESSIONAL GEOSCIENTIST
AUSTRALIAN INSTITUTE OF GEOSCIENTISTS
TROY CROZIER
10197

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1(a) - Checklist of Requirements For Geotechnical Risk Management Report for Development Application

Development Application for ____

Name of Applicant

Address of site ____38 Park Street & 1795-1797, &1793 Pittwater Road, Mona Vale, NSW_______________

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

Geotechnical Report Details:

Report Title: Geotechnical Investigation for Proposed New Development
Report Date: 7th September 2020 **Project No.:** 2019-132.1
Author: Jun Yan
Author's Company/Organisation: Crozier Geotechnical Consultants

Please mark appropriate box

- ■ Comprehensive site mapping conducted __21st August 2019 & 26th August 2020______ (date)
- ☐ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- ■ Subsurface investigation required
  - ☐ No Justification ....
  - ■ Yes Date conducted ...21st August 2019 & 26th August 2020
- ■ Geotechnical model developed and reported as an inferred subsurface type-section
- ■ Geotechnical hazards identified
  - ☐ Above the site
  - ■ On the site
  - ☐ Below the site
  - ☐ Beside the site
- ■ Geotechnical hazards described and reported
- ■ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
  - ■ Consequence analysis
  - ■ Frequency analysis
- ■ Risk calculation
- ■ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ■ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ■ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
- ■ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- ■ Design Life Adopted:
  - ■ 100 years
  - ☐ Other ... . specify
- ■ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- ■ Additional action to remove risk where reasonable and practical have been identified and included in the report.
- ☐ Risk assessment within Bushfire Asset Protection Zone.

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

Signature ....

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

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

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

Company... **Crozier Geotechnical Consultants**

AUSTRALIAN INSTITUTE OF GEOSCIENTISTS
TROY CROZIER
10,197

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GEOTECHNICAL INVESTIGATION FOR PROPOSED NEW DEVELOPMENT 38 PARK STREET & 1795-1797 & 1793 PITTWATER ROAD, MONA VALE, NSW

1. INTRODUCTION:

This report details the results of geotechnical investigations carried out for a proposed new Senior Living development at 38 Park Street, 1795-1797 Pittwater Road and 1793 Pittwater Road, Mona Vale, NSW. The investigation was undertaken by Crozier Geotechnical Consultants (CGC) at the request of the clients Mona Vale 3 Pty Ltd and 1793 Pittwater Road Pty Ltd.

The site is not located within a landslip hazard zone as identified within Northern Beaches Council (Pittwater) Geotechnical Hazard Mapping (Geotechnical Risk Management Policy for Pittwater - 2009). However, the works trigger the policy regarding excavation and filling - Section 3.2 (b) (iv).

It is understood that the Development Application at 38 Park Street and 1795-1797 Pittwater Road (DA2019/1072), which was supported by CGCȏs previous investigation and reporting (Project No.: 2019-132, Dated: 17th September 2019), has been approved. It is further understood that an extension of the approved works has been proposed within 1793 Pittwater Road. Therefore, a new DA will be submitted and an additional geotechnical investigation and reporting where requested.

To meet the Councils Policy requirements for works which trigger the landslip policy we need to provide a detailed Geotechnical Report which meets the requirements of Paragraph 6.5 of that policy. Therefore, this report includes a review and inclusion of the previous geotechnical investigation report data, details from the new investigation, a landslide risk assessment of the site and proposed works, plans, geological sections and provides recommendations for construction and to ensure stability is maintained for a design life of 100 years. It is recommended that the client make themselves aware of the Policy and its requirements.

The initial investigation and reporting were undertaken as per the Tender P19-288, Dated: 9th August 2019. The investigation comprised:

a) A detailed geotechnical inspection and mapping of the northern portion of the site (38 Park St and 1795-1797 Pittwater Rd) and adjacent properties by a Geotechnical Engineer.
b) DBYD plan request and clearance of test locations by accredited contractor.

c) Drilling of five boreholes using a restricted access drill rig and one borehole using hand tools along with Dynamic Cone Penetrometer (DCP) testing to investigate the subsurface geology, depth to bedrock and identification of ground water conditions.
d) Soil sampling and geotechnical testing by NATA accredited laboratory for site classification and geotechnical conditions.

The additional investigation was undertaken as per the Tender: P20-347, Dated: 19th August 2020.
The investigation comprised:

a) A detailed geotechnical inspection and mapping of the southern portion of the site (1793 Pittwater Road) and adjacent properties by a Geotechnical Engineer.
b) DBYD plan request and clearance of test locations by accredited contractor.
c) Drilling of two boreholes using a restricted access drill rig along with Dynamic Cone Penetrometer (DCP) testing to investigate the subsurface geology, depth to bedrock and identification of ground water conditions.

The following plans and drawings were supplied by the Architect for the work;

- Architectural drawings by Gartner Trovato Architects, Project No.: 1835, Drawing No.: DA02 to DA05, DA07 and DA08, Revision: B, Dated: 3rd September 2019.
- Architectural drawings by Gartner Trovato Architects, Project No.: 2015, Drawing No.: DA02 to DA05, DA10, Revision: C, Dated: 29th July 2020.
- Survey Plan by DP Surveying, Reference: 3190, Dated: 16th January 2019.

2. PROPOSED DEVELOPMENT:

It is understood that the proposed new Senior Living development comprises two separate two-storey buildings over basement level carparks with shared driveway access in the middle.

It is understood that the northern portion of the development at 38 Park Street and 1795-1797 Pittwater Road has been approved. The works require excavation of up to 5.00m depth, with the maximum depth at the northwest corner, to achieve the basement level with a finished floor level (FFL) at RL8.60 and RL8.45. The excavation reduces to 2.90m depth towards the east and will extend to within 3.30m of the north boundary, 3.50m of the west boundary and 7.70m of the east boundary.

The proposed extension works in the south at 1973 Pittwater Road involve demolition of the existing residential house and construction of a two storey structure over a basement level carpark. It appears that the works require excavation of up to 3.70m depth to achieve the basement level with FFL7.73. The excavation will extend to within 0.90m of the south boundary, 4.70m of the west boundary and 6.70m of the east boundary.

3. SITE FEATURES:

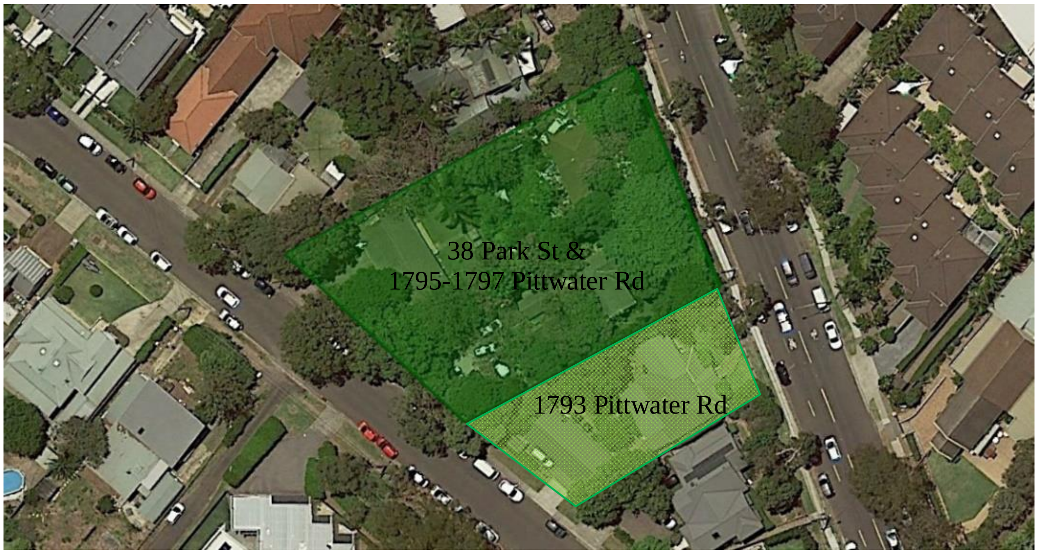
3.1. Description:

The site is a trapezoid shaped block formed of 4 separate ôLotsö located on the high west side of Pittwater Road and low east side of Park Street, within gently east dipping topography. The site has a front east boundary of 60.2m, rear west boundary of 63.3m, north side boundary of 68.47m and south side boundary of 36.4m.

An aerial photograph of the site and its surrounds is provided below, as sourced from Google Earth data, as Photograph 1.

The site contains four properties with four one and two storey brick and weatherboard residences, which are located at the centre of each property with lawns and mature trees up to approximately 20m in height surrounding.

The ground surface of the site displays a gentle dip towards the east from a high of approximately RL14.3 at the northwest corner to a low of approximately RL9.8 at the southeast corner. The existing residential buildings appear approximately 70 years old. An inspection of the existing dwellings and the properties identified no obvious geotechnical problems.



Photograph: 1 – Aerial photo of site and surrounds.

The neighbouring property to the south (No. 1791 Pittwater Rd) contains a single storey weatherboard building at the centre of the property with a concrete carpark at the west rear. The structures appear in good condition with no sign of cracking or settlement on the external walls. The property is at a similar ground level as the site along the common boundary. The building structures are located within 1.00m of the common boundary.

The neighbouring properties to the north (No. 40 Park Street and No. 1799 Pittwater Road) contain single storey weatherboard residences located broadly at the centre of the properties. The house structures appear in good condition with no sign of cracking or settlement on the external walls. The properties are at a similar ground level as the site along the common boundary. The building structures are located within 0.50m of the common boundary.

The neighbouring buildings and properties were only inspected from within the site or from the road reserve however the visible aspects did not show any significant signs of large scale slope instability or other major geotechnical concerns which would impact the site or the proposed development.

3.2. Geology:

Reference to the Sydney 1:100,000 Geological Series sheet (9130) indicates that the site is underlain by Newport Formation (Upper Narrabeen Group) rock (Rnn) which is of middle Triassic Age. The Newport Formation typically comprises interbedded laminite, shale and quartz to lithic quartz sandstones and pink clay pellet sandstones.

4. FIELD WORK:

4.1. Methods:

The initial field investigation comprised a walk over inspection and mapping of the north portion of the site (38 Park Street and 1795-1797 Pittwater Road) and adjacent properties on the 21st August 2019 by a Geotechnical Engineer. It included a photographic record of site conditions with examination of existing structures and soil slopes. It also included the drilling of five auger boreholes (BH1 to BH4, BH3a) using a restricted access drill rig employing solid stem spiral flight augers and a tungsten carbide bit and one auger borehole (BH5) using hand tools, due to limited access, to investigate sub-surface geology.

The additional investigation comprised a walk over inspection and mapping of the southern portion of the site (1793 Pittwater Road) and adjacent properties on the 26th August 2020 by a Geotechnical Engineer. It also included the drilling of two auger boreholes (BH6 and BH7) using a restricted access drill rig employing solid stem spiral flight augers and a tungsten carbide bit to investigate sub-surface geology.

Dynamic Cone Penetrometer (DCP) testing was carried out from ground surface adjacent to the boreholes and through the base of the boreholes when they had progressed, in accordance with AS1289.6.3.2 ï 1997, ñDetermination of the penetration resistance of a soil ï 9kg Dynamic Cone Penetrometerò to estimate near surface soil conditions and depth to bedrock.

Strata identification was undertaken on material recovered from the boreholes with samples collected as per ñAS1726: 2017 Geotechnical Site Investigationò for logging purposes and submission to NATA accredited laboratories.

Explanatory notes are included in Appendix: 1. Mapping information and test locations are shown on Figure: 1 and 3, along with detailed log sheets in Appendix: 2. A geological model/section is provided as Figure: 2 and 4, Appendix: 2.

4.2. Field Testing:

The boreholes (BH1 to BH5) were drilled approximately at the corners of the northern basement. Auger refusal (BH1 to BH4) was encountered at varying depths between 0.70m (BH3 and BH3a) and 3.40m (BH1) on interpreted low strength ironstone, siltstone and sandstone, whilst hand auger refusal in BH5 was encountered at 0.30m depth on compacted fill. DCP testing encountered refusal at depths from 1.05m (DCP3) to 2.70m (DCP1b).

The boreholes (BH6 and BH7) were drilled at the front and rear of the property 1793 Pittwater Road. Auger refusal was encountered at 4.70m depth in BH6 on interpreted low strength siltstone, whilst refusal was not encountered in BH7 to the maximum investigation depth at 5.50m depth.

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

- **TOPSOIL/FILL –** this layer was encountered at all test locations to depths varying from 0.30m (BH5) to 0.70m (BH3). It is classified as dark brown, fine to medium grained silty sand trace of brick and tile in BH1 and with slag in BH5.
- **Silty CLAY –** this layer was encountered in BH1, BH2, BH4, BH6 and BH7 to varying depths between 1.30m (BH4) and 4.70m (BH6). It is classified as stiff to hard, orange and pale brown mottled grey, low to medium plasticity, moist silty clay with gravel
- **SILTSTONE –** this layer was encountered below the silty clay in BH2 and BH7 from 1.50m and 4.50m depth, respectively. It is classified as extremely low strength to low strength, grey brown mottled.
- **IRONSTONE –** BH3 and BH3a encountered this material below the topsoil/fill at 0.70m depth with auger refusal occurring on this layer. It is classified as at least low strength, red and is expected to be related to siltstone units, though it could be underlain by clay soils.
- **Sandy CLAY –** this layer was encountered in BH1 below the silty clay to 3.40m depth. It is classified as hard, red, low plasticity sandy clay with fine grained gravel.
- **SANDSTONE** ï this layer was interpreted below the sandy clay and as at least low strength at 3.40m depth in BH1.

A freestanding ground water table or signs of significant water seepage were not identified to the maximum investigation depth of 5.50m.

4.3. Laboratory Testing:

Soil samples collected from the boreholes were sent to NATA accredited laboratories for chemical testing (Envirolab) and geotechnical testing (Macquarie Geotechnical) and the results are summerised in the following sections.

4.3.1 Chemical Testing

Three samples were tested at Envirolab to determine the aggressivity of the soils below the site to provide durability classification for new concrete/steel structures as per AS2159. The samples were tested after preparing a 1:5 soil:water suspension. The results are summarised in Table 1:

Table 1: Summary of Envirolab Laboratory Test Results

Borehole:	Depth (m)	pH	Chloride, Cl (mg/kg)	Sulphate, SO4 (mg/kg)	Electrical Conductivity, (µS/cm)
BH1	3.2-3.4	5.4	24	240	150
BH2	0.8-1.0	6.3	270	140	280
BH4	0.9-1.0	6.6	22	43	49

4.3.2 Geotechnical Laboratory Testing

Four soil samples were tested for measurement of field moisture content in accordance with Australian Standard AS 1289 2.1.1 and the results are summarised in Table 2.

Table 2: Summary of Reported Moisture Content Results

Borehole:	Depth (m)	Sample Description	Moisture Content (%)
BH1	0.8-0.9	Silty CLAY	18.1
BH1	2.4-2.5	Silty CLAY	20.4
BH2	0.8-1.0	Silty CLAY	17.4
BH4	0.9-1.0	Silty CLAY	15.1

Two samples were tested for measurement of plasticity using Atterberg limit test methods as per Australian Standard AS 1289.3.1.1, 3.2.1., 3.3.1, 3.4.1. These results are summarised in Table 3 below and indicate that the samples tested are medium to high plasticity, and by inference would be expected to display moderate to high potential for volume change in response to moisture content variation.

Table 3: Summary of Reported Plasticity Results

Sample Location:	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Sample Description	Sample Classification*
BH1, 0.8-0.9m	43	18	25	Silty CLAY	CI
BH1, 2.4-2.5m	64	19	45	Silty CLAY	CH
BH2, 0.8-1.0m	49	19	30	Silty CLAY	CI

* Australian Standard AS1726-2017 *Geotechnical Site Investigations*

Detailed laboratory test results sheet is provided in Appendix: 3.

5. COMMENTS:

5.1. Geotechnical Assessment:

The site investigations identified the presence of a layer of topsoil/fill to 0.70m depth overlying stiff to hard silty clay. Consistent low strength siltstone/sandstone bedrock is interpreted below the clayey soils at approximately 3.40m depth in the north and below 5.50m depth in the south. It appears that the silty clay layer is interbedded by layers of sandstone, siltstone and ironstone of at least low strength at varying levels across the site. In the northern portion, siltstone and sandstone are interpreted at RL7.1 (BH1) in the east and RL10.6 (BH2) in the west. In the middle portion, ironstone is interpreted at RL11.4 (BH3). This material may be related to weathered siltstone, however, it may also be underlain by clay soils. In the southern portion, siltstone is interpreted at RL5.3 (BH6) in the east, whilst silty clay extends to below RL6.2 in the west. A groundwater table was not identified in the investigation to 5.50m depth (RL6.20)

The proposed new Senior Living development requires excavations to accommodate a basement with FFL8.45 in the north and a basement with FFL7.73 in the south. The northern basement excavation will be approximately 5.00m depth and will extend to within 3.30m of the north boundary, 3.50m of the west boundary and 7.70m of the east boundary. The southern basement excavation will be approximately 3.70m depth and will extend to within 0.90m of the south boundary, 4.70m of the west boundary and 6.70m of the east boundary. The two basements share a common driveway access in the centre of the site.

Based on the investigation results, the proposed excavation in the north is anticipated to encounter granular topsoil/fill and stiff to hard silty clay/sandy clay to a maximum depth of 3.40m across the eastern half and potentially to only 1.50m depth on the western half. Interpreted sandstone and siltstone bedrock is expected under the clay soils. Bands of at least low strength ironstone from varying depths between 0.70m and 1.50m are expected across the southern half, though these may be underlain by clay. The proposed excavation in the south is anticipated to encounter granular topsoil/fill and stiff to hard silty clay to the base of excavation.

Considering the depth of excavation and distance to the boundaries, the recommended safe temporary batter slopes provided in Section 5.3.2 are not achievable on the southern side of the excavations. Therefore, we recommend the installation of support measures either prior to bulk excavation (i.e. soldier pile wall) or in 1.50m depth intervals as the excavation progresses down (i.e. reinforced and anchored shotcrete wall) to maintain stability. Safe temporary batter slopes appear possible on northern, eastern and western sides of the excavations. However, due to the limited penetration of the boreholes on the northern side of the site, it is recommended to undertake core boreholes to confirm conditions and ability to excavate without prior installation of support or the need for rock excavation equipment. Whilst steeper batters may be marginally stable in the short term, CGC can not certify their stability for the entire period from excavation to construction of backfilled retaining walls.

The investigation did not identify any hard bedrock (medium to high strength) however there is the potential for higher (or lower) strength bedrock to be located in the deeper portions of the excavation in the north, below auger refusal depth, which will require rock excavation equipment (i.e. rock hammer). The use of rock hammers has the potential to create ground vibrations which could impact neighbouring structures. Therefore, these should be limited to Ò500kg to maintain low ground vibration levels as per AS2187.2-2006 requirements at adjacent structures. This will result in slower excavation progress, however, it will remove the need for vibration monitoring. Should large hammers be proposed then a geotechnical professional should be consulted for equipment assessment prior to its use.

Where additional core drilling it not undertaken it is recommended that machinery selected is capable of excavating/drilling higher strength rock than was encountered in the boreholes to avoid potential construction delays if hard rock is encountered below investigation refusal depth. Local variations in rock strength could be expected to occur over the site and it is suggested that a óflexibleô approach be adopted to the footing design, construction methodology and costing, so that footing sizes/founding depths can be readily adjusted as required during construction.

It is recommended that new footings should be founded off material of similar strength to reduce the potential for differential settlement, unless the structure has been designed to accommodate differential movement. Ground movement from moisture changes should also be considered as the site is classified as moderately to highly reactive clay site.

The results of the chemical testing undertaken on soil samples recovered were compared against the Australian Standard AS 2159 ï 2009 Pile Design and Installation Table 6.4.2 (C) and Table 6.5.2 (C) Exposure Classification for Concrete and Steel Piles ï Piles in Soil. The results indicate that the soils are ónon-aggressiveô to concrete from sulphate and ónon-aggressiveô to steel with regard to pH and chlorides.

Provided the recommendations of this report are implemented in the design and construction phases the proposed development is considered suitable for the site.

The recommendations and conclusions in this report are based on an investigation utilising only surface observations and a small drill rig using auger drilling techniques. This test equipment provides small isolated test points across the entire site, with limited penetration into rock therefore some variation to the interpreted sub-surface conditions is possible, especially between test locations or below maximum drill depths. However, these results of the investigation provide a reasonable basis for the analysis of Development Application.

5.2. Site Specific Risk Assessment:

Based on our site investigation we have identified the following credible geological/geotechnical hazards which need to be considered in relation to the existing site and the proposed works. The hazards are:

A. Landslip of soils from northern basement excavation (<15m³)
B. Landslip of rock around perimeter of excavation for northern basement (<3m³)
C. Landslip of soils from southern basement excavation (<15m³)

A qualitative assessment of risk to life and property related to this hazard is presented in Table A and B, Appendix: 3, and is based on methods outlined in Appendix: C of the Australian Geomechanics Society (AGS) Guidelines for Landslide Risk Management 2007. AGS terms and their descriptions are provided in Appendix: 4.

The **Risk to Life** from **Hazard A** to **C** was estimated to be up to **1.25 x 10^{-5}** for a single person, whilst the **Risk to Property** was considered to be up to **'High'**.

Although the óHighô Risk to Property is considered to be óUnacceptableô, the assessments were based on excavations with no support or planning. Provided the recommendations of this report are implemented including regular detailed geotechnical mapping of the excavation and installation of determined support systems prior to excavation or in 1.50m depth intervals in a timely manner, the likelihood of any failure becomes óRareô and as such the consequences reduce and risk becomes within óAcceptableô levels when assessed against the criteria of the AGS 2007 and the Geotechnical Risk Policy for Pittwater 2009. As such the project is considered suitable for the site provided the recommendations of this report are implemented.

5.3. Design & Construction Recommendations:

Design and construction recommendations are tabulated below:

5.3.1. New Footings:	
Site Classification as per AS2870 ï 2011 for new footing design	Class óAô for footings founded on bedrock at base of excavation, otherwise Class óMô site for shallow footings near surface
Type of Footing	Strip/Pad or Slab at base of excavation, piles external to the excavation or for higher loads
Maximum Allowable Bearing Capacity	- Very Stiff Clay: 200kPa

	- Hard Clay: 400kPa - Weathered, XLS-VLS Bedrock: 700kPa - Weathered LS Bedrock: 1000kPa (unconfirmed)
Site sub-soil classification as per *Structural design actions AS1170.4 – 2007, Part 4: Earthquake actions in Australia*	B_e ï rock site
Remarks: All footings should be founded off material of similar strength to prevent differential settlement. All new footings must be inspected 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. This is mandatory to allow them to be ócertifiedô at the end of the project.	

5.3.2. Excavation:	
Depth of Excavation	Up to 5.00m depth for northern basement Up to 3.70m depth for southern basement
Distance of Excavation to Neighbouring Properties/structures	No. 1791 Pittwater Rd ï 0.90m to boundary, building another 1.00m No. 40 Park St, No. 1799 Pittwater Rd ï 3.30m to boundary, building another 0.50m Park Street ï 3.50m to boundary Pittwater Road ï 6.70m to boundary
Type of Material to be Excavated	Topsoil/fill up to 0.70m depth
	Silty clay/sandy clay up to 3.40m depth for northern basement and to the base of southern basement
	ELS-VLS/LS rock or ironstone from 0.70m depth in parts, generally >3.40m depth
Guidelines for unsurcharged batter slopes are tabulated below:	

Material	Safe Batter Slope (H:V)	
	Short Term/Temporary	Long Term/Permanent
Granular topsoil/fill	1.5:1	2:1
Silty/sandy clay to extremely low strength bedrock	1:1	1.5:1*
Very low strength bedrock	0.75:1*	1.25:1*
Low to medium strength, defect free bedrock	Vertical*	Vertical*

Remarks: *Dependent on assessment by geotechnical engineer. Seepage at the bedrock surface or along defects in the soil/rock can also reduce the stability of batter slopes and invoke the need to implement additional support measures. Where safe batter slopes are not implemented the stability of the excavation cannot be guaranteed until the installation of permanent support measures. This should also be considered with respect to safe working conditions.		
Equipment for Excavation	Fill / Clayey soils / ELS	Excavator with bucket
	VLS bedrock	Excavator with bucket and ripper
	LS ï MS bedrock	Rock hammer and saw
ELS ï extremely low strength, VLS ï very low strength, LS ï low strength, MS ï medium strength		
Recommended Vibration Limits (Maximum Peak Particle Velocity (PPV))	Neighbouring residential dwellings = 5mm/s Road Reserve = 5mm/s Services = 3mm/s	
Vibration Calibration Tests Required	If medium to high strength bedrock is exposed at base of excavation and large (>500kg) rock hammers proposed.	
Full time vibration Monitoring Required	Pending proposed equipment and vibration calibration testing results	
Geotechnical Inspection Requirement	Yes, recommended that these inspections be undertaken as per below mentioned sequence: • During installation of the excavation support system • For assessment of batter slopes • Where unexpected ground conditions are identified or any other concerns are held. • At completion of the excavation • Following footing excavations to confirm founding material strength	
Dilapidation Surveys Requirement	Recommended on neighbouring structures or parts thereof within 10m of the excavation perimeter prior to site work to allow assessment of the recommended vibration limit and protect the client against spurious claims of damage.	
Remarks: Water ingress into exposed excavations can result in erosion and stability concerns in both soil and rock portions. Drainage measures will need to be in place during excavation works to divert any surface flow away from the excavation crest and any batter slope, whilst any groundwater seepage must be controlled within the excavation and prevented from ponding or saturating slopes/batters.		

5.3.3. Retaining Structures:	
Required	New retaining structures/excavation support wall will be required as part of the proposed development, with critical installation on south boundary
Types	Steel reinforced concrete/concrete block wall where safe batters possible. Soldier pile or sequenced shotcrete wall for south boundary and pending core borehole results to confirm conditions and ability to excavate without prior install of support on other boundaries. Designed as per AS4678-2002 Earth Retaining Structures.

Parameters for calculating pressures acting on retaining walls for the materials likely to be retained:

Material	Unit Weight (kN/m³)	Long Term (Drained)	Earth Pressure Coefficients		Passive Earth Pressure Coefficient *
			Active (K_a)	At Rest (K_0)	
Topsoil/fill	18	$\phi' = 29°$	0.35	0.52	N/A
Silty clay/sandy clay (stiff to hard)	20	$\phi' = 35°$	0.27	0.40	N/A
Extremely low strength rock	22	$\phi' = 38°$	0.15	0.20	200kPa
Low strength rock	23	$\phi' = 40°$	0.10	0.15	400kPa

Remarks:

In suggesting these parameters it is assumed that the retaining walls will be fully drained with suitable subsoil drains provided to allow release of groundwater seepage. If this is not done, then the walls should be designed to support full hydrostatic pressure in addition to pressures due to the soil backfill. It is suggested that the retaining walls should be back filled with free-draining granular material (preferably not recycled concrete) which is only lightly compacted in order to minimize horizontal stresses.

Retaining structures near site boundaries or existing structures should be designed with the use of at rest (K_0) earth pressure coefficients and incorporate surcharge loading to reduce the risk of movement in the excavation support and resulting surface movement in adjoining areas. Backfilled retaining walls within the site, away from site boundaries or existing structures, that may deflect can utilize active earth pressure coefficients (Ka).

5.3.4. Drainage and Hydrogeology		
Groundwater Table or Seepage identified in Investigation		No
Excavation likely to intersect	Water Table	No
	Seepage	Minor (<2L /min) estimated
Site Location and Topography		High west side of Pittwater Road and low east side of Park Street within gently sloping topography
Impact of development on local hydrogeology		Negligible
Onsite Stormwater Disposal		Not recommended
Remarks: As the excavation faces are expected to encounter some seepage, an excavation trench should be installed at the base of excavation cuts to below floor slab levels to reduce the risk of resulting dampness issues. Trenches, as well as all new building gutters, down pipes and stormwater intercept trenches should be connected to a stormwater system designed by a Hydraulic Engineer which preferably discharges to the Councilôs stormwater system off site.		

5.4. Conditions Relating to Design and Construction Monitoring:

To comply with Councils conditions and to enable us to complete Forms: 2b and 3 required as part of construction, building and post-construction certificate requirements of the Councils Geotechnical Risk Management Policy 2009, it will be necessary for Crozier Geotechnical Consultants to:

1. Conduct further geotechnical investigation to confirm accurate soil and bedrock parameters/conditions to below excavation support levels, pending structural/support design
2. Review and approve the structural design drawings for compliance with the recommendations of this report prior to construction,
3. Inspection of site and works as per Section 5.3.2 of this report
4. Inspect all new footings and earthworks to confirm compliance to design assumptions with respect to allowable bearing pressure, basal cleanness and the stability prior to the placement of steel or concrete,
5. Inspect completed works to ensure construction activity has not created any new hazards and that all retention and stormwater control systems are completed.

The client and builder should make themselves familiar with the Councils Geotechnical Policy and the requirements spelled out in this report for inspections during the construction phase. Crozier Geotechnical Consultants <u>cannot</u> sign Form: 3 of the Policy if it has not been called to site to undertake the required inspections.

5.5. Design Life of Structure:

We have interpreted the design life requirements specified within Councilõs Risk Management Policy to refer to structural elements designed to support the existing structures, control stormwater and maintain the risk of instability within acceptable limits. Specific structures and features that may affect the maintenance and stability of the site in relation to the proposed and existing development are considered to comprise:

- stormwater and subsoil drainage systems,
- retaining walls and instability,
- maintenance of trees/vegetation on this and adjacent properties.

Man-made features should be designed and maintained for a design life consistent with surrounding structures (as per AS2870 ï 2011 (100 years)). It will be necessary for the structural and geotechnical engineers to incorporate appropriate design and inspection procedures during the construction period. Additionally, the property owner should adopt and implement a maintenance and inspection program.

If this maintenance and inspection schedule are not maintained the design life of the property cannot be attained. A recommended program is given in Table: C in Appendix: 3 and should also include the following guidelines.

- The conditions on the block donõt change from those present at the time this report was prepared, except for the changes due to this development.
- There is no change to the property due to an extraordinary event external to this site
- The property is maintained in good order and in accordance with the guidelines set out in;
  - a) CSIRO sheet BTF 18
  - b) Australian Geomechanics ñLandslide Risk Managementò Volume 42, March 2007.
  - c) AS 2870 ï 2011, Australian Standard for Residential Slabs and Footings

Where changes to site conditions are identified during the maintenance and inspection program, reference should be made to relevant professionals (e.g. structural engineer, geotechnical engineer or Council). Where the property owner has any lack of understanding or concerns about the implementation of any component of the maintenance and inspection program the relevant engineer should be contacted for advice or to complete the component. It is assumed that Council will control development on neighbouring properties, carry out regular inspections and maintenance of the road verge, stormwater systems and large trees on public land adjacent to the site so as to ensure that stability conditions do not deteriorate with potential increase in risk level to the site. Also, individual Government Departments will maintain public utilities in the form of power lines, water and sewer mains to ensure they donõt leak and increase either the local groundwater level or landslide potential.

6. CONCLUSION:

The site investigation identified the presence of a layer of topsoil/fill to 0.70m depth overlying stiff to hard silty clay. Consistent low strength siltstone/sandstone bedrock is expected below the clayey soils at approximately 3.40m depth in the north and over 5.50m depth in the south. It appears that the silty clay layer is interbedded by layers of ironstone and siltstone of at least low strength across the northern portion of the site from varying depths between 0.70m and 1.50m. No significant seepage or a water table were identified during the investigation.

The proposed development requires an excavation of up to 5.00m depth for the northern basement and an excavation of up to 3.70m depth for the southern basement. The excavations will extend to within 3.30m of the north boundary, 3.50m of the west boundary, 0.90m of the south boundary and 6.70m of the east boundary.

Based on the identified sub-surface conditions, safe temporary batter slopes are not achievable on the southern side of the excavations. Therefore, we recommend the installation of support measures either prior to bulk excavation (i.e. soldier pile wall) or in 1.50m depth intervals as the excavation progresses down (i.e. reinforced and anchored shotcrete wall) to maintain stability. Temporary batter slopes appear possible on northern, eastern and western sides of the excavations. However, due to the limited penetration of the boreholes on the northern side of the site, it is recommended to undertake core boreholes to confirm conditions and ability to excavate without prior installation of support or the need for rock excavation equipment.

The lower portions of the northern basement excavation may intersect medium to high strength bedrock which would require rock excavation equipment (i.e. rock hammers). If this occurs a geotechnical professional should be consulted to assess the bedrock strength and provide guidance on suitable equipment.

It is recommended to undertake confirmatory site investigation using core drilling techniques to allow refinement of footing/retaining wall design and determine whether hard rock excavation techniques are likely to be required to complete basement excavation as cost/delays during excavation/construction could occur if not identified prior.

Due to the observed geology and ground water conditions, the proposed excavation will not intersect the groundwater table, therefore, tanking or dewatering are not required however, ongoing seepage inflow should be expexted. The likelihood of intersecting Acid Sulfate Soils or impacting the water table is extremely low therefore no further investigation or reporting into these soils is necessary.

The potential risks associated with the proposed development will be within óUnacceptableô levels where insufficient/unsuitable support systems are implemented. However, where suitable engineer designed systems are implemented as per the recommendations of this report the risks will be reduced and can be maintained within the óAcceptableô risk management criteria for the design life of the development, taken as 100 years.

Similar excavations have been successfully completed in nearby properties within similar geological conditions. As such the proposed development is considered suitable for the site.

Prepared By:	Reviewed By:
Jun Yan	Troy Crozier
Geotechnical Engineer	Principal
	MAIG, RPGeo ï Geotechnical and Engineering
	Registration No.: 10197

7. REFERENCES:

1. Australian Geomechanics Society 2007, ñLandslide Risk Assessment and Managementò, Australian Geomechanics Journal Vol. 42, No 1, March 2007.
2. Geological Society Engineering Group Working Party 1972, ñThe preparation of maps and plans in terms of engineering geologyò Quarterly Journal Engineering Geology, Volume 5, Pages 295 - 382.
3. C. W. Fetter 1995, ñApplied Hydrologyò by Prentice Hall. V. Gardiner & R. Dackombe 1983, ñGeomorphological Field Manualò by George Allen & Unwin
4. Australian Standard AS 3798 ï 2007, Guidelines on Earthworks for Commercial and Residential Developments.
5. Australian Standard AS 2870 ï 2011, Residential Slabs and Footings ï Construction
6. Australian Standard AS1170.4 ï 2007, Part 4: Earthquake actions in Australia

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 1

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Brookvale NSW 2100 Email: info@croziergeotech.com.au
Crozier Geotechnical Consultants, a division of PJC Geo-Engineering Pty Ltd

NOTES RELATING TO THIS REPORT

Introduction

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

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

Description and classification Methods

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

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

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

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

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

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

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

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

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

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

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

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

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

Large Diameter Auger (eg. Pengo) – the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

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

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

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

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

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

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedures is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test 6.3.1.

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

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150mm of say 4, 6 and 7
  as 4, 6, 7 then N = 13
- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm then as 15, 30/40mm.

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

Cone Penetrometer Testing and Interpretation

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

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

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

The information provided on the plotted results comprises: -

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

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

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

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

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

Q_c = (12 to 18) C_u

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

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

Dynamic Penetrometers

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

Two relatively similar tests are used.

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

Laboratory Testing

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

Borehole Logs

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

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

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

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

Ground Water

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

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made. More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. A three-storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty-storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

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

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

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

Site Anomalies

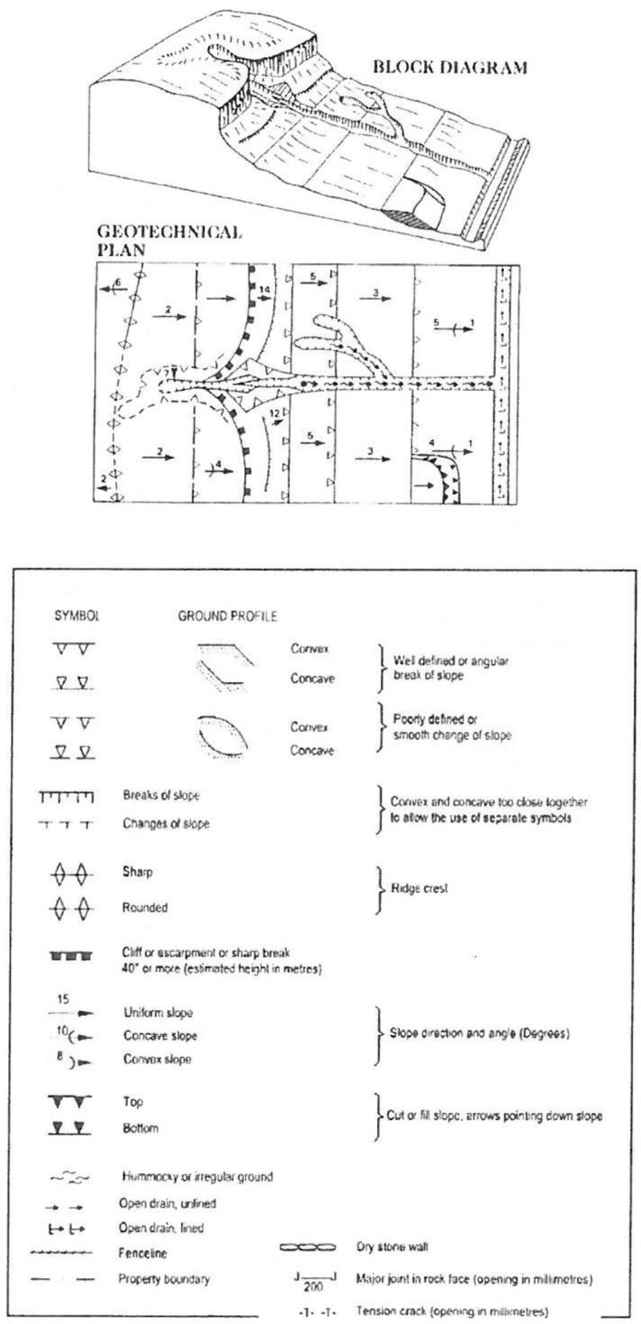
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some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

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a special ally edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

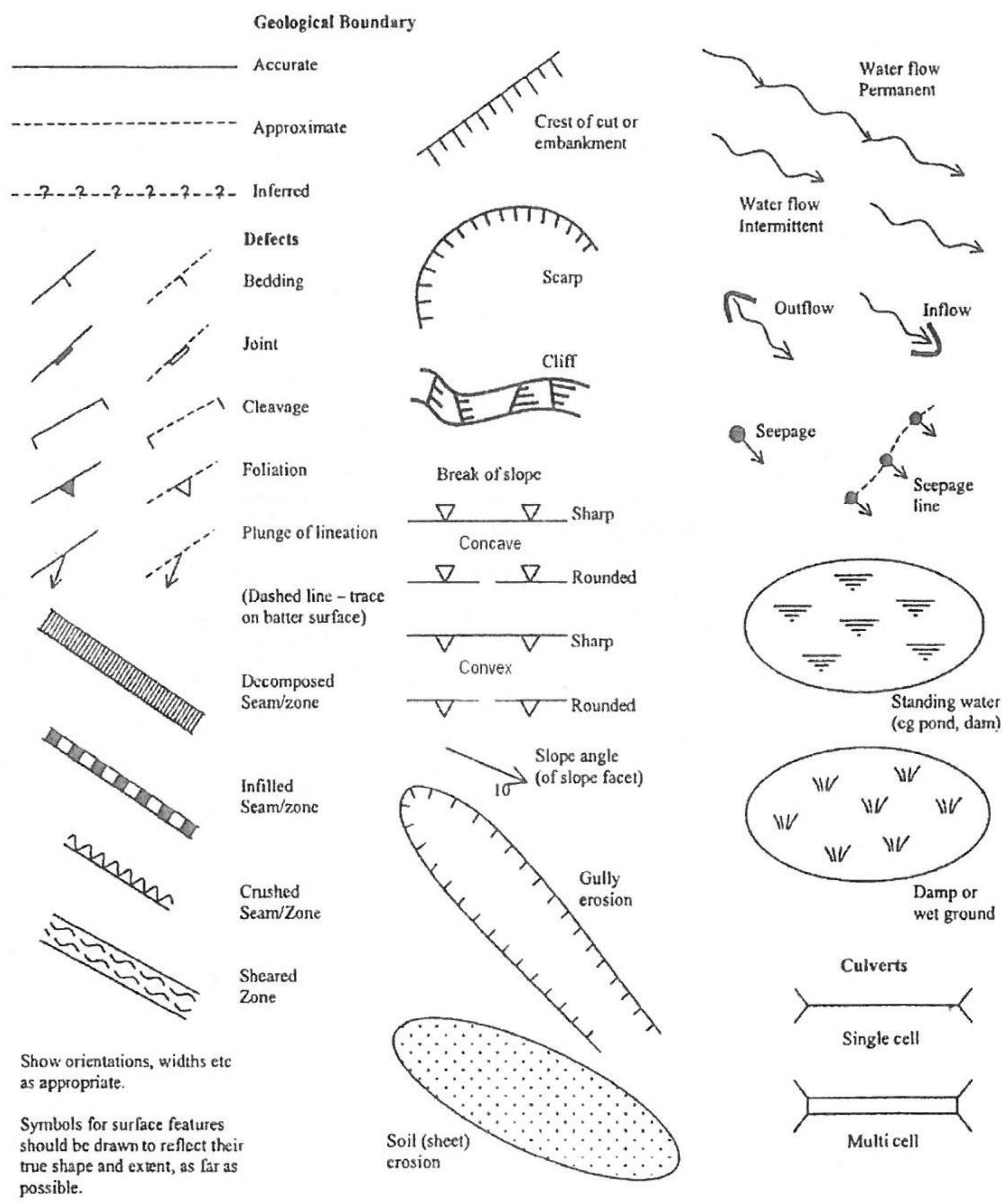
Site Inspection

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



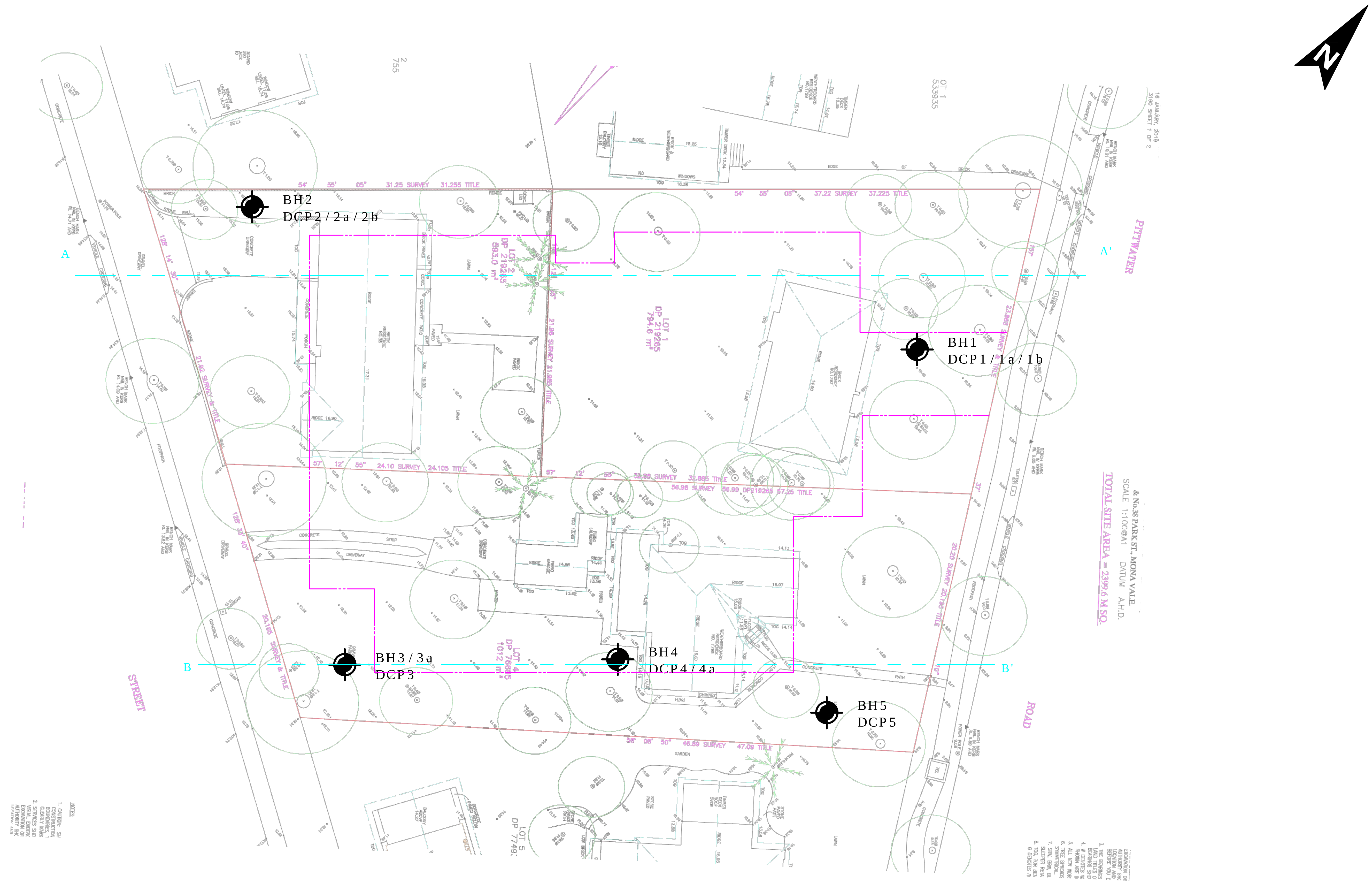
Example of Mapping Symbols
(after V Gardiner & R V Dackombe (1983).Geomorphological Field Manual. George Allen & Unwin).

APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY



Examples of Mapping Symbols (after Guide to Slope Risk Analysis Version 3.1 November 2001, Roads and Traffic Authority of New South Wales).

Appendix 2



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:300

SITE PLAN & TEST LOCATIONS FIGURE 1.

CROZIER
GEOTECHNICAL CONSULTANTS

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

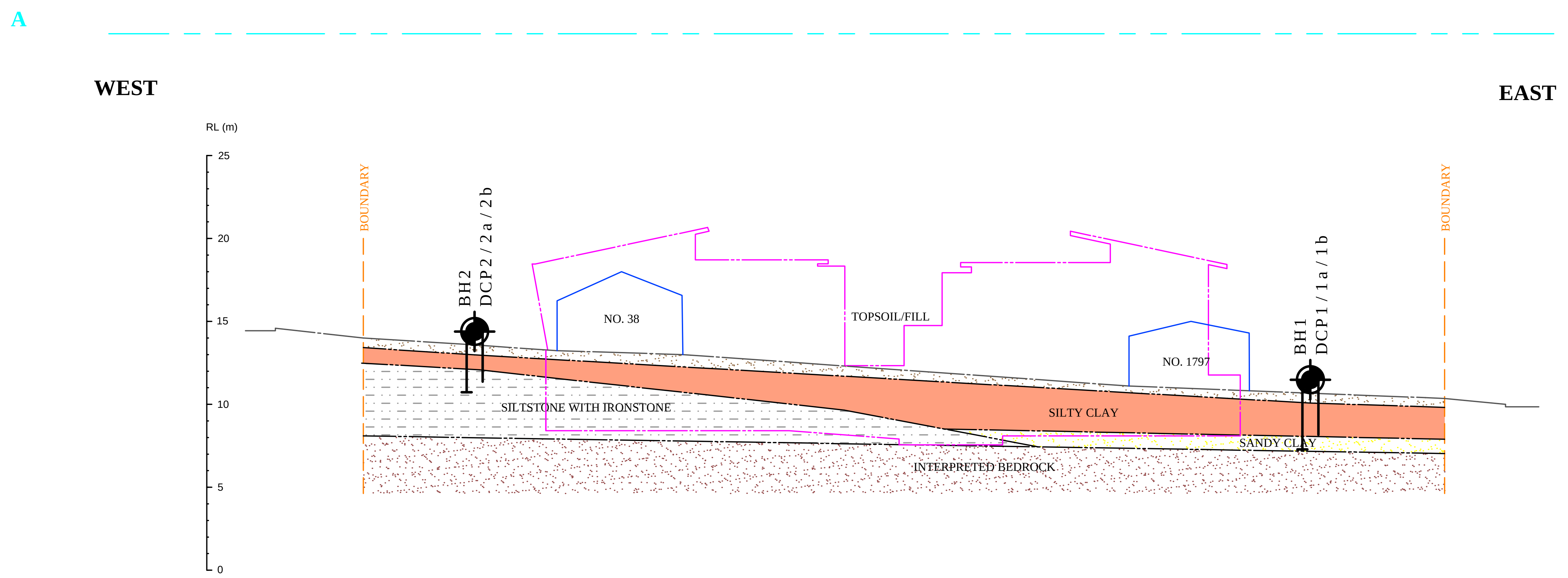
LEGEND

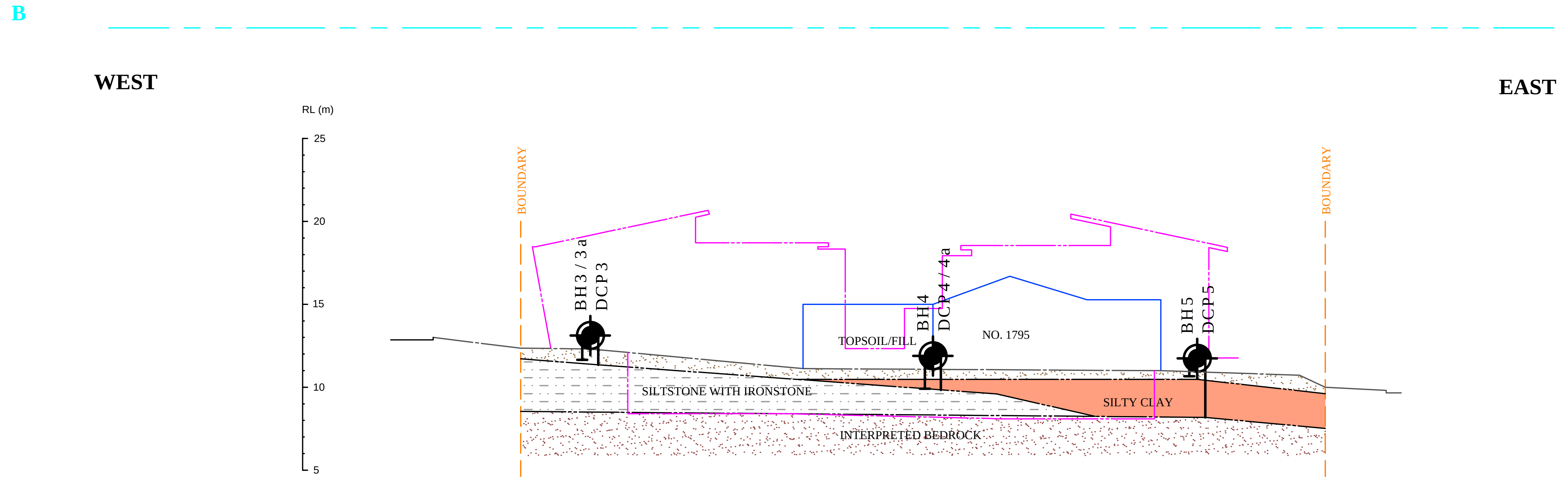
- A — A' CROSS-SECTION REFERENCE LINE
- PROPOSED WORK
- BH / DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION

SCALE:	1:300 @ A3
DRAWING:	FIGURE 1
DATE:	03/09/2020
APPROVED BY:	TMC
DRAWN BY:	JY
PROJECT:	2019-132

PREPARED FOR:
Mona Vale 3 Pty Ltd

ADDRESS:
38 Park Street & 1793-1797 Pittwater Road, Mona Vale





0 1 2 3 4 5 6 7 8 9 10
SCALE: 1:300

VL - Very Loose	VS - Very Soft	ELS - Extremely Low Strength	EW - Extremely Weathered	fg - Fine Grained
L - Loose	S - Soft	VLS - Very Low Strength	HW - Highly Weathered	mg - Medium Grained
MD - Medium Dense	F - Firm	LS - Low Strength	DW - Distinctly Weathered	cg - Coarse Grained
D - Dense	St - Stiff	MS - Medium Strength	MW - Moderately Weathered	MAS - Massive
VD - Very Dense	VSt - Very Stiff	HS - High Strength	SW - Slightly Weathered	BD - Bedded
	H - Hard	VHS - Very High Strength	FR - Fresh	OC - Outcrop

NB. FOR LOCATION OF SECTION A-A', PLEASE REFER TO FIGURE 1. SITE PLAN AND TEST LOCATIONS

GEOLOGICAL MODEL FIGURE 2.

LEGEND

A — A' CROSS-SECTION REFERENCE LINE	BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION	SILTY CLAY	SILTSTONE WITH IRONSTONE
PROPERTY BOUNDARY	TOPSOIL/FILL	BEDROCK	

CROZIER
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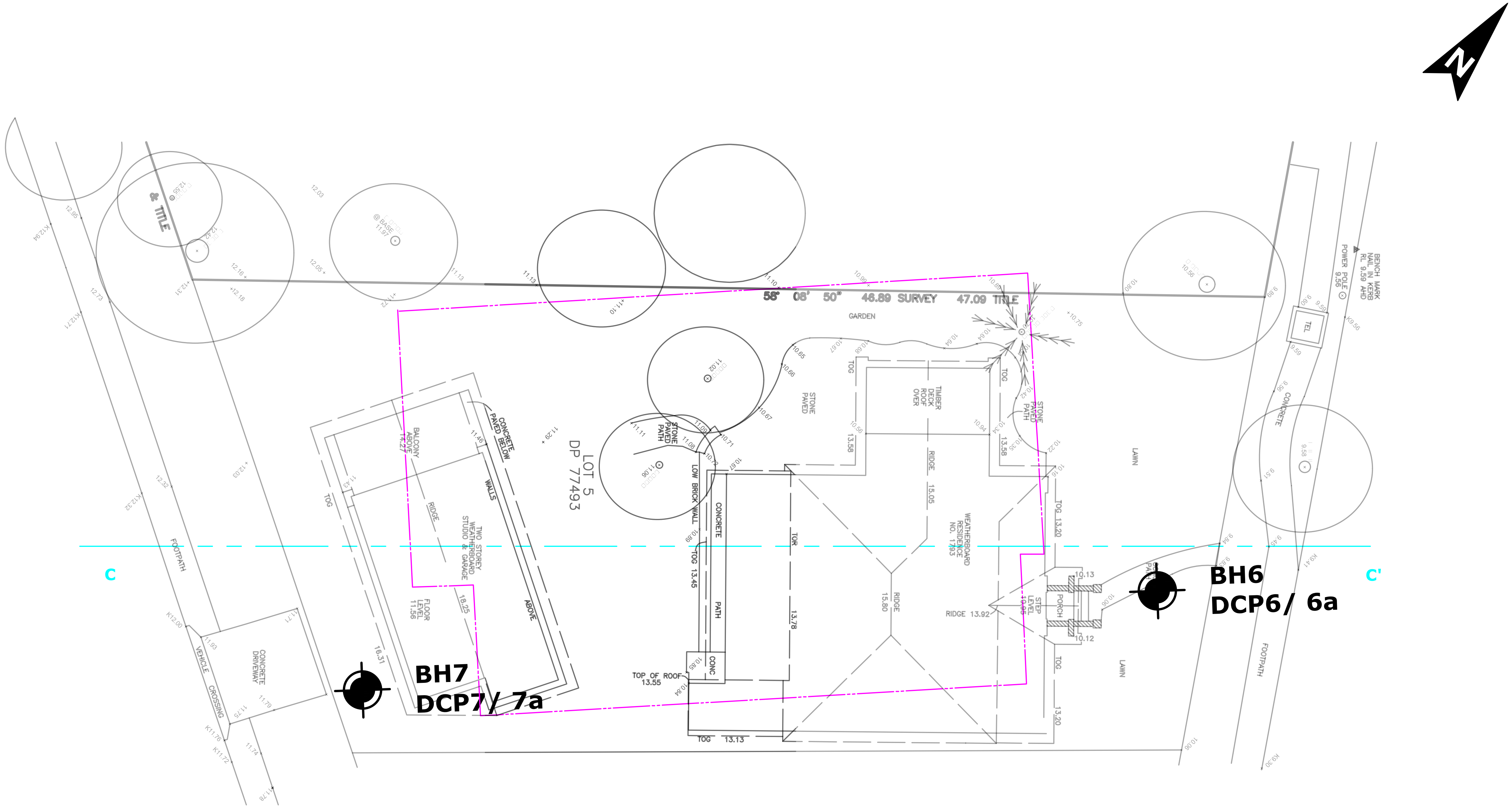
Crozier Geotechnical is a division of PJC Geo-Engineering Pty Ltd

SCALE: 1:300 @ A3
DRAWING: FIGURE 2
DATE: 03/09/2020

APPROVED BY: TMC
DRAWN BY: JY
PROJECT: 2019-132

PREPARED FOR:
Mona Vale 3 Pty Ltd

ADDRESS:
38 Park Street & 1795-1797 Pittwater Road, Mona Vale



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

VL - Very Loose	VS - Very Soft	ELS - Extremely Low Strength	EW - Extremely Weathered	fg - Fine Grained
L - Loose	S - Soft	VLS - Very Low Strength	HW - Highly Weathered	mg - Medium Grained
MD - Medium Dense	F - Firm	LS - Low Strength	DW - Distinctly Weathered	cg - Coarse Grained
D - Dense	St - Stiff	MS - Medium Strength	MW - Moderately Weathered	MAS - Massive
VD - Very Dense	VSt - Very Stiff	HS - High Strength	SW - Slightly Weathered	BD - Bedded
	H - Hard	VHS - Very High Strength	FR - Fresh	OC - Outcrop

SITE PLAN & TEST LOCATIONS FIGURE 3.

CROZIER GEOTECHNICAL CONSULTANTS

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

LEGEND

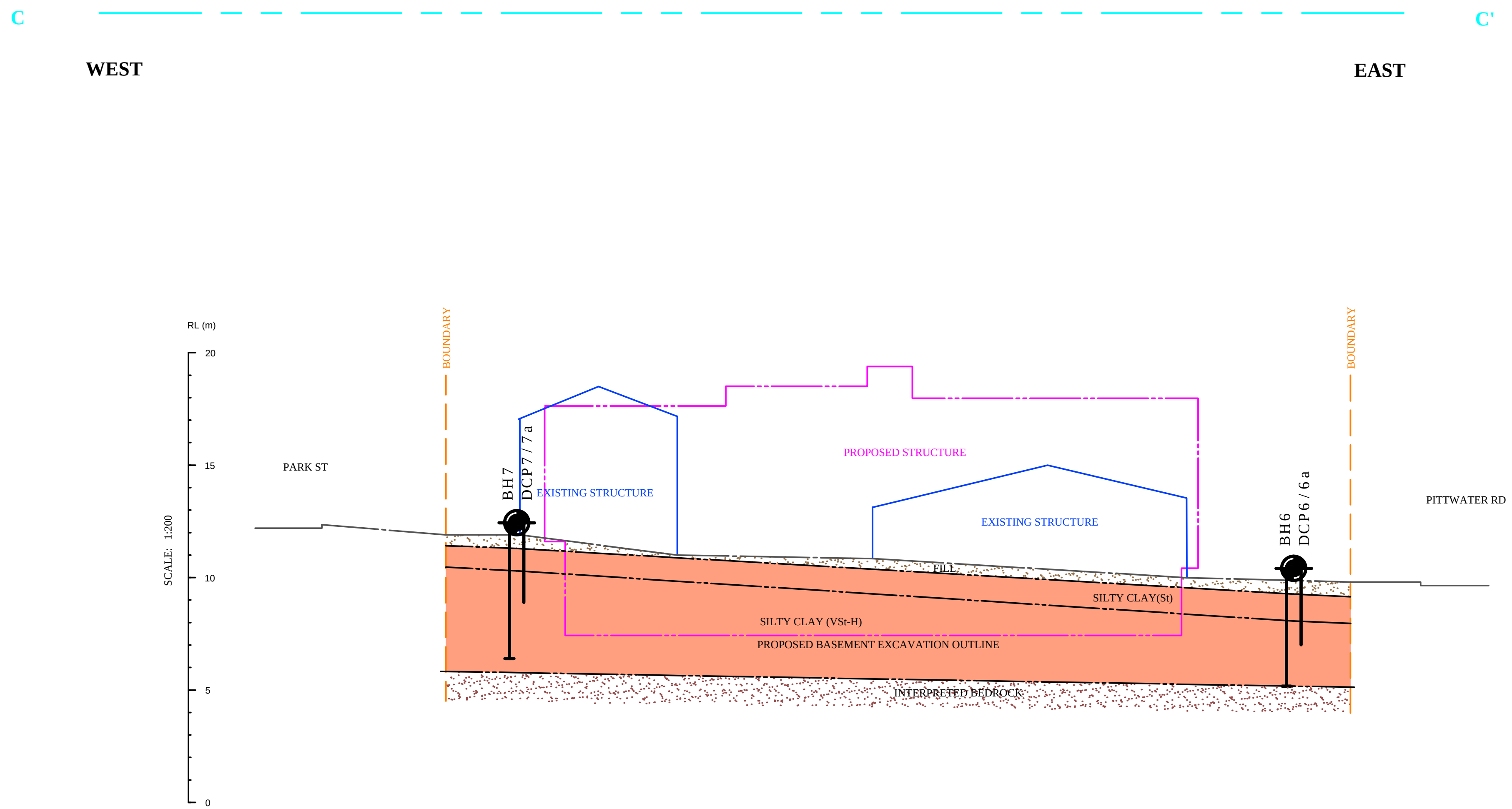
A — A'	CROSS-SECTION REFERENCE LINE
(magenta line)	PROPOSED WORK
BH DCP	AUGER / DYNAMIC CONE PENETROMETER LOCATION

SCALE: 1:200 @ A3
DRAWING: FIGURE 3
DATE: 03/09/2020

APPROVED BY: TMC
DRAWN BY: JY
PROJECT: 2019-132.1

PREPARED FOR:
Mona Vale 3 Pty Ltd

ADDRESS:
38 Park Street & 1793-1797 Pittwater Road, Mona Vale



0 1 2 3 4 5 6 7 8 9 10

SCALE: 1:200

VL - Very Loose	VS - Very Soft	ELS - Extremely Low Strength	EW - Extremely Weathered	fg - Fine Grained
L - Loose	S - Soft	VLS - Very Low Strength	HW - Highly Weathered	mg - Medium Grained
MD - Medium Dense	F - Firm	LS - Low Strength	DW - Distinctly Weathered	cg - Coarse Grained
D - Dense	St - Stiff	MS - Medium Strength	MW - Moderately Weathered	MAS - Massive
VD - Very Dense	VSt - Very Stiff	HS - High Strength	SW - Slightly Weathered	BD - Bedded
	H - Hard	VHS - Very High Strength	FR - Fresh	OC - Outcrop

NB. FOR LOCATION OF SECTION C-C', PLEASE REFER TO FIGURE 1. SITE PLAN AND TEST LOCATIONS

GEOLOGICAL MODEL FIGURE 4.

CROZIER
GEOTECHNICAL CONSULTANTS

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

LEGEND

A — A' CROSS-SECTION REFERENCE LINE	BH DCP AUGER / DYNAMIC CONE PENETROMETER LOCATION	SILTY CLAY
PROPERTY BOUNDARY	TOPSOIL/FILL	BEDROCK

SCALE: 1:300 @ A3
DRAWING: FIGURE 4
DATE: 03/09/2020

APPROVED BY: TMC
DRAWN BY: JY
PROJECT: 2019-132.1

PREPARED FOR:
Mona Vale 3 Pty Ltd

ADDRESS:
38 Park Street & 1793-1797 Pittwater Road, Mona Vale

BOREHOLE LOG

CLIENT: **Mona Vale 3 Pty Ltd** **DATE:** 21/08/2019 **BORE No.:** 1

PROJECT: **New senior living development** **PROJECT No.:** 2019-132 **SHEET:** 1 of 2

LOCATION: **38 Park Street and 1795-1797 Pittwater Road, Mona Vale** **SURFACE LEVEL:** RL10.50

Depth (m)	Classification	Description of Strata PRIMARY SOIL - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		TOPSOIL/FILL: Dark brown, fine to medium grained silty sand trace of brick, tile				
0.60	CI/CH	Silty CLAY: Very Stiff, orange, medium to high plasticity, moist silty clay				
			D	0.80 0.90	LL PL PI water content	43% 18% 25% 18.10%
1.00						
1.50		é became hard below 1.50m depth				
2.00						
2.40		é became red mottled pale grey, trace of fine grained subrounded gravel below 2.40m depth	D	2.40 2.50	LL PL PI water content	64% 19% 45% 20.40%

RIG: Dingo restricted access rig DRILLER: AC LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd **DATE:** 21/08/2019 **BORE No.:** 1

PROJECT: New senior living development **PROJECT No.:** 2019-132 **SHEET:** 2 of 2

LOCATION: 38 Park Street and 1795-1797 Pittwater Road, Mona Vale **SURFACE LEVEL:** RL10.50

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
2.50	CL	Sandy CLAY: Hard, red, low plasticity, sandy clay with fine grained gravel				
				3.20		
			D			
3.40				3.40		
		Auger refusal at 3.40m depth on interpreted bedrock of at least low strength				
3.50						
4.50						

RIG: Dingo restricted access rig DRILLER: AC LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT:	**Mona Vale 3 Pty Ltd**	**DATE:**	21/08/2019	**BORE No.:**	2
PROJECT:	**New senior living development**	**PROJECT No.:**	2019-132	**SHEET:**	1 of 2
LOCATION:	**38 Park Street and 1795-1797 Pittwater Road, Mona Vale**	**SURFACE LEVEL:**	RL13.50		

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		TOPSOIL/FILL: Dark brown, fine to medium grained silty sand				
0.60	CI/CH	Silty CLAY: Hard, pale brown mottled grey, medium to high plasticity, moist silty clay trace of medium to coarse grained sub-angular gravel				
			D	0.80	LL	49%
					PL	19%
					PI	30%
1.00				1.00	water content	17.40%
1.50		SILTSTONE: Extremely low strength to very low strength, pale grey brown				
2.00						

RIG: Dingo restricted access rig — DRILLER: AC — LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS:

CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd | **DATE:** 21/08/2019 | **BORE No.:** 2

PROJECT: New senior living development | **PROJECT No.:** 2019-132 | **SHEET:** 2 of 2

LOCATION: 38 Park Street and 1795-1797 Pittwater Road, Mona Vale | **SURFACE LEVEL:** RL13.50

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
2.50						
2.90						
		Auger refusal at 2.90m depth in siltstone of at least low strength				
3.50						
4.50						

RIG: Dingo restricted access rig | DRILLER: AC | LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: | CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd | **DATE:** 21/08/2019 | **BORE No.:** 3

PROJECT: New senior living development | **PROJECT No.:** 2019-132 | **SHEET:** 1 of 1

LOCATION: 38 Park Street and 1795-1797 Pittwater Road, Mona Vale | **SURFACE LEVEL:** RL12.10

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		TOPSOIL/FILL: Dark brown, fine to medium grained silty sand				
0.70		Auger refusal at 0.70m depth on interpreted ironstone of at least low strength				
1.00						
2.00						

RIG: Dingo restricted access rig | DRILLER: AC | LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: | CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd | **DATE:** 21/08/2019 | **BORE No.:** 3a

PROJECT: New senior living development | **PROJECT No.:** 2019-132 | **SHEET:** 1 of 1

LOCATION: 38 Park Street and 1795-1797 Pittwater Road, Mona Vale | **SURFACE LEVEL:** RL12.10

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		TOPSOIL/FILL: Dark brown, fine to medium grained silty sand				
0.70		Auger refusal at 0.70m depth on interpreted ironstone of at least low strength				
1.00						
2.00						

RIG: Dingo restricted access rig | DRILLER: AC | LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: | CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd | **DATE:** 21/08/2019 | **BORE No.:** 4

PROJECT: New senior living development | **PROJECT No.:** 2019-132 | **SHEET:** 1 of 1

LOCATION: 38 Park Street and 1795-1797 Pittwater Road, Mona Vale | **SURFACE LEVEL:** RL11.07

Depth (m)	Classification	Description of Strata PRIMARY SOIL - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		TOPSOIL/FILL: Dark brown, fine to medium grained silty sand				
0.50	CI/CH	Silty CLAY: Stiff to very stiff, orange, medium to high plasticity, moist silty clay with medium to coarse grained sub-angular gravel				
			D	0.90 1.00	water content	15.10%
1.00						
			D	1.20 1.30		
1.30		Auger refusal at 1.30m depth in gravel				
2.00						

RIG: Dingo restricted access rig | DRILLER: AC | LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS:

CHECKED:

BOREHOLE LOG

CLIENT: **Mona Vale 3 Pty Ltd** **DATE:** 21/08/2019 **BORE No.:** 5

PROJECT: **New senior living development** **PROJECT No.:** 2019-132 **SHEET:** 1 of 1

LOCATION: **38 Park Street and 1795-1797 Pittwater Road, Mona Vale** **SURFACE LEVEL:** RL10.90

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
0.00		TOPSOIL/FILL: Dark brown, fine to medium grained silty sand with slags				
0.30		Auger refusal at 0.30m depth in fill				
1.00						
2.00						

RIG: NA DRILLER: JY LOGGED:JY

METHOD: Hand auger

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd | **DATE:** 26/08/2020 | **BORE No.:** 6

PROJECT: New senior living development | **PROJECT No.:** 2019-132.1 | **SHEET:** 1 of 2

LOCATION: 1793 Pittwater Road, Mona Vale | **SURFACE LEVEL:** RL10.00

Depth (m)	Classification	Description of Strata PRIMARY SOIL - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		TOPSOIL/FILL: Dark brown, fine to medium grained silty sand				
0.60	CI/CH	Silty CLAY: Stiff, orange, medium to high plasticity, moist silty clay with medium to coarse grained sub-angular gravel		0.70		
0.90		becoming medium plasticity, orange below 0.90m depth	D			
1.00				1.00		
1.20		becoming very stiff below 1.20m depth				
1.80		becoming hard below 1.80m depth				
2.00						
2.30		becoming red mottled grey with medium to coarse grained rounded gravel		2.30		
			D	2.50		

RIG: Dingo restricted access rig | DRILLER: AC | LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS:

CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd **DATE:** 26/08/2020 **BORE No.:** 6

PROJECT: New senior living development **PROJECT No.:** 2019-132.1 **SHEET:** 2 of 2

LOCATION: 1793 Pittwater Road, Mona Vale **SURFACE LEVEL:** RL10.00

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling		In Situ Testing	
			Type	Tests	Type	Results
2.50		As above				
3.50						
4.50						
4.70		Auger refusal on interpreted bedrock of at least low strength				

RIG: Dingo restricted access rig DRILLER: AC LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd | **DATE:** 26/08/2020 | **BORE No.:** 7

PROJECT: New senior living development | **PROJECT No.:** 2019-132.1 | **SHEET:** 1 of 2

LOCATION: 1793 Pittwater Road, Mona Vale | **SURFACE LEVEL:** RL11.70

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
0.00		TOPSOIL/FILL: Dark brown, fine to medium grained silty sand				
0.60	CI/CH	Silty CLAY: Stiff, brown, low plasticity, moist silty clay with medium to coarse grained sub-angular gravel				
0.90		becoming medium plasticity, orange below 0.90m depth				
1.00						
1.05		becoming very stiff below 1.05m depth				
1.60		becoming hard, red mottled grey with ironstone gravels below 1.60m depth				
2.00						

RIG: Dingo restricted access rig | DRILLER: AC | LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: | CHECKED:

BOREHOLE LOG

CLIENT: Mona Vale 3 Pty Ltd | **DATE:** 26/08/2020 | **BORE No.:** 7

PROJECT: New senior living development | **PROJECT No.:** 2019-132.1 | **SHEET:** 2 of 2

LOCATION: 1793 Pittwater Road, Mona Vale | **SURFACE LEVEL:** RL11.70

Depth (m)	Classification	Description of Strata **PRIMARY SOIL** - consistency / density, colour, grainsize or plasticity, moisture condition, soil type and secondary constituents, other remarks	Sampling Type	Sampling Tests	In Situ Testing Type	In Situ Testing Results
2.50		As above				
3.50						
4.50		SILTSTONE: Extremely low strength to very low strength, red grey mottled				
5.50		End of borehole at 5.50m depth				

RIG: Dingo restricted access rig | DRILLER: AC | LOGGED: JY

METHOD: Solid stem spiral flight auger, tungsten carbide bit

GROUND WATER OBSERVATIONS: No freestanding groundwater found

REMARKS: | CHECKED:

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Mona Vale 3 Pty Ltd **DATE:** 21/08/2019

PROJECT: New senior living development **PROJECT No.:** 2019-132

LOCATION: 38 Park Street and 1793-1797 Pittwater Rc **SHEET:** 1 of 2

	Test Location							
Depth (m)	DCP1	DCP1a	DCP1b	DCP2	DCP2a	DCP2b	DCP3	DCP5
0.00 - 0.15	3	--	--	2	--	--	5	2
0.15 - 0.30	9	--	--	14	--	--	5	4
0.30 - 0.45	15	--	--	38	--	--	6	21
0.45 - 0.60	7	--	--		--	--	15	10
0.60 - 0.75	12	--	--		--	--	15	8
0.75 - 0.90	10	--	--		--	--	35	6
0.90 - 1.05	11	--	--		--	--	29	4
1.05 - 1.20	9	--	--		16	--		7
1.20 - 1.35		9	--		23 (B) ref at 1.32m	--		9
1.35 - 1.50		10	--			--		8
1.50 - 1.65		16	--			--		7
1.65 - 1.80		16	--			--		7
1.80 - 1.95		16	--			--		6
1.95 - 2.10			--			18		9
2.10 - 2.25			--			30 (B) ref at 2.17m		14
2.25 - 2.40			--					19
2.40 - 2.55			--					18
2.55 - 2.70			42 (B) ref at 2.70m					30 (B) ref at 2.68m
2.70 - 2.85								
2.85 - 3.00								
3.00 - 3.15								
3.15 - 3.30								
3.30 - 3.45								
3.45 - 3.60								
3.60 - 3.75								
3.75 - 3.90								
3.90 - 4.05								

TEST METHOD: AS 1289. F3.2, CONE PENETROMETER

REMARKS:

(B) Test hammer bouncing upon refusal on solid object

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

DYNAMIC PENETROMETER TEST SHEET

CLIENT: Mona Vale 3 Pty Ltd **DATE:** 21/08/2019

PROJECT: New senior living development **PROJECT No.:** 2019-132

LOCATION: 38 Park Street and 1793-1797 Pittwater Rc **SHEET:** 2 of 2

	Test Location							
Depth (m)	DCP4	DCP4a	DCP6	DCP6a	DCP7	DCP7a		
0.00 - 0.15	3	--	1	--	2	--		
0.15 - 0.30	3	--	2	--	2	--		
0.30 - 0.45	8	--	2	--	3	--		
0.45 - 0.60	4	--	3	--	1	--		
0.60 - 0.75	4	--	2	--	2	--		
0.75 - 0.90	5	--	4	--	2	--		
0.90 - 1.05	7	--	5	--	5	--		
1.05 - 1.20	24	10 for 5mm	6	--	5	--		
1.20 - 1.35			7	--	8	--		
1.35 - 1.50			8	--	5	--		
1.50 - 1.65			10	--	12	--		
1.65 - 1.80			12	--	11	--		
1.80 - 1.95			18	--	40	--		
1.95 - 2.10			24	--		--		
2.10 - 2.25				--		--		
2.25 - 2.40				--		--		
2.40 - 2.55				--		--		
2.55 - 2.70				20		13		
2.70 - 2.85				27		13		
2.85 - 3.00						25 (B) at 2.95m		
3.00 - 3.15								
3.15 - 3.30								
3.30 - 3.45								
3.45 - 3.60								
3.60 - 3.75								
3.75 - 3.90								
3.90 - 4.05								

TEST METHOD: AS 1289. F3.2, CONE PENETROMETER

REMARKS:

(B) Test hammer bouncing upon refusal on solid object

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

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 3

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

CERTIFICATE OF ANALYSIS 224699

Client Details

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

Sample Details

Your Reference	**Mona Vale, 38 Park St, 1795-1797 Pittwater Rd**
Number of Samples	3 Soil
Date samples received	26/08/2019
Date completed instructions received	26/08/2019

Analysis Details

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

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

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

Report Details

Date results requested by	02/09/2019
Date of Issue	30/08/2019

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Soil Aggressivity				
Our Reference		224699-1	224699-2	224699-3
Your Reference	UNITS	BH1	BH2	BH4
Depth		3.2-3.4	0.8-1.0	0.9-1.0
Date Sampled		26/08/2019	26/08/2019	26/08/2019
Type of sample		Soil	Soil	Soil
pH 1:5 soil:water	pH Units	5.4	6.3	6.6
Electrical Conductivity 1:5 soil:water	µS/cm	150	280	49
Chloride, Cl 1:5 soil:water	mg/kg	24	270	22
Sulphate, SO4 1:5 soil:water	mg/kg	240	140	43

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

QUALITY CONTROL: Soil Aggressivity					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	102	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	101	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	89	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	95	[NT]

Result Definitions

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

Quality Control Definitions

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

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

Laboratory Acceptance Criteria

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

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

Spikes for Physical and Aggregate Tests are not applicable.

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

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

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

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

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

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Appendix 4

TABLE : A

Landslide risk assessment for Risk to life

HAZARD	Description	Impacting	Likelihood of Slide	Spatial Impact of Slide		Occupancy	Evacuation	Vulnerability	Risk to Life
A	Landslip of soils from northern basement excavation (<15m³)		up to approximately 3.40m of fill and clay soils with bands of siltstone and ironstone	a) excavation within 3.30 of the common boundary, garden adjacent to boundary, impact 10%, house another 0.50m, impact 10% b) excavation within 3.30 of the common boundary, garden adjacent to boundary, impact 10%, house another 7.50m, impact 1% c) excavation within 3.50 of the common boundary, road reserve/footpath adjacent to boundary, impact 10%, pavement another 5.00m, impact 1% d) excavation within 7.70 of the common boundary, road reserve/footpath adjacent to boundary, impact 10%,		a) Person in garden, 0.5hr/day avg. Person in house, 10hr/day avg. b) Person in garden, 0.5hr/day avg. Person in house, 10hr/day avg. c) Person in road reserve/footpath, 12hr/day avg. traffic in pavement, 24hr/day avg. d) Person in road reserve/footpath, 12hr/day avg.	a) Unlikely to not evacuate Possible to not evacuate b) Unlikely to not evacuate Possible to not evacuate c) Unlikely to not evacuate Possible to not evacuate d) Unlikely to not evacuate	a) Person in open space, partly buried Person in building, minor injured b) Person in open space, partly buried Person in building, minor injured c) Person in open space, partly buried Person in open space, partly buried d) Person in open space, partly buried	
			Likely	**Prob. of Impact**	**Impacted**				
		a) No. 1799 Pittwater Rd (garden)	0.01	0.10	0.10	0.0208	0.25	0.5	**2.60E-07**
		No. 1799 Pittwater Rd(house)	0.01	0.10	0.10	0.4167	0.5	0.25	**5.21E-06**
		b) No. 40 Park St (garden)	0.01	0.10	0.10	0.0208	0.25	0.5	**2.60E-07**
		No. 40 Park St (house)	0.01	0.005	0.01	0.4167	0.5	0.25	**2.60E-08**
		c) Park St (road reserve/footpath)	0.01	0.10	0.10	0.5000	0.25	0.5	**6.25E-06**
		Park St (pavement)	0.01	0.01	0.01	1.0000	0.5	0.5	**2.50E-07**
		d) Pittwater Rd (road reserve/footpath)	0.01	0.01	0.01	0.5000	0.25	0.5	**6.25E-08**
B	Landslip of rock around perimeter of excavation for northern basement (<3m³)		Up to approximately 1.60m of excavation into bedrock	a) excavation within 3.30 of the common boundary, garden adjacent to boundary, impact 10%, house another 0.50m, impact 10% b) excavation within 3.30 of the common boundary, garden adjacent to boundary, impact 10%, house another 7.50m, impact 1% c) excavation within 3.50 of the common boundary, road reserve/footpath adjacent to boundary, impact 10%, pavement another 5.00m, impact 1% d) excavation within 7.70 of the common boundary, road reserve/footpath adjacent to boundary, impact 10%,		a) Person in garden, 0.5hr/day avg. Person in house, 10hr/day avg. b) Person in garden, 0.5hr/day avg. Person in house, 10hr/day avg. c) Person in road reserve/footpath, 12hr/day avg. traffic in pavement, 24hr/day avg. d) Person in road reserve/footpath, 12hr/day avg.	a) Unlikely to not evacuate Possible to not evacuate b) Unlikely to not evacuate Possible to not evacuate c) Unlikely to not evacuate Possible to not evacuate d) Unlikely to not evacuate	a) Person in open space, partly buried Person in building, minor injured b) Person in open space, partly buried Person in building, minor injured c) Person in open space, partly buried Person in open space, partly buried d) Person in open space, partly buried	
			Possible	**Prob. of Impact**	**Impacted**				
		a) No. 1799 Pittwater Rd (garden)	0.001	0.01	0.10	0.0208	0.25	0.5	**2.60E-09**
		No. 1799 Pittwater Rd(house)	0.001	0.01	0.10	0.4167	0.5	0.25	**5.21E-08**
		b) No. 40 Park St (garden)	0.001	0.05	0.10	0.0208	0.25	0.5	**1.30E-08**
		No. 40 Park St (house)	0.001	0.001	0.01	0.4167	0.5	0.25	**5.21E-10**
		c) Park St (road reserve/footpath)	0.001	0.05	0.10	0.5000	0.25	0.5	**3.13E-07**
		Park St (pavement)	0.001	0.01	0.01	1.0000	0.5	0.5	**2.50E-08**
		d) Pittwater Rd (road reserve/footpath)	0.001	0.01	0.01	0.5000	0.25	0.5	**6.25E-09**
C	Landslip of soils from southern basement excavation (<15m³)		up to approximately 3.70m of fill and clay soils	a) excavation within 0.90 of the common boundary, carpark adjacent to boundary, impact 10%, house another 1.00m, impact 5% b) excavation within 4.70 of the common boundary, road reserve/footpath adjacent to boundary, impact 5%, pavement another 5.00m, impact 1% c) excavation within 6.70 of the common boundary, road reserve/footpath adjacent to boundary, impact 1%,		a) Person in carpark, 8hr/day avg. Person in building, 12hr/day avg. b) Person in road reserve/footpath, 12hr/day avg. traffic in pavement, 24hr/day avg. c) Person in road reserve/footpath, 12hr/day avg.	a) Unlikely to not evacuate Unlikely to not evacuate b) Unlikely to not evacuate Possible to not evacuate c) Unlikely to not evacuate	a) Person in open space, partly buried Person in building, minor injured b) Person in open space, partly buried Person in open space, partly buried c) Person in open space, partly buried	
			Likely	**Prob. of Impact**	**Impacted**				
		a) No. 1791 Pittwater Rd (carpark)	0.01	0.30	0.10	0.3333	0.25	0.5	**1.25E-05**
		No. 1791 Pittwater Rd (building)	0.01	0.25	0.05	0.5000	0.25	0.25	**3.91E-06**
		b) Park St (road reserve/footpath)	0.01	0.05	0.05	0.5000	0.25	0.5	**1.56E-06**
		Park St (pavement)	0.01	0.01	0.01	1.0000	0.5	0.5	**2.50E-07**
		c) Pittwater Rd (road reserve/footpath)	0.01	0.01	0.01	0.5000	0.25	0.5	**6.25E-08**

TABLE : B

Landslide risk assessment for Risk to Property

HAZARD	Description	Impacting	Likelihood		Consequences		Risk to Property
A	Landslip of soils from northern basement excavation (<15m^3)	a) No. 1799 Pittwater Rd	Possible	The event could occur under adverse conditions over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring properties.	Moderate
		b) No. 40 Park St	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	Very Low
		c) Park St	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	Very Low
		d) Pittwater Rd	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	Very Low
B	Landslip of rock around perimeter of excavation for northern basement (<3m^3)	a) No. 1799 Pittwater Rd	Unlikely	The event might occur under very adverse circumstances over the design life.	Minor	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring properties.	Low
		b) No. 40 Park St	Unlikely	The event might occur under very adverse circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	Very Low
		c) Park St	Unlikely	The event might occur under very adverse circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	Very Low
		d) Pittwater Rd	Unlikely	The event might occur under very adverse circumstances over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	Very Low
C	Landslip of soils from southern basement excavation (<15m^3)	a) No. 1791 Pittwater Rd	Likely	The event could occur under adverse conditions over the design life.	Medium	Limited Damage to part of structure or site requires some stabilisation or INSIGNIFICANT damage to neighbouring properties.	High
		b) Park St	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	Low
		c) Pittwater Rd	Possible	The event could occur under adverse conditions over the design life.	Insignificant	Little Damage, no significant stabilising required or no impact to neighbouring properties.	Low

* hazards considered in current condition, without remedial/stabilisation measures and during construction works.
* qualitative expression of likelihood incorporates both frequency analysis estimate and spatial impact probability estimate as per AGS guidelines.
* qualitative measures of consequences to property assessed per Appendix C in AGS Guidelines for Landslide Risk Management.
* Indicative cost of damage expressed as cost of site development with respect to consequence values: Catastrophic : 200%, Major: 60%, Medium: 20%, Minor: 5%, Insignificant: 0.5%.

TABLE: C

Recommended Maintenance and Inspection Program

Structure	Maintenance/ Inspection Item	Frequency
Stormwater drains.	Owner to inspect to ensure that the open drains, and pipes are free of debris & sediment build-up. Clear surface grates and litter. Owner to check and flush retaining wall drainage pipes/systems	Every year or following each major rainfall event. Every 10 years or where issue/dampness identified
Retaining Walls. or remedial measures	Owner to inspect walls for deveation from as constructed condition and repair/replace. Replace non engineered rock/timber walls prior to collapse	Every two years or following major rainfall event. As soon as practicable
Large Trees on or adjacent to site	Arborist to check condition of trees and remove as required. Where tree within steep slopes (>18°) or adjacent to structures requires geotechincal inspection prior to removal	Every five years

N.B. Provided the above shedule is maintained the design life of the property should conform with Councils Risk Management Policy.

CROZIER
GEOTECHNICAL CONSULTANTS

Appendix 5

APPENDIX A

DEFINITION OF TERMS

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES WORKING GROUP ON LANDSLIDES, COMMITTEE ON RISK ASSESSMENT

Risk – A measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability x consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form.

Hazard – A condition with the potential for causing an undesirable consequence (*the landslide*). The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the likelihood of their occurrence within a given period of time.

Elements at Risk – Meaning the population, buildings and engineering works, economic activities, public services utilities, infrastructure and environmental features in the area potentially affected by landslides.

Probability – The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome, and 1 indicating that an outcome is certain.

Frequency – A measure of likelihood expressed as the number of occurrences of an event in a given time. See also Likelihood and Probability.

Likelihood – used as a qualitative description of probability or frequency.

Temporal Probability – The probability that the element at risk is in the area affected by the landsliding, at the time of the landslide.

Vulnerability – The degree of loss to a given element or set of elements within the area affected by the landslide hazard. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is affected by the landslide.

Consequence – The outcomes or potential outcomes arising from the occurrence of a landslide expressed qualitatively or quantitatively, in terms of loss, disadvantage or gain, damage, injury or loss of life.

Risk Analysis – The use of available information to estimate the risk to individuals or populations, property, or the environment, from hazards. Risk analyses generally contain the following steps: scope definition, hazard identification, and risk estimation.

Risk Estimation – The process used to produce a measure of the level of health, property, or environmental risks being analysed. Risk estimation contains the following steps: frequency analysis, consequence analysis, and their integration.

Risk Evaluation – The stage at which values and judgements enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental, and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk Assessment – The process of risk analysis and risk evaluation.

Risk Control or Risk Treatment – The process of decision making for managing risk, and the implementation, or enforcement of risk mitigation measures and the re-evaluation of its effectiveness from time to time, using the results of risk assessment as one input.

Risk Management – The complete process of risk assessment and risk control (*or risk treatment*).

Individual Risk – The risk of fatality or injury to any identifiable (named) individual who lives within the zone impacted by the landslide; or who follows a particular pattern of life that might subject him or her to the consequences of the landslide.

Societal Risk – The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental, and other losses.

Acceptable Risk – A risk for which, for the purposes of life or work, we are prepared to accept as it is with no regard to its management. Society does not generally consider expenditure in further reducing such risks justifiable.

Tolerable Risk – A risk that society is willing to live with so as to secure certain net benefits in the confidence that it is being properly controlled, kept under review and further reduced as and when possible.

In some situations risk may be tolerated because the individuals at risk cannot afford to reduce risk even though they recognise it is not properly controlled.

Landslide Intensity – A set of spatially distributed parameters related to the destructive power of a landslide. The parameters may be described quantitatively or qualitatively and may include maximum movement velocity, total displacement, differential displacement, depth of the moving mass, peak discharge per unit width, kinetic energy per unit area.

Note: Reference should also be made to Figure 1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		**Implied Indicative Landslide Recurrence Interval**		**Description**	**Descriptor**	**Level**
Indicative Value	**Notional Boundary**					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		**Description**	**Descriptor**	**Level**
Indicative Value	**Notional Boundary**			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	**1: CATASTROPHIC 200%**	**2: MAJOR 60%**	**3: MEDIUM 20%**	**4: MINOR 5%**	**5: INSIGNIFICANT 0.5%**
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or **L** (5)
B - LIKELY	10^{-2}	VH	VH	H	M	**L**
C - POSSIBLE	10^{-3}	VH	H	M	M	**VL**
D - UNLIKELY	10^{-4}	H	M	**L**	**L**	**VL**
E - RARE	10^{-5}	M	**L**	**L**	**VL**	**VL**
F - BARELY CREDIBLE	10^{-6}	**L**	**VL**	**VL**	**VL**	**VL**

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.

(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.