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

Development Application for Mr Kevin Xue
Name of Applicant
Address of site No. 206 Hudson Pde, clareville, NSW 2107

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

I, JIAMENG LI *on behalf of* ESWNMAN Pty Ltd
(Insert Name) (Trading or Company Name)

on this the 03/12/2023 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 $10million.

I:
Please mark appropriate box

- ∍ have prepared the detailed Geotechnical Report referenced below in accordance with the Australia Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- ∍ am willing to technically verify that the detailed Geotechnical Report referenced below has been prepared in accordance with the Australian Geomechanics Society's Landslide Risk Management Guidelines (AGS 2007) and the Geotechnical Risk Management Policy for Pittwater - 2009
- ∍ have examined the site and the proposed development in detail and have carried out a risk assessment in accordance with Section 6.0 of the Geotechnical Risk Management Policy for Pittwater - 2009. I confirm that the results of the risk assessment for the proposed development are in compliance with the Geotechnical Risk Management Policy for Pittwater - 2009 and further detailed geotechnical reporting is not required for the subject site.
- ∍ have examined the site and the proposed development/alteration in detail and I am of the opinion that the Development Application only involves Minor Development/Alteration that does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- ∍ have examined the site and the proposed development/alteration is separate from and is not affected by a Geotechnical Hazard and does not require a Geotechnical Report or Risk Assessment and hence my Report is in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009 requirements.
- ∍ have provided the coastal process and coastal forces analysis for inclusion in the Geotechnical Report

Geotechnical Report Details:

Report Title: Geotechnical Report
Report Date: 04/12/2023
Author: JIAMENG LI
Author's Company/Organisation: ESWNMAN Pty Ltd

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

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 ......[signature]......
Name ......JIAMENG LI 3/12/2023......
Chartered Professional Status......Chartered Engineer......
Membership No. ......2493013......
Company......ESWNMAN Pty Ltd......

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

Development Application for Mr Kevin Xue
Name of Applicant
Address of site No. 206 Hudson Pde, Clareville, 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 Report
Report Date: 04/12/2023
Author: JIAMENG LI
Author's Company/Organisation: ESWNMAN Pty Ltd

Please mark appropriate box

- [x] Comprehensive site mapping conducted 25/10/2022 (date)
- [ ] Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- [x] Subsurface investigation required
  - [ ] No Justification ……………………………………………
  - [x] Yes Date conducted 25/10/2022
- [x] Geotechnical model developed and reported as an inferred subsurface type-section
- [x] Geotechnical hazards identified
  - [ ] Above the site
  - [x] On the site
  - [x] Below the site
  - [x] Beside the site
- [x] Geotechnical hazards described and reported
- [x] Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
  - [x] Consequence analysis
  - [x] Frequency analysis
- [x] Risk calculation
- [x] Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- [x] Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- [x] Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
- [x] Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- [x] Design Life Adopted:
  - [x] 100 years
  - [ ] Other ……………………………………… specify
- [x] Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- [x] 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 [signature]
Name JIAMENG LI
Chartered Professional Status Chartered Engineer
Membership No. 2493013
Company ESWNMAN Pty Ltd

GEOTECHNICAL INVESTIGATION REPORT

No. 206 Hudson Parade
Clareville, NSW

Prepared for

Mr Kevin Xue
C/- RM Designers

Reference No. ESWN-PR-2022-1546

4th December 2023

Geotechnical Engineering Services

- *Geotechnical investigation*
- *Lot classification*
- *Geotechnical design*
- *Footing inspections*
- *Excavation methodology and monitoring plans*
- *Slope stability analysis*
- *Landslide risk assessment*
- *Tests on soil permeability and absoprtion rate*
- *Finite element analysis(FEA)*

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CONTROLLED DOCUMENT

DISTRIBUTION AND REVISION REGISTER

Revision	Details	Date	Amended By
00	Original	31/10/2022	J.L.
01	Updated	04/12/2023	

Author: Jiameng Li..

Signed: .....Jli ....

Date: 04/12/2023 ....

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REFERENCES

1. Australian Standard – AS 1726-2017 Geotechnical Site Investigation.
2. Australian Standard AS 1289.6.3.2 – Determination of the penetration resistance of a soil – 9 kg dynamic cone penetrometer test.
3. Australian Standard – AS 2870-2011 Residential Slabs and Footings.
4. Australian Standard – AS 2159-2009 Piling - Design and Installation.
5. Australian Standard – AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments.
6. Australian Standard – AS 1170.4-2007 Structural Design Actions – Part 4: Earthquake actions in Australia.
7. Australian Standard – AS 4678-2002 Earth-retaining Structures.
8. Austroads – “Pavement Design – A Guide to the Structural Design of Road Pavements”, 2004.
9. “NSW WorkCover: Code of Practice – Excavation” July 2015.
10. Pells, P.J.N, Mostyn, G. & Walker B.F., “Foundations on Sandstone and Shale in the Sydney Region”, Australian Geomechanics Journal, 1998.
11. CSIRO, BTF 18 - “Foundation Maintenance and Footing Performance: A Homeowner’s Guide”.
12. Australian Geomechanics Society, Landslide Risk Management Sub-Committee Guidelines: Landslip Risk Management Concepts and Guidelines, March 2007.
13. Part 7.7 – Geotechnical Hazards, Pittwater Local Environmental Plan 2014, dated 30th June 2022.
14. Geotechnical Hazard Map – Sheet GTH_010, Pittwater Local Environmental Plan 2014.
15. B3.1 Landslip Hazard, Pittwater 21 Development Control Plan, 8 December 2003.
16. Appendix 5 – Geotechnical Risk Management Policy for Pittwater – 2009, Pittwater Council.

1. INTRODUCTION

ESWNMAN Pty Ltd (ESWNMAN) was commissioned by Mr Kevin Xue c/- RM Designers to undertake a geotechnical investigation for a proposed development at No. 206 Hudson Parade, Clareville, NSW 2107. The fieldwork was completed on 25th October 2022 by ESWNMAN staff under the supervision of an experienced Geotechnical Engineer.

The purpose of geotechnical investigation was to assess the feasibility of site in geotechnical prospective for a proposed residential development.

This report presents results of geotechnical investigation & in-situ tests, interpretation and assessment, and provides comments on geotechnical related issues and recommendations.

1.1 Available Information

The following information was provided to ESWNMAN prior to the fieldwork:

- Architectural drawings titled "New Single Dwelling 2 Storey House, No. 206 Hudson Parade, Clareville, NSW 2107" prepared by RM Designers, referenced Project No. 22009, including drawing nos. DA00 to DA70 (29 sheets), Issue A to D and dated 19th October 2023 (latest).
- A site survey plan titled "Plan of Detail & Levels over Lot 38 in DP13760, Being No. 206 Hudson Parade, Clareville, NSW" prepared by M. Y. Xu & Co., referenced 14985-T1 and dated 4th June 2022.

1.2 Proposed Development

Based on the information provided in Section 1.1, the proposed development will comprise the demolition of existing structures and construction of a two & three storey dwelling, with an inground swimming pool.

Based on proposed FFL of RL12.010m for Private Open Space Level and existing surface elevations shown on a surface plan provided, an approximate excavation between 2.5m and 2.8m deep at rear and 5.2m-6.3m deep at front portion of Private Open Space Level would be required during construction. An approximate setback of 1.0m from northern side boundary and 2.5m from southern side boundary was proposed for excavation at Private Open Space Level.

Other minor excavation and cut/fill earthwork may include the following:

- Excavation of proposed swimming pool at rear by further 1.7m deep below Private Open Space Level;
- Further excavation of 1.5m deep for proposed lift shaft;
- Excavations of structural footing areas for building and retaining walls;
- Trench excavation for installations of services pipes; and
- Cut/fill earthwork and landscaping.

1.3 Scope of Work

The geotechnical investigation was carried out by ESWNMAN staff supervised by an experienced Geotechnical Engineer, including the following:

- Desktop study of **Geotechnical Hazard Map** and related policies on **"Geotechnical Hazards**", i.e. Pittwater Council's Environmental Plan and Control Plan (References 13 to 16);
- Collection and review of Before-You-Dig-Australia (BYDA) plans and our in-house dataset near the subject site;
- A site walkover to assess the surface conditions, identify relevant site features and nominate borehole and testing locations;
- Augering of boreholes to check thickness of fill and natural soils;
- Undertaking Dynamic Cone Penetrometer (DCP) Tests to assess the strength of soils with depth and rock profile;
- Geological mapping of rock outcrops within the site;
- **Identifying and assessing potential landslide hazard, mechanism of instability, adverse impacts, landslide risk assessment and likely counter-measures;**
- Reinstatement of site with soil cuttings from boreholes;
- Interpretation of investigation data obtained; and
- Preparation of a geotechnical report.

The approximate locations of sandstone outcrops, boreholes and DCP tests completed during site investigation are shown on Figure 1 – "Site Location Plan" as included in Appendix A of this report.

2. SITE DESCRIPTION

The site is located within Northern Beaches Council area, approximately 27.7km to the southwest of Sydney CBD, 1km to the northwest of Bilgola Plateau Public School and bounded by Pittwater in the west.

The site is a semi rectangular-shaped land, identified as Lot 38 in Deposited Plan (DP)13760, with an approximate area of 632.3m^2, At time of site investigation, the site was occupied by a two storey brick house, which was likely supported by shallow type foundations.

Based on the plans provided and our observations during a site walkover, the site is characterised by gentle and moderate sloping ground at front portion, through steep & very stiff sloping ground at middle (approximate location of proposed pool) and becoming very steep sloping ground further to the west at rear portion of the site. Some sandstone outcrops were present on the cuts along the existing stairs, leading to a Pontoon Jetty and Boat Rail.

Selected site photographs recorded during site investigation are provided in Appendix B.

3. LOCAL GEOLOGY

Reference to the Sydney 1:100,000 Geological Series Sheet 9130 (Edition 1), dated 1983, by the Geological Survey of New South Wales, Department of Mineral Resources, indicates the site is located within an area underlain by Newport Formation and Garie Formation (Rnn) of Narrabeen Group. The Newport Formation and Garie Formation is described as “Interbedded laminite, shale, and quartz, to lithic-quartz sandstone. Minor red claystone north of Hawkesbury River. Clay pellet sandstone (Garie Fm) south of Hawkesbury River.”

The map also shows the site is close to another geological unit, i.e. Hawkesbury Sandstone (Rh), which consists of “Medium to coarse-grained quartz sandstone, very minor shale and laminite lenses”.

Results of site investigation, including visual examination of sandstone outcrops exposed within the site as provided in Section 5.2 confirmed the published geology.

4. METHODOLOGY OF INVESTIGATION

4.1 Pre-fieldwork

Prior to the commencement of the fieldwork, a desktop study on local geology, **Pittwater Council's polices on "Geotechnical Hazard"** and our in-house dataset were undertaken.

BYDA services search was also conducted and reviewed prior to the commencement of fieldwork and in-situ tests.

4.2 Borehole Drilling

At time of investigation, the site was inaccessible by any drilling machines due to constraints in site access and steep sloping ground. Therefore, a portable geotechnical investigation involved drilling of boreholes to a variable refusal depth of 1.2m, 1.4m, 1.4m and 0.7m existing ground level (BGL), using a hand operated equipment assisted with in-situ tests.

The approximate location of boreholes is shown on Figure 1 attached in Appendix A. Engineering logs of boreholes processed using Bentley gINT software along with an explanatory note are presented in Appendix C.

4.3 Dynamic Cone Penetrometer (DCP) Test

The Dynamic Cone Penetrometer (DCP) Test involves hammering cone tipped rods using a standard weight and drop height. The number of blows required to penetrate each 100 mm is recorded (Reference 2). The DCP test is used to assess in-situ strength of undisturbed soil and/or compacted materials. The penetration rate of the 9-kg DCP can be used to estimate in-situ CBR (California Bearing Ratio) and to identify strata thickness and other material characteristics.

A total of four(4) DCP tests, positioned next to boreholes and identified as DCPs 1 to 4 accordingly, were also completed during site investigation. The DCP tests reached refusal depth and bounce of DCP hammer occurred approximately at 1.3m, 1.5m, 1.5m and 0.8m BGL at location of DCPs 1 to 4 respectively.

The location of DCP tests is shown on Figure 1 attached in Appendix A. The record of DCP test results is presented in Appendix D.

4.4 Geological Mapping and Visual Examination of Rock

Geological mapping and visual examination of sandstone outcrops exposed within the site or in surrounding areas by a Geotechnical Engineer or Engineering Geologist is proven to be an effective approach of investigation when machine drilling is not possible.

Sandstone outcrops exposed at rear portion of the site were visually examined. It confirmed the shallow rock within the site, as shown on Figure 1 in Appendix A and indicated on Photos 5 & 6 attached in Appendix B of this report. The grain size and colour, weathering degree, and estimated strength were recorded and assessed on-site by an experienced Geotechnical Engineer from ESWNMAN.

All fieldwork was supervised on a full time basis by an experienced Geotechnical Engineer who was responsible for nominating locations of boreholes and DCP tests, preparing field engineering logs of the subsurface strata encountered in accordance with AS 1726 for Geotechnical Site Investigation(Reference 1), mapping of sandstone outcrops, **assessing landslide hazards, conducting on-site landslide risk assessment**, undertaking in-situ tests and taking site photographs.

The approximate reduced levels of boreholes & DCP tests, which were estimated based on the survey plan provided as referenced in Section 1.1, are presented in the attached engineering logs and record sheet of DCP tests.

5. RESULTS OF INVESTIGATION

5.1 Surface Conditions

At time of site investigation, apart from existing house, a carport, a timber shed, a Pontoon Jetty and Boat Rail, concrete stairs, retaining walls and concrete driveway, the remainder of outdoor areas was covered with grass and lawn. Some sandstone outcrops and boulders were present on the surface or on slopes at rear portion of the site.

5.2 Subsurface Conditions

Based on visual examination of sandstone outcrops, borehole information and interpreted results of DCP test, subsurface conditions encountered mainly consisted of the following:

- **Fill** (Unit 1): SAND/clayey SAND, fine grained, grey, some gravel, trace sandstone boulder, some colluvium, poorly compacted, approximately extending to 0.8m, 1.1m, 1.0m and 0.5m BGL at location of BH1 to BH4 respectively; overlying
- **Residual Soils** (Unit 2): SAND, medium grained, brown, moist, medium dense & dense, extending to inferred top of rock at 1.3m, 1.5m, 1.5m and 0.8m BGL at location of DCPs 1 to 4 respectively; overlying

- **Weathered Sandstone** (Unit 3): Class IV-III Sandstone, medium to coarse grained, brown, moderately weathered, medium and high strength, based on examination of sandstone outcrops exposed within the site (see Figure 1 attached in Appendix A and Photos 5 & 6 included in Appendix B) and interpreted results of DCP test.

The subsurface conditions described above are also summarised in Table 1 below.

Table 1 – Subsurface Conditions at Testing Locations

Geotechnical Unit and Description		**Inferred Depth to Top of Unit** (m, BGL)			
		BH1/ DCP1	BH2/ DCP2	BH3/ DCP3	BH4/ DCP4
Fill (Unit 1)	SAND/Clayey SAND, poorly compacted	0	0	0	0
Residual Soils (Unit 2)	Clayey SAND, medium dense & dense	0.8	1.1	1.0	0.5
Weathered Sandstone (Unit 3)	Class IV-III SANDSTONE, medium and high strength	1.3	1.5	1.5	0.8

5.3 Groundwater

No groundwater was encountered during drilling of boreholes up to 1.4m BGL. No indicates of water seepage or inflow on faces of sandstone cuts and outcrops exposed within the site during a site walkover.

6. GEOTECHNICAL ASSESSMENT

The main geotechnical aspects associated with proposed development are assessed to include the following:

- Site classifications;
- Excavation conditions;
- Excavation stability/support;
- Earth retaining structures;
- Foundations;
- Excavation method & vibration control measures;
- Earthworks and material use;
- **Landslide risk assessment and control measures**; and
- Further geotechnical investigation.

The assessment of geotechnical aspects listed above and recommendations for the proposed development are presented in the following sections.

6.1 Site Classifications

(a) Site reactive classification

Based on ground profile of the site and the criteria specified in AS 2870 (Reference 3), the site is assessed as initially Class A – "Most sand and rock sites" with little or no ground movement from moisture changes. However, due to presence of steep sloping ground within the site with instability considerations, Class "P" can be adopted and our recommendations in Sections 6.5 & 6.8.4 should be adopted during design and construction.

The above classification and footing recommendations are provided on the basis that the performance expectations set out in Appendix B of AS2870 are accepted.

Design, construction and maintenance of plumbing, ground drainage, protection of building perimeter, the garden, etc. should be carried out in accordance with CSIRO BTF18 (Reference 11) to avoid any water related problems or significant changes of moisture in building foundations, which may contribute to surface movement.

(b) Site earthquake classification

The results of the site investigation indicate the presence of fill and natural soils, underlain by Class IV Sandstone or stronger rock. In accordance with Australian Standard AS 1170.4, the site may be classified as a "Rock site" (Class B_e) for foundation design of building and retaining walls embedded in the underlying sandstone. The Hazard Factor (Z) for Clareville in accordance with AS 1170.4 (Reference 6) is considered to be 0.08.

(c) Landslide risk Zoning

Based on Geotechnical Hazard Map – Sheet GTH_010, Pittwater Local Environmental Plan 2014 (Reference 14), the site is partially located within an area affected by Geotechnical Hazard H1.

6.2 Excavation Conditions

The design information summarised in Section 1.2 for the proposed development indicates an approximate variable excavation up to 2.5m deep at eastern or front of Lower Level 01 (or Cinema Room), and excavation of 2.0m-3.5m deep for Lower Level 02 (or Entertainment Area) and swimming pool, due to sloping effect.

The observations and results of boreholes indicate the presence of Fill(Unit 1), Residual Soils(Unit 2) and Weathered Sandstone(Unit 3) during construction excavation.

Any fill and deleterious materials, including old footings/buried structures, concrete slabs, plant/tree roots, redundant services, timber/brick material, and sandstone boulders, are expected to be stripped and removed from development area to spoils.

Excavation of the soils, low strength Class V Sandstone (may encounter locally) would be feasible using conventional earthmoving equipment. Heavy ripping and rock breaking equipment or vibratory rock breaking equipment is expected to be required for excavation in medium strength Class IV Sandstone or higher strength rock.

The excavation methods and control measures to minimise induced vibration during excavation within medium and high strength sandstone are provided in Section 6.6.

Based on groundwater conditions in Section 5.3, **we assessed it is unlikely to encounter groundwater during excavation for proposed Lower Levels and swimming pool.**

6.3 Excavation Support / Stability of Excavation

(a) ***Shallow Excavation*** (i.e. <1.0 m in Depth)

The excavations should be carried out in accordance with the 'NSW WorkCover: Code of Practice – Excavation' (Reference 9).

Temporary excavations **away from site boundaries** through the underlying soils can be excavated using a safe excavation batter provided that:

- They do not encroach ZOI(Zone of Influence, defined as 45° angle of draw from nearest edge of footing underside) of any site or adjoining structures;
- They are barricaded when not in use;
- They are not left open for more than 24 hours;
- No surcharge loading is applied within 2.0m from edge of excavation;
- No groundwater flows are encountered; and
- They are not used for access by a worker.

Where access is required for workers, the temporary excavation batters should be re-graded to no steeper than 2 Horizontal (H) to 1 Vertical (V) for the soils above the natural groundwater level, or supported by a suitable temporary shoring measure, such as reinforced shotcrete with adequate drainage (strip drain & weepholes).

We recommend a permanent safe batter of 3H:1V or flatter can be adopted for soil materials within the site for re-battering and landscaping.

Any permanent excavation (or filling) greater than 0.6m in height should be retained by a permanent retaining wall to be designed by a qualified Engineer based on the recommendation provided in Section 6.4 of this report.

(b) ***Deep Excavations*** (i.e. >1.0 m in Depth)

Any excavation batters in rock and soils away from site boundaries greater than 1.0 m in depth, the temporary safe batters for excavated slopes in Table 2 below can be adopted under dry conditions:

Table 2 - Recommended Safe Excavation Batters[1]

Geotechnical Unit	Maximum Batter Angle	
	Temporary	Permanent
Fill (Unit 1)	2H:1V	To be retained
Residual Soils (Unit 2)	1.75H:1V	To be retained
Sandstone (Unit 3): Class IV – Class III Sandstone	Sub-vertical[2], self-supporting	Reinforced shotcrete or to be retained

Notes:
[1] –Typical batters of excavated slopes (Hoerner, 1990). Also applicable to excavation <1.0m depth.
[2] – Shotcrete and/or rock bolts may be required for vertical or sub-vertical cut slope subject to assessment by an experienced Geotechnical Engineer during excavation.

Based on proposed setbacks and depth of excavation as mentioned in Section 1.2, we assessed that excavation using temporary safe batters recommended in Table 2 are typically applicable for proposed excavation away from site boundaries.

However, it is noted that safe excavation batters in Table 2 may not be practical or possible for excavation along site northern and southern side boundaries due to inadequate setback proposed, to control lateral ground movement, the following temporary excavation support/shoring measures should be adopted **prior to any excavation**:

- **Contiguous piles; or**
- **A line of closely spaced piles socketed into rock next to boundary fence.**

For excavation away from site northern and southern boundaries, the following temporary excavation support/shoring measures should be considered **immediate after excavation**:

- **Reinforced shotcrete** with adequate drainage(To be stabilised on sandstone at lower part and founded in rock at base of cut); or
- Raking or inclined shores/braces; or
- Earth berm in front of cut/excavation.

Other alternative shoring options may be considered subject to assessment by the project Structural Engineer in consultation with the project Geotechnical Engineer.

We strongly recommend the construction excavation should be carried out in a sequence "from middle of site towards side boundaries" so as to obtain a reliable ground profile to review excavation shoring and vibration control measures to be adopted.

Inspections of the excavation faces and requirements for shotcrete/rock bolts by a Geotechnical Engineer during construction will be required.

Earth retention structures can be designed using the recommended parameters provided in Section 6.4.

Dilapidation survey of adjoining properties and roads should be carried out prior to commencement of construction.

With the recommended safe excavation batters, shoring/support measures, and geotechnical inspection, construction of the proposed basement in the short and long terms is expected to have no impacts on the adjoining buildings, roads and public infrastructure.

6.4 Earth Retaining Structures

The earth retaining structure should be designed to withstand the applied lateral pressures of the subsurface layers, the existing surcharges in their zone of influence, including existing structures, construction machines, traffic and construction related activities. The design of retaining structures should also take into consideration hydrostatic pressures and lateral earthquake loads as appropriate. **Filter type geofabric should be considered to be installed between wall backfill area and surrounding soils** to avoid soil erosion and to prevent the fines from entering the wall drainage system.

The retaining wall design should be carried out in accordance with AS 4678 (Reference 7).

The recommended preliminary parameters for design of retaining structures are presented in Tables 3 and 4 below. The coefficients provided are based on drained conditions.

Table 3 - Preliminary Geotechnical Design Parameters for Retaining Walls

Geotechnical Unit	Unit Weight (kN/m^3)	Effective Cohesion c′ (kPa)	Angle of Effective Internal Friction ϕ'(°)	Modulus of Elasticity E_{sh} (MPa)	Poisson Ratio ν
Fill (Unit 1)	17	0	30	10	0.35
Residual Soils (Unit 2)	18	0	33	25	0.35
Class IV Sandstone (Unit 3)	24	100	35	100	0.20

Table 4 - Preliminary Coefficients of Lateral Earth Pressure

Geotechnical Unit	Coefficient of Active Lateral Earth Pressure (Ka)	Coefficient of Active Lateral Earth Pressure at Rest (Ko)	Coefficient of Passive Lateral Earth Pressure (Kp)
Fill (Unit 1)	0.33	0.50	3.0
Residual Soils (Unit 2)	0.29	0.46	3.4
Class IV Sandstone[1] (Unit 3)	0.27	0.43	3.7

The coefficients of lateral earth pressure should be verified by the project Structural Engineer prior to use in the design of retaining walls. Simplified calculations of lateral active (or at rest) and passive earth pressures can be carried out using Rankine's equation shown below:

$Pa = K\,\gamma\,H - 2c\sqrt{K}$ For calculation of Lateral Active or At Rest Earth Pressure

$Pp = K_p\,\gamma\,H + 2c\sqrt{K_p}$ For calculation of Passive Earth Pressure

Where:

P_a = Active (or at rest) Earth Pressure (kN/m^2)
P_p = Passive Earth Pressure (kN/m^2)
γ = Bulk density (kN/m^3)
K = Coefficient of Earth Pressure (K_a or K_o)
Kp = Coefficient of Passive Earth Pressure
H = Retained height (m)
c = Effective Cohesion (kN/m^2)

6.5 Foundations

Results of geotechnical investigation indicate the ground conditions at this site are suitable for the proposed dwelling and associated works.

It is noted that after excavation to proposed FFLs for Private Open Space Level and bottom of the pool, the materials at bulk excavation level are likely occupied by Unit 3 – "Class IV Sandstone" or stronger rock. Therefore, **cast-in-situ reinforced concrete shallow foundations**, such as pad or strip footings under columns and walls, can be adopted.

For those areas with depth to top of rock is greater than 0.8m deep, piers/piled foundations can be considered during construction. Bored piles can be adopted.

For both footing systems above, **we recommend the suitable founding materials should be Unit 3 – "Class IV Sandstone"** (instead of a boulder or a floater), **with minimum footing embedment of 300mm into underlying rock,** to eliminate sloping effect and potential for site instability as further discussed in Section 6.8.4.

The preliminary geotechnical parameters recommended for design of shallow and piled foundations are provided in Table 5 below.

Table 5 - Preliminary Geotechnical Foundation Design Parameters

Geotechnical Unit	Allowable Bearing Capacity (kPa[1])	Allowable Shaft Adhesion (kPa)	Modulus of Elasticity (Es,v, MPa)
Fill (Unit 1)	N/A[2]	N/A[2]	15
Residual Soils (Unit 2)	150 (Shallow footings)[2]	15	30
Class IV Sandstone[3](Unit 3)	800 (Shallow footing/piles)	50	150

[1] With a minimum embedment depth of 300mm into Class IV Sandstone.
[2] N/A, Not Applicable, not recommended for building or retaining wall structures at this site.
[3] Class of rock to be confirmed by the project Geotechnical Engineer during excavation.

Design of shallow and piled foundations should be carried out in accordance with Australian Standards AS2870(Reference 3) and AS2159 (Reference 4).

To minimise the potential effects of differential settlement under the buildings loads, it is recommended all foundations of the proposed building should be founded on consistent materials of similar properties or rock of similar class.

Any water, debris, loose and wet materials should be removed from excavations prior to placement of reinforcement and pouring of concrete.

Adequate surface drains and subsoil drains should be provided to prevent the soil erosion surrounding the structures.

A Geotechnical Engineer should be engaged to inspect footing excavations to ensure foundation bases have suitable materials with adequate bearing capacity, and to check the adequacy of footing embedment/socket depth if unexpected ground conditions are encountered.

6.6 Excavation Methods & Vibration Control Measures

For this site, the majority of rock excavation will occur in the excavation for the proposed Private Open Space Level and swimming pool during construction.

Induced vibrations in structures adjacent to the excavation should not exceed a Peak Particle Velocity (PPV) of 10mm/sec for brick or unreinforced structures in good condition, 5mm/sec for residential and low rise buildings or 2mm/sec for historical or structures in sensitive conditions.

Based on the subsurface conditions, the excavation equipment listed in Table 6 below can be adopted as a guidance during construction excavation.

Table 6 – Preliminary Type of Typical Excavation Plant

Geotechnical Unit*	Likely Plant Requirements
Soils and Class V Sandstone	Buckets attached to large excavators or dozers, using "tiger teeth"
Class IV Sandstone	Medium size rock breaking hammer, ripper on 20 tonne excavator, large dozer or 30 tonne Excavator, Caterpillar D9 or larger
Class III Sandstone	Heavy rock breaking, hydraulic rock Hammers

For excavation in rock, plant selection will depend on the proximity of neighbouring structures and their susceptibility to damage caused by vibration induced by excavation plant.

The propagation of vibrations at a site will depend on the plant used and the ground conditions, construction activities, and type of foundations of the structure receiving the vibrations. The ground conditions, including type of soils and rocks, unit thickness, rock strength and defects, and groundwater condition, are unique for each site.

It should be noted that buffer distances for rock hammer may be reduced appreciably by application of prior saw cutting along excavation near site boundaries.

Dilapidation survey of adjoining properties and road infrastructure should be carried out prior to commencement of construction.

To achieve the required vibration limits, the operating limits of maximum capacity for different types of rock excavation plants and distance to nearest structures are provided in Table 7 below.

Table 7 - Preliminary Vibration Limits related to Buffer Distance and Type of Plant

Distance from adjoining structure (m)	Maximum Peak Particle Velocity (PPV)			
	PPV= 5mm/sec		PPV=10mm/sec	
	Plant	Operating Limit (% of Maximum Capacity)	Plant	Operating Limit (% of Maximum Capacity)
1.5 to 2.5	Hand operated Jack Hammer	50	Hand operated Jack Hammer	100
	Rock saw on excavator	50	Rock saw on excavator	100
2.5 to 5.0	Ripper on 20 tonne excavator	50	300kg Rock Hammer	100
	300kg Rock Hammer	50	600kg Rock Hammer	50
5.0 to 10.0	300kg Rock Hammer	100	600kg Rock Hammer	100
	600kg Rock Hammer	50	900kg Rock Hammer	50

To ensure vibration levels remain within acceptable levels and minimise the potential effects of vibration, **excavation into Class IV Sandstone & Class III Sandstone should be carried out in a controlled & careful manner, and complemented with saw cutting or other appropriate methods prior to excavation**. Rock saw cutting should be carried out using an excavator mounted rock saw, or the like, so as to minimise transmission of vibrations to any adjoining properties that may be affected. Hammering is not recommended and should be avoided. However, if necessary, hammering should be carried out horizontally along bedding planes of (pre-cut) broken rock blocks or boulders where possible with noise levels restricted to acceptable to comfortable limits to adjacent residents.

6.7 Earthworks and Material Use

The excavated materials from excavation are assessed to be generally suitable for landscaping provided they are free of any contaminants.

The suitability of site excavated or imported materials should be subject to satisfying the following criteria:

- The materials should be Virgin Excavated Natural Material (VNEM) and clean (i.e. free of contaminants, deleterious or organic material), free of inclusions of >75mm in size, high plasticity material be removed and suitably conditioned to meet the design assumptions where fill material is proposed to be used.
- The materials should satisfy the Australian Standard AS 3798 Guidelines on Earthworks for Commercial and Residential Developments (Reference 5).

The final surface levels of all excavation and filling areas should be compacted in order to achieve an adequate strength for subgrade.

As a guidance for fill construction, the following compaction targets can be adopted:

- Moisture content of ±2% of OMC (Optimal Moisture Content);
- Minimum density ratio of 100% of MDD (Maximum Dry Density) for filling within building/structural foundation areas;
- Minimum density ratio of 98% of MDD for filling surrounding the pipes within trenches or behind retaining walls (unless otherwise specified on design drawings);
- The loose thickness of layer should not exceed 200mm for cohesionless soils; and
- For the footpath and pavement areas, minimum density ratio of 95% of MDD for general fill and 98% for the subgrade to 0.5m depth.

Design and construction of earthworks should be carried out in accordance with Australian Standard AS 3798 (Reference 5).

6.8 Landslide Risk Assessment and Mitigations

6.8.1 General

Review of Landslide Risk Map, Pittwater Local Environmental Plan 2014 (Reference 14), and our on-site assessment as provided in Section 6.1 (c) indicate the site is partially located within an area affected by Geotechnical Hazard H1.

Due to presence of moderate sloping ground at front portion, steep & very steep sloping ground at middle and rear portion of the site, with some sandstone vertical cut presented within rear the site, slope stability and landslide risk assessment in accordance with Guidelines by the Australian Geomechanics Society(AGS) (Reference 12) was also included in this report.

During the site investigation, there were no obvious signs of previous, current or incipient instability or landslide within the areas upslope or downslope. The existing slope batters and retaining walls are generally in stable conditions without any signs of distressing. Nevertheless, geotechnical investigation and assessment in accordance with guidelines published by AGS (Reference 12) were carried out for this site in order to demonstrate the proposed development is justified in terms of geotechnical stability.

The Australian Geomechanics Society (AGS) recommends the landslide risk of a site be assessed on the basis of the likelihood of a landslide event and the consequences of that event. The guidelines on qualitative measures for the likelihood and consequence of landslides and assumed level of risk are provided in Appendix E – Risk Assessment Matrix.

The stability of the site before and after construction of proposed development was preliminarily assessed based on AGS guidelines as provided in the following Sections.

6.8.2 Predevelopment

The stability of a site is generally governed by site factors such as slope angles, properties and depth of soils, strength of sub-surface material, groundwater and surface runoff conditions, drainage, vegetation, potential sliding planes such as interface of rock/soil and large scale defects such as faults within rock formation.

Based on an examination of existing slope and guidelines for landslide risk assessment as set out in the Australian Geomechanics Vol 42 No 1 March 2007, the site can be classified as gentle and moderate sloping ground of 10° at front portion and steep sloping ground up to 30° at rear portion of proposed development. The following potential landslip hazards have been identified for this particular site:

- Soil creep;
- Rockfall (loose sandstone block or boulders) on steep slope or cuts;
- Earth slump and earth slide (along interface of rock/soils);
- Deep seated and shallow landslide; and
- Instability of existing masonry and sandstone walls at rear along stairs.

The assessed risk levels of the hazards at the existing conditions are summarised in Table 8 overleaf. In the assessment, consideration was given to the potential effects of instability on the adjoining properties, in particular those at downhill side, including effects on the land, setback of structures, buildings and occupiers within the adjoining properties.

Table 8 - Assessed Risk to Property - Predevelopment

Potential Hazard	Qualitative Measures of Likelihood	Qualitative Measures of Consequences to Property	Qualitative Risk Analysis – Level of Risk to Property
Soil creep	D – Unlikely (10^{-4})	3: Medium 20%	Low
Rockfall from slope/cuts	C – Possible (10^{-3})	3: Medium 20%	**Moderate**
Earth slump and earth slide	C – Possible (10^{-3})	3: Medium 20%	**Moderate**
Deep seated landslide	E – Rare (10^{-5})	2: Major 60%	Low
Shallow landslide (along soil/rock interface)	D – Unlikely (10^{-4})	3: Medium 20%	Low
Instability of existing masonry and sandstone walls	D – Unlikely (10^{-4})	4: Minor (5%)	Low

The overall slope instability risk of the site under existing conditions is assessed to be **"Low to moderate"** resulting from downslope soil creep, rockfall, earth slump and earth slide, potential deep seated or shallow landslide. According to AGS 2007c, "Low & Moderate Risk Level" is usually acceptable to regulators where treatment is required to reduce risk to this level, with ongoing maintenance if any.

The annual probability of risk to life for the person most at risk pre-development due to the above listed hazards is assessed to be in the order of 5×10^{-5} /annum. The AGS guidelines (Reference 12) recommend tolerable loss of life risk for the person most at risk for the "existing slopes" is 1×10^{-4}/annum.

6.8.3 Post-Development

The construction activities that are anticipated to be carried out for the proposed development on sloping ground indicate the potential for "Moderate Risk" rockfall resulting from sandstone boulders and loose sandstone bedrock, and shallow landslide along interface between soil and rock **if footings of proposed development are not adequately embedded**. Therefore, appropriate measures are required to mitigate against landslide risks should be incorporated into the design and construction of the proposed development.

Provided that the recommendations and design parameters provided in this report, in particular, control measures and recommendations in Section 6.8.4, are taken into consideration during design, construction and post construction, the assessed risks related to stability of the site after construction of the structures associated with the proposed development are summarised in Table 9 below.

Table 9 - Assessed Risk to Property– Post-development as per Our Recommendations

Potential Hazard	Qualitative Measures of Likelihood	Qualitative Measures of Consequences to Property	Qualitative Risk Analysis – Level of Risk to Property
Soil creep	E – Rare (10^{-5})	3: Medium 20%	Low
Rockfall from excavation and existing uphill cut/slopes	D - Unlikely (10^{-4})	3: Medium 20%	Low
Earth slump and earth slide	D – Unlikely (10^{-4})	3: Medium 20%	Low
Deep seated landslide	E – Rare (10^{-5})	2: Major 60%	Low
Shallow landslide (soil/rock interface)[1]	D – Unlikely (10^{-4})	3: Medium 20%	Low
Instability of footing/retaining walls[1]	D – Unlikely (10^{-4})	3: Medium 20%	Low
Instability of cut/fill and excavation[1]	E – Rare (10^{-5})	4: Minor 5%	Very Low

Note:

[1] Probability of failure was assessed based on the adoption of the control measures and recommendations made in Section 6.8.4.

The overall slope instability risk associated with the site post construction of the currently proposed development is assessed to be **"Low"** to **"Very Low"** resulting from activities within the site based on design and construction of the development to be in accordance with our recommendations**.**

The risk to life for the person most at risk post-development due to the above listed hazards is assessed to be in the order of 4×10^{-6}/annum. The AGS guidelines recommend tolerable loss of life risk for the person most at risk for the "new constructed slope/new development" is 1×10^{-5}/annum.

6.8.4 Mitigation and Control Measures

To reduce the level of risk of instability within this site, the proposed development at this site should be constructed according to the recommendations presented in this report alongside with following provisions:

- The design and construction of proposed development should be carried out taking into consideration the recommendations and parameters provided in this report.

- Footings for all proposed structures, including building structures, retaining walls and pool, **should be keyed into underlying stable ground adequately to reduce the risk of instability**. We assessed stable ground should be Unit 3– "Class IV Sandstone" or better bedrock (instead of a boulder or floater). A minimum footing embedment of 300mm into underlying sandstone is recommended.
- **To avoid rockfall, any unstable/loose sandstone bedrock or sandstone boulders** on ground surface or top of slope or cliff if presented should be removed from site or stabilised as directed by a Geotechnical Engineer.
- We recommend a safety protection fence should be built along rear of excavation to capture rockfall/falling objects that may occur prior to construction.
- Footings on top of cliff/vertical cuts should be minimum 2.0m offset from edge of any cliff line/vertical cuts subject to a geotechnical inspection.
- A Geotechnical Engineer should be engaged to inspect excavations to ensure the foundation bases have suitable materials with adequate bearing capacity and embedment depth if unexpected ground conditions are encountered.
- All stormwater systems, including pipe lines and pits should be founded in stable natural soils with surrounding areas compacted adequately. Erosion control measures should be taken for areas surrounding the stormwater system and slopes.
- Adequate surface drain and subsoil drain should be provided. Inspection and maintenance of batter slopes, erosion control and drainage system should be carried out regularly.
- The design and construction works should be carried out in accordance with Some AGS Guidelines for Hillside Construction in Appendix F.
- Construction activities should be carefully planned and be observed by an experienced Geotechnical Engineer familiar with content of this report for further assessment of the necessary mitigation and control measures.
- Implementation of the above measures should constitute as "Hold Points".

Provided that the above provisions and recommendations in this report are taken into consideration during design and construction, **the level of risk of the overall site instability due to proposed development can be considered to be low and risks for life reduced to normally acceptable levels** in accordance with AGS 2007 (Reference 12).

6.9 Further Geotechnical Investigation

As mentioned in Section 4.2, "At time of investigation, the site was inaccessible by any drilling machines due to constraints in site access and steep sloping ground", therefore, a portable geotechnical investigation was undertaken and involved hand augering of boreholes, DCP tests and visual examination of rock outcrops exposed within the site.

We recommend a detailed geotechnical investigation is necessary and should be carried out following the demolition of existing site structures. The following plan and program should be included in further geotechnical investigation:

- Machine drilling of at least two(2) boreholes up to minimum 2m below bulk excavation level and Class III Sandstone or stronger rock is encountered.
- Installation of a standpipe piezometer to monitor groundwater level if it is encountered during drilling.
- Review of subsurface conditions, in particular, the rock classifications provided in Section 5.2.
- Review and update geotechnical report as appropriate including consideration of review comments from Crozier.
- Progressive inspection of excavation and shoring systems.

7. CONCLUSIONS AND RECOMMENDATIONS

- Results of geotechnical investigation and assessment indicate the ground conditions at this site are suitable for proposed development and associated works.
- We assessed a footing system consisting of **cast-in-situ reinforced concrete shallow foundations** are applicable for proposed development at this site. Piers/piled foundations can be considered for localised areas where depth to top of rock is relatively deep (e.g. >0.8m deep if encountered) during construction. **We recommend the suitable founding materials should be Unit 3 – "Class IV Sandstone" or stronger rock with a minimum 300mm footing embedment for any footing systems adopted.** The footing systems and recommended geotechnical design parameters are provided in Section 6.5.
- The vibration control, including selection of plants, working distances and excavation methodologies are discussed in Section 6.6. We recommend rock saw should be used if excavation encounters medium & high strength sandstone.
- **The excavation should be carried out in a sequence "from middle of excavation towards side boundaries" so as to obtain a reliable ground profile to review excavation shoring and vibration control measures to be adopted.**
- Landslide hazards were identified for this particular site and a qualitative risk assessment was undertaken with landslide risk mitigation measures recommended as provided in Section 6.8.

- The construction, including cut/fill & earthworks, excavations methods, safe excavation batters, **excavation shoring/support measures,** footing systems, retaining walls, drainage works and landslip mitigation and control measures should be implemented in accordance with our recommendations provided in Section 6.
- A Geotechnical Engineer should be engaged to inspect footing excavations to ensure the foundation base have been taken to suitable materials of appropriate bearing capacity and adequate embedment depth/socket length prior to pouring of concrete.
- **We recommend a further geotechnical investigation detailed in Section 6.9 should be carried out immediate following the demolition of site structures.**
- If the recommendations in this report are adopted during design and construction, the construction of proposed development in the short and long terms is expected to have no impacts on the adjoining buildings, roads and public infrastructure.

8. LIMITATIONS

This report should be read in conjunction with the “Limitations of Geotechnical Investigation Statement” attached as Appendix G, which provides important information regarding geotechnical investigation, assessment and reporting. If the actual subsurface conditions exposed during construction vary significantly from those discussed in this report, this report should be reviewed, and the undersigned should be contacted for further advices.

For and on behalf of
ESWNMAN Pty Ltd

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APPENDIX A

SITE LOCATION PLAN

Image source: An architectural drawing prepared by RM Designers.

LEGEND

- 🔴 Approximate Location of Borehole (BH)
- ▲ Approximate Location of Dynamic Cone Penetrometer (DCP) Test
- Approximate Location of Sandstone outcrops

PROJECT: 206 Hudson Parade, Clareville, NSW	**DRAWN BY:** J.L.	ESWNMAN 25 YEARS EXPERIENCE	**CLIENT:** Mr Kevin Xue
PROJECT NO: ESWN-PR-2022-1546	**DATE:** 4th December 2023		**TITLE:** Site Location Plan — FIGURE 1

APPENDIX B

SITE PHOTOGRAPHS

Photograph 1
Dynamic Cone Penetrometer(DCP) Test at DCP1 within rear garden

Photograph 2
DCP test in progress at DCP2 within rear garden

Photograph 3
DCP test at location of DCP3 within rear garden

Photograph 4
DCP test at location of DCP4 within front yard

Photograph 5
Sandstone outcrops exposed along rear stairs

Photograph 6
Sandstone outcrops exposed along rear stairs

Appendix B Site Photographs

APPENDIX C

ENGINGGERING BOREHOLE LOGS AND EXPLANATORY NOTES

BOREHOLE NUMBER BH1

ESWNMAN 25 YEARS EXPERIENCE ESWNMAN Pty Ltd

CLIENT Mr Kevin Xue | **PROJECT NAME** Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2022-1546 | **PROJECT LOCATION** 206 Hudson Parade, Clareville, NSW

DATE STARTED 25/10/22 **COMPLETED** 25/10/22 **R.L. SURFACE** 12.8 **DATUM** m AHD
DRILLING CONTRACTOR ESWNMAN Pty Ltd **SLOPE** 90° **BEARING** ---
EQUIPMENT Hand Auger & DCP Test **HOLE LOCATION** Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm **LOGGED BY** W.L. **CHECKED BY** J.L.
NOTES Rear garden

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered	12.5, 12.0	0.5		SC	Clayey SAND, fine grained, grey, some gravel, moist, poorly compacted.		FILL
			1.0		SC	SAND, medium grained, brown, moist, medium dense.		RESIDUAL SOILS DCP test indicates top of rock below 1.3m depth
		11.5, 11.0	1.5, 2.0			Borehole BH1 terminated at 1.2m		

BOREHOLE NUMBER BH2

ESWNMAN 25 YEARS EXPERIENCE ESWNMAN Pty Ltd

CLIENT Mr Kevin Xue | **PROJECT NAME** Geotechnical Investigation

PROJECT NUMBER ESWN-PR-2022-1546 | **PROJECT LOCATION** 206 Hudson Parade, Clareville, NSW

DATE STARTED 25/10/22 **COMPLETED** 25/10/22 | **R.L. SURFACE** 12.2 | **DATUM** m AHD

DRILLING CONTRACTOR ESWNMAN Pty Ltd | **SLOPE** 90° | **BEARING** ---

EQUIPMENT Hand Auger & DCP Test | **HOLE LOCATION** Refer to Figure 1 Site Location Plan

HOLE SIZE 70mm | **LOGGED BY** W.L. | **CHECKED BY** J.L.

NOTES Rear garden

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered	12.0			SC	Clayey SAND, fine grained, grey, some gravel, moist, poorly compacted.		FILL
		11.5	0.5		SC	Gravelly SAND, fine-medium grained, grey, some sandstone boulder, moist, variable compacted. (Some Colluvium)		
		11.0	1.0		SC	SAND, medium grained, brown, moist, medium dense.		RESIDUAL SOILS DCP test indicates top of rock below 1.5m depth
		10.5	1.5			Borehole BH2 terminated at 1.4m		
			2.0					

ESWNMAN ESWNMAN Pty Ltd
25 YEARS EXPERIENCE

BOREHOLE NUMBER BH3

CLIENT Mr Kevin Xue
PROJECT NAME Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2022-1546
PROJECT LOCATION 206 Hudson Parade, Clareville, NSW

DATE STARTED 25/10/22 **COMPLETED** 25/10/22
R.L. SURFACE 13.5 **DATUM** m AHD
DRILLING CONTRACTOR ESWNMAN Pty Ltd
SLOPE 90° **BEARING** ---
EQUIPMENT Hand Auger & DCP Test
HOLE LOCATION Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm
LOGGED BY W.L. **CHECKED BY** J.L.
NOTES Rear garden

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered				SC	SAND, fine grained, grey, some clay, trace gravel, moist, poorly compacted.		FILL
		13.0	0.5					
					SC	SAND, fine grained, grey, some gravel, moist, fairly compacted.		
		12.5	1.0		SC	SAND, medium grained, brown, moist, medium dense.		RESIDUAL SOILS
					SC	SAND, medium grained, brown, moist, dense & very dense.		DCP test indicates top of rock below 1.5m depth
						Borehole BH3 terminated at 1.4m		
		12.0	1.5					
		11.5	2.0					

BOREHOLE NUMBER BH4

ESWNMAN 25 YEARS EXPERIENCE ESWNMAN Pty Ltd

CLIENT Mr Kevin Xue **PROJECT NAME** Geotechnical Investigation
PROJECT NUMBER ESWN-PR-2022-1546 **PROJECT LOCATION** 206 Hudson Parade, Clareville, NSW

DATE STARTED 25/10/22 **COMPLETED** 25/10/22 **R.L. SURFACE** 18.9 **DATUM** m AHD
DRILLING CONTRACTOR ESWNMAN Pty Ltd **SLOPE** 90° **BEARING** ---
EQUIPMENT Hand Auger & DCP Test **HOLE LOCATION** Refer to Figure 1 Site Location Plan
HOLE SIZE 70mm **LOGGED BY** W.L. **CHECKED BY** J.L.
NOTES Front yard

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA	Not Encountered				SC	Clayey SAND, fine grained, grey, some topsoil near surface, moist, poorly compacted.		FILL
		18.5			SC	Clayey SAND, fine grained, grey, some gravel, trace sandstone boulder, moist, fairly compacted.		
			0.5		SC	SAND, medium grained, brown, moist, medium dense.		RESIDUAL SOILS DCP test indicates top of rock below 0.8m depth
		18.0	1.0			Borehole BH4 terminated at 0.7m		
		17.5	1.5					
		17.0	2.0					

Explanatory Notes – Description for Soil

In engineering terms soil includes every type of uncemented or partially cemented inorganic material found in the ground. In practice, if the material can be remoulded by hand in its field condition or in water it is described as a soil. The dominant soil constituent is given in capital letters, with secondary textures in lower case. The dominant feature is assessed from the Unified Soil Classification system and a soil symbol is used to define a soil layer .

METHOD

Method	Description
AS	Auger Screwing
BH	Backhoe
CT	Cable Tool Rig
EE	Existing Excavation/Cutting
EX	Excavator
HA	Hand Auger
HQ	Diamond Core-63mm
JET	Jetting
NMLC	Diamond Core –52mm
NQ	Diamond Core –47mm
PT	Push Tube
RAB	Rotary Air Blast
RB	Rotary Blade
RT	Rotary Tricone Bit
TC	Auger TC Bit
V	Auger V Bit
WB	Washbore
DT	Diatube

WATER

Water level at date shown

Partial water loss

Water inflow

Complete water loss

NFGWO: The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.

NFGWE: The borehole/test pit was dry soon after excavation. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING

Sample	Description
B	Bulk Disturbed Sample
D	Disturbed Sample
Jar	Jar Sample
SPT	Standard Penetration Test
U50	Undisturbed Sample –50mm
U75	Undisturbed Sample –75mm

UNIFIED SOIL CLASSIFICATION

The appropriate symbols are selected on the result of visual examination, field tests and available laboratory tests, such as, sieve analysis, liquid limit and plasticity index.

USC Symbol	Description
GW	Well graded gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayey gravel
SW	Well graded sand
SP	Poorly graded sand
SM	Silty sand
SC	Clayey sand
ML	Silt of low plasticity
CL	Clay of low plasticity
OL	Organic soil of low plasticity
MH	Silt of high plasticity
CH	Clay of high plasticity
OH	Organic soil of high plasticity
Pt	Peaty Soil

MOISTURE CONDITION

Dry - Cohesive soils are friable or powdery
Cohesionless soil grains are free-running

Moist - Soil feels cool, darkened in colour
Cohesive soils can be moulded
Cohesionless soil grains tend to adhere

Wet - Cohesive soils usually weakened
Free water forms on hands when handling

For cohesive soils the following codes may also be used:

MC>PL Moisture Content greater than the Plastic Limit.
MC~PL Moisture Content near the Plastic Limit.
MC<PL Moisture Content less than the Plastic Limit.

PLASTICITY

The potential for soil to undergo change in volume with moisture change is assessed from its degree of plasticity. The classification of the degree of plasticity in terms of the Liquid Limit (LL) is as follows:

Description of Plasticity	LL (%)
Low	<35
Medium	35 to 50
High	>50

COHESIVE SOILS - CONSISTENCY

The consistency of a cohesive soil is defined by descriptive terminology such as very soft, soft, firm, stiff, very stiff and hard. These terms are assessed by the shear strength of the soil as observed visually, by hand penetrometer values and by resistance to deformation to hand moulding.

A Hand Penetrometer may be used in the field or the laboratory to provide an approximate assessment of the unconfined compressive strength (UCS) of cohesive soils. The undrained shear strength of cohesive soils is approximately half the UCS. The values are recorded in kPa as follows:

Strength	Symbol	Undrained Shear Strength, C_u (kPa)
Very Soft	VS	< 12
Soft	S	12 to 25
Firm	F	25 to 50
Stiff	St	50 to 100
Very Stiff	VSt	100 to 200
Hard	H	> 200

COHESIONLESS SOILS - RELATIVE DENSITY

Relative density terms such as very loose, loose, medium, dense and very dense are used to describe silty and sandy material, and these are usually based on resistance to drilling penetration or the Standard Penetration Test (SPT) 'N' values. Other condition terms, such as friable, powdery or crumbly may also be used.

Term	Symbol	Density Index	N Value (blows/0.3 m)
Very Loose	VL	0 to 15	0 to 4
Loose	L	15 to 35	4 to 10
Medium Dense	MD	35 to 65	10 to 30
Dense	D	65 to 85	30 to 50
Very Dense	VD	>85	>50

COHESIONLESS SOILS PARTICLE SIZE DESCRIPTIVE TERMS

Name	Subdivision	Size
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

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Description for Rock

The rock is described with strength and weathering symbols as shown below. Other features such as bedding and dip angle are given.

METHOD

Refer soil description sheet

WATER

Refer soil description sheet

ROCK QUALITY

The fracture spacing is shown where applicable and the Rock Quality Designation (RQD) or Total Core Recovery (TCR) is given where:

$$TCR\ (\%) = \frac{\text{length of core recovered}}{\text{length of core run}}$$

$$RQD\ (\%) = \frac{\text{Sum of Axial lengths of core > 100mm long}}{\text{length of core run}}$$

ROCK MATERIAL WEATHERING

Rock weathering is described using the abbreviations and definitions used in AS1726. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between (but not including) XW and SW. For projects where it is not practical to delineate between HW and MW or it is deemed that there is no advantage in making such a distinction, DW may be used with the definition given in AS1726.

Symbol	Term	Definition
RS	Residual Soil	Soil definition on extremely weathered rock; the mass structure and substance are no longer evident; there is a large change in volume but the soil has not been significantly transported
XW	Extremely Weathered	Rock is weathered to such an extent that it has 'soil' properties, ie. It either disintegrates or can be remoulded in water
HW	Highly Weathered	The rock substance is affected by weathering to the extent that limonite staining or bleaching affects the whole rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength is usually decreased compared to the fresh rock. The colour and strength of the fresh rock is no longer recognisable.
DW (HW to MW)	*Distinctly Weathered (see AS1726 Definition below)*	
MW	Moderately Weathered	The whole of the rock substance is discoloured, usually by iron staining or bleaching, to the extent that the colour of the fresh rock is no longer recognisable
SW	Slightly Weathered	Rock is slightly discoloured but shows little or no change of strength from fresh rock
FR	Fresh	Rock shows no sign of decomposition or staining

"Distinctly Weathered: Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to the deposition of weathering products in pores." (AS1726)

ROCK STRENGTH

Rock strength is described using AS1726 and ISRM - Commission on Standardisation of Laboratory and Field Tests, "Suggested method of determining the Uniaxial Compressive Strength of Rock materials and the Point Load Index", as follows:

Term	Symbol	Point Load Index $Is_{(50)}$ (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1
High	H	1 to 3
Very High	VH	3 to 10
Extremely High	EH	>10

● Diametral Point Load Index test

■ Axial Point Load Index test

DEFECT SPACING/BEDDING THICKNESS

Measured at right angles to defects of same set or bedding.

Term	Defect Spacing	Bedding
Extremely closely spaced	<6 mm	Thinly Laminated
	6 to 20 mm	Laminated
Very closely spaced	20 to 60 mm	Very Thin
Closely spaced	0.06 to 0.2 m	Thin
Moderately widely spaced	0.2 to 0.6 m	Medium
Widely spaced	0.6 to 2 m	Thick
Very widely spaced	>2 m	Very Thick

DEFECT DESCRIPTION

Type:	Definition:
B	Bedding
BP	Bedding Parting
F	Fault
C	Cleavage
J	Joint
SZ	Shear Zone
CZ	Crushed Zone
DB	Drill Break

Planarity:	Roughness:
P – Planar	R – Rough
Ir – Irregular	S – Smooth
St – Stepped	Sl – Slickensides
U – Undulating	Po – Polished

Coating or Infill:	Description
Clean	No visible coating or infilling
Stain	No visible coating or infilling but surfaces are discoloured by mineral staining
Veneer	A visible coating or infilling of soil or mineral substance but usually unable to be measured (<1mm). If discontinuous over the plane, patchy veneer
Coating	A visible coating or infilling of soil or mineral substance, >1mm thick. Describe composition and thickness

The inclinations of defects are measured from perpendicular to the core axis.

Graphic Symbols for Soil and Rock

Graphic symbols used on borehole and test pit reports for soil and rock are as follows. Combinations of these symbols may be used to indicate mixed materials such as clayey sand.

Soil Symbols

Main Components

- CLAY
- SILT
- SAND
- GRAVEL
- BOULDERS / COBBLES
- PEAT (Organic)

Minor Components

- Clayey
- Silty
- Sandy
- Gravelly

Other Symbols

- TOPSOIL
- FILL
- ASPHALT
- CONCRETE
- NO CORE

Rock Symbols

Sedimentary Rocks

- SANDSTONE
- SILTSTONE
- CLAYSTONE, MUDSTONE
- SHALE
- LAMINITE
- CONGLOMERATE
- BRECCIA
- TILL
- COAL
- LIMESTONE

Igneous Rocks

- PLUTONIC IGNEOUS (eg: Granite)
- VOLCANIC IGNEOUS (eg: Basalt)
- PYROCLASTIC IGNEOUS (eg: Ignimbrite)

Metamorphic Rocks

- SLATE, PHYLLITE, SCHIST
- GNEISS
- QUARTZITE

Engineering classification of shales and sandstones in the Sydney Region - A summary guide

The Sydney Rock Class classification system is based on rock strength, defect spacing and allowable seams as set out below. All three factors must be satisfied.

CLASSIFICATION FOR SANDSTONE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>24	>600	<1.5
II	>12	>600	<3
III	>7	>200	<5
IV	>2	>60	<10
V	>1	N.A.	N.A.

CLASSIFICATION FOR SHALE

Class	Uniaxial Compressive Strength (MPa)	Defect Spacing (mm)	Allowable Seams (%)
I	>16	>600	<2
II	>7	>200	<4
III	>2	>60	<8
IV	>1	>20	<25
V	>1	N.A.	N.A.

1. ROCK STRENGTH

For expedience in field/construction situations the uniaxial (unconfined) compressive strength of the rock is often inferred, or assessed using the point load strength index (Is_{50}) test (AS 4133.4.1 - 1993). For Sydney Basin sedimentary rocks the uniaxial compressive strength is typically about 20 x (Is_{50}) but the multiplier may range from about 10 to 30 depending on the rock type and characteristics. In the absence of UCS tests, the assigned Sydney Rock Class classification may therefore include rock strengths outside the nominated UCS range.

2. DEFECT SPACING

The terms relate to spacing of natural fractures in NMLC, NQ and HQ diamond drill cores and have the following definitions:

Defect Spacing (mm)	Terms Used to Describe Defect Spacing[1]
>2000	Very widely spaced
600 – 2000	Widely spaced
200 – 600	Moderately spaced
60 – 200	Closely spaced
20 – 60	Very closely spaced
<20	Extremely closely spaced

[1]After ISO/CD14689 and ISRM.

3. ALLOWABLE SEAMS

Seams include clay, fragmented, highly weathered or similar zones, usually sub-parallel to the loaded surface. The limits suggested in the tables relate to a defined zone of influence. For pad footings, the zone of influence is defined as 1.5 times the least footing dimension. For socketed footings, the zone includes the length of the socket plus a further depth equal to the width of the footing. For tunnel or excavation assessment purposes the defects are assessed over a length of core of similar characteristics.

Source: Based on Pells, P.J.N, Mostyn, G. and Walker, B.F. (1998) – Foundations on sandstone and shale in the Sydney region. Australian Geomechanics Journal, No 33 Part 3

APPENDIX D

RESULTS OF DYNAMIC CONE PENETROMETER(DCP) TEST

RESULTS OF DYNAMIC CONE /PERTH SAND PENETROMETER TEST

ESWNMAN
25 YEARS EXPERIENCE

Client:	Mr Kevin Xue	Ref No:	ESWN-PR-2022-1546
Project:	Geotechnical Investigation	Date tested:	25/10/2022
Location:	206 Hudson Parade, Clareville, NSW 2107	Tested By:	W.L./J.L.

Depth (mm)	DCP No.				Depth (mm)	DCP No.			
	DCP1	DCP2	DCP3	DCP4		5	6	7	8
0-100	0	0	0	0	0-100				
100-200			1		100-200				
200-300		1		1	200-300				
300-400		1	1	2	300-400				
400-500	1	6	2	2	400-500				
500-600	1	10	1	8	500-600				
600-700	1	3		3	600-700				
700-800	1	2	3	9/70mm	700-800				
800-900	2	6	3	Bounce	800-900				
900-1000	2	6	2		900-1000				
1000-1100	2	10	3		1000-1100				
1100-1200	4	7	9		1100-1200				
1200-1300	16/80mm	5	15		1200-1300				
1300-1400	Bounce	6	14		1300-1400				
1400-1500		5/10mm	8/60mm		1400-1500				
1500-1600		Bounce	Bounce		1500-1600				
1600-1700					1600-1700				
1700-1800					1700-1800				
1800-1900					1800-1900				
1900-2000					1900-2000				
2000-2100					2000-2100				
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2700-2800					2700-2800				
2800-2900					2800-2900				
2900-3000					2900-3000				
3000-3100					3000-3100				
3100-3200					3100-3200				
3200-3300					3200-3300				
3300-3400					3300-3400				
3400-3500					3400-3500				
3500-3600					3500-3600				
3600-3700					3600-3700				
3700-3800					3700-3800				
3800-3900					3800-3900				
3900-4000					3900-4000				
RL (m)	12.8	12.2	13.5	18.9	RL (m)				

Notes:

1. Australian Standard AS 1289.6.3.2 – Determination of the penetration resistance of a soil – 9 kg dynamic cone penetrometer test.
2. Australian Standard AS 1289.6.3.3 – Determination of the penetration resistance of a soil – Perth Sand Penetrometer (PSP) test.

APPENDIX E

RISK ASSESSMENT MATRIX

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}	5×10^{-2}	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	5×10^{-3}	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	5×10^{-4}	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	5×10^{-5}	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	5×10^{-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.

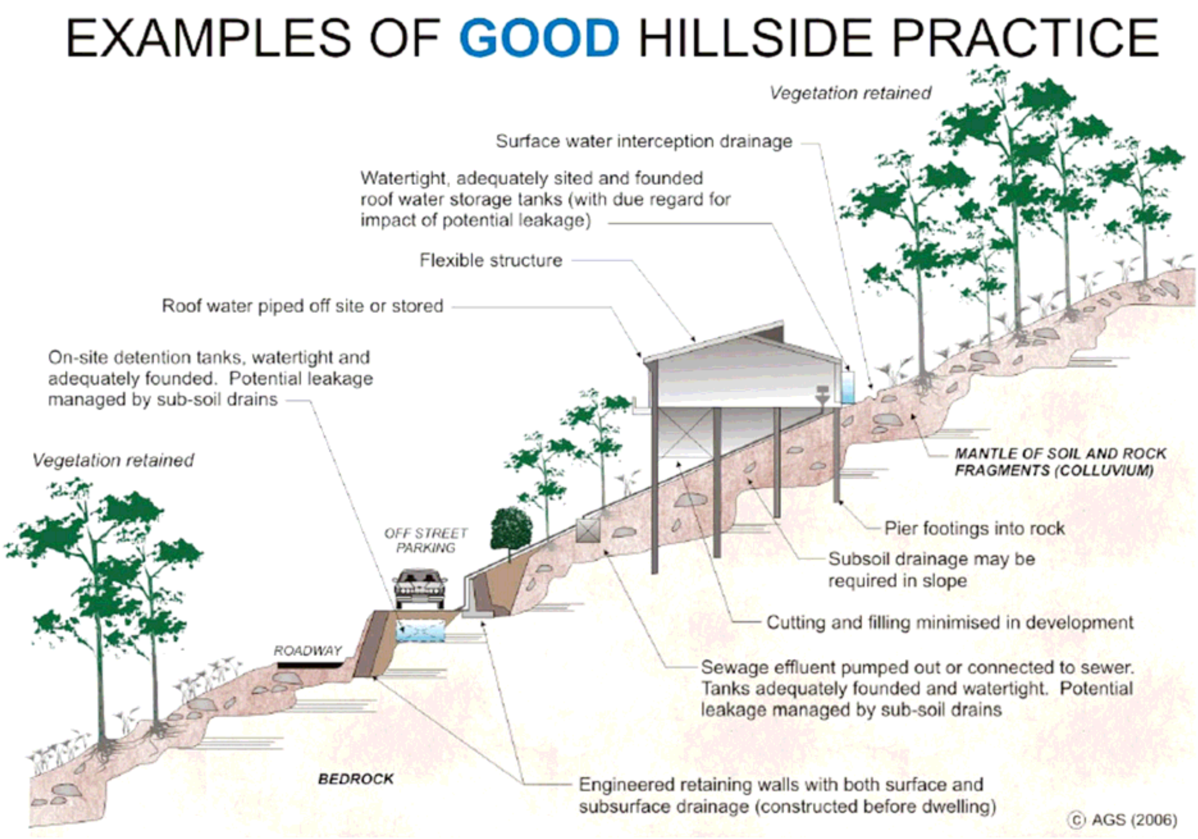
Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

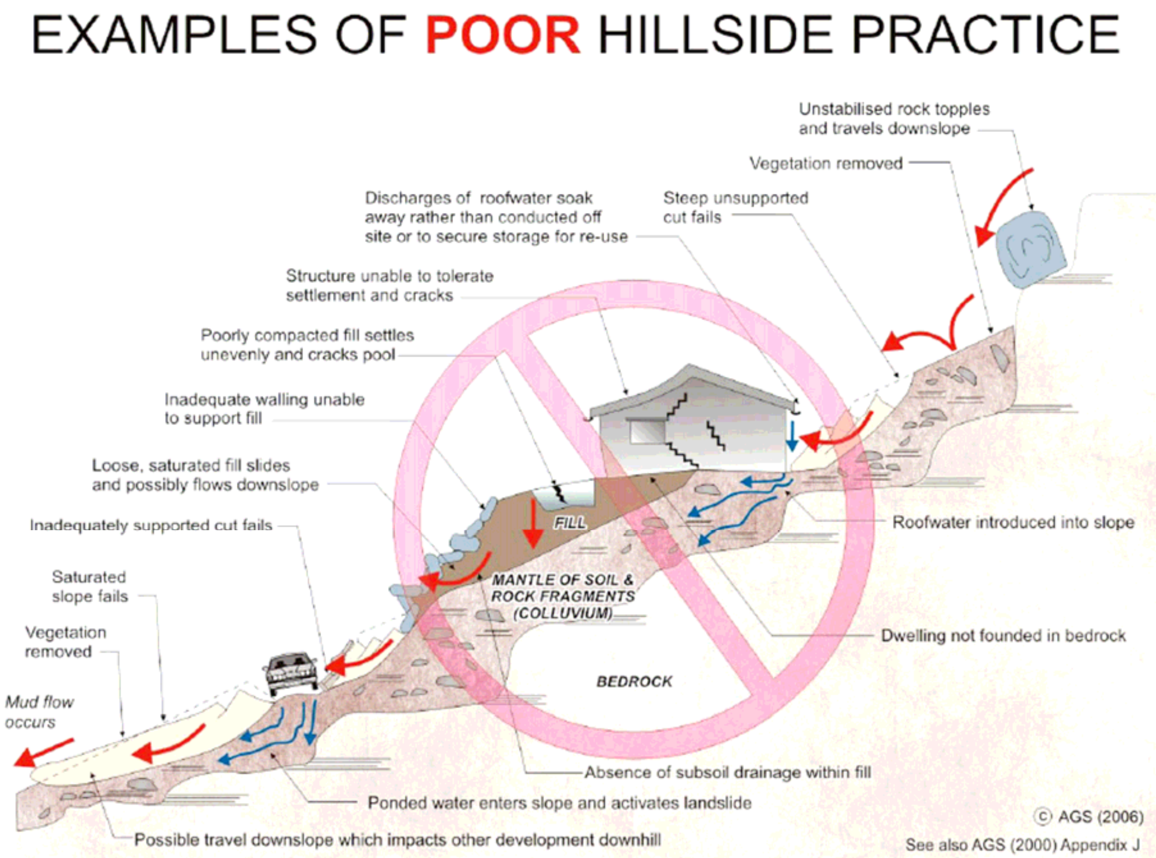
APPENDIX F

SOME AGS GUIDELINES FOR HILLSIDE CONSTRUCTION

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	


EXAMPLES OF GOOD HILLSIDE PRACTICE
Vegetation retained
Surface water interception drainage
Watertight, adequately sited and founded roof water storage tanks (with due regard for impact of potential leakage)
Flexible structure
Roof water piped off site or stored
On-site detention tanks, watertight and adequately founded. Potential leakage managed by sub-soil drains
Vegetation retained
OFF STREET PARKING
ROADWAY
MANTLE OF SOIL AND ROCK FRAGMENTS (COLLUVIUM)
Pier footings into rock
Subsoil drainage may be required in slope
Cutting and filling minimised in development
Sewage effluent pumped out or connected to sewer. Tanks adequately founded and watertight. Potential leakage managed by sub-soil drains
BEDROCK
Engineered retaining walls with both surface and subsurface drainage (constructed before dwelling)
© AGS (2006)


EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
Saturated slope fails
Vegetation removed
Mud flow occurs
FILL
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Roofwater introduced into slope
Dwelling not founded in bedrock
BEDROCK
Absence of subsoil drainage within fill
Ponded water enters slope and activates landslide
Possible travel downslope which impacts other development downhill
© AGS (2006)
See also AGS (2000) Appendix J

APPENDIX G

LIMITATIONS OF GEOTECHNICAL INVESTIGATION

General

In making an assessment of a site from a limited number of boreholes or test pits there is the possibility that variations may occur between testing locations. Site exploration identifies specific subsurface conditions only at those points from which samples have been taken. The risk that variations will not be detected can be reduced by increasing the frequency of testing locations. The investigation program undertaken is a professional estimate of the scope of investigation required to provide a general profile of the subsurface conditions. The data derived from the site investigation program and subsequent laboratory testing are extrapolated across the site to form an inferred geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The borehole/test pit logs are the subjective interpretation of subsurface conditions at a particular location, made by trained personnel. The interpretation may be limited by the method of investigation, and cannot always be definitive.

Subsurface conditions

Subsurface conditions may be modified by changing natural forces or man-made influences. A geotechnical report is based on conditions which existed at the time of subsurface exploration.

Construction operations at or adjacent to the site, and natural events such as rainfall events, floods, or groundwater fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept appraised of any such events, and should be consulted to determine if additional tests are necessary.

Assessment and interpretation

A geotechnical engineer should be retained to work with other appropriate design professionals explaining relevant geotechnical findings and in reviewing the adequacy of their drawings/plans and specifications relative to geotechnical issues.

Information and documentations

Final logs are developed by geotechnical engineers based upon their interpretation of field description and laboratory results of field samples. Customarily, only the final logs are included in geotechnical engineering reports. These logs should not under any circumstances be redrawn for inclusion in architectural or other design drawings. To minimise the likelihood of bore/profile log misinterpretation, contractors should be given access to the complete geotechnical engineering report prepared or authorised for their use. Providing the best available information to contractors helps prevent costly construction problems.

Construction phase service (CPS)

During construction, excavation is frequently undertaken which exposes the actual subsurface conditions. For this reason geotechnical consultants should be retained through the construction stage, to identify variations if they are exposed and to conduct additional tests which may be required and to deal quickly with geotechnical problems if they arise.

Report

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

Other limitations

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