

GEOTECHNICAL INVESTIGATION REPORT

No. 4 Belinda Place Newport, NSW

Prepared for
Mr Simon Dong
C/O RPDC

Reference No. **ESWN-PR-2025-2886**

29th September 2025

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 absorption rate*
- *Finite element analysis(FEA)*



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Date: 29/09/2025

TABLE OF CONTENTS

1. INTRODUCTION	6
1.1 Available Information	6
1.2 Proposed Development	6
1.3 Scope of Work	7
2. SITE DESCRIPTION.....	7
3. LOCAL GEOLOGY	8
4. METHODOLOGY OF INVESTIGATION.....	8
4.1 Pre-fieldwork	8
4.2 Borehole Drilling	8
4.3 Dynamic Cone Penetrometer (DCP) Test	8
4.4 Geological Mapping	9
5. RESULTS OF INVESTIGATION.....	10
5.1 Surface Conditions	10
5.2 Subsurface Conditions	10
5.3 Groundwater	10
6. GEOTECHNICAL ASSESSMENT.....	11
6.1 Site Classifications and Characterisation.....	11
6.2 Excavation Conditions	12
6.3 Stability of Excavation/Safe Excavation Batters	12
6.4 Earth Retaining Structures	14
6.5 Foundations	16
6.6 Excavation Methods & Vibration Control Measures	17
6.7 Earthworks and Material Use	19
6.8 Landslide Risk Assessment and Mitigations	20
6.8.1 General	20
6.8.2 Predevelopment	20
6.8.3 Post-Development	22
6.8.4 Mitigation and Control Measures	23
7. CONCLUSIONS AND RECOMMENDATIONS.....	24
8. LIMITATIONS.....	25

LIST OF TABLES

Table 1 - Subsurface Conditions at Testing Locations	10
Table 2 - Recommended Safe Excavation Batters	13
Table 3 - Preliminary geotechnical Parameters for Retaining Walls	15
Table 4 - Preliminary Coefficients of Lateral Earth Pressure	15
Table 5 - Preliminary Geotechnical Foundation Design Parameters	16
Table 6 - Preliminary Type of Typical Excavation Plant	17
Table 7 - Preliminary Vibration Limits Related to Buffer Distance & Type of Plant	18
Table 8 - Assessed Risk to Property – Predevelopment	21
Table 9 - Assessed Risk to Property – Post-development as per Our Recommendations	22

LIST OF APPENDICES

APPENDIX A	SITE LOCATION PLAN
APPENDIX B	SITE PHOTOGRAPHS
APPENDIX C	ENGINEERING BOREHOLE LOGS AND EXPLANATORY NOTES
APPENDIX D	RESULTS OF DYNAMIC CONE PENETROMETER(DCP) TEST
APPENDIX E	RISK ASSESSMENT MATRIX
APPENDIX F	SOME AGS GUIDELINES FOR HILLSIDFE CONSTRUCTION
APPENDIX G	LIMITATIONS OF GEOETCHNICAL INVESTIGATION

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.
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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_017, 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 Simon Dong c/o Residential Property Development Consultants (RPDC) to undertake a geotechnical investigation for a proposed development at No. 4 Belinda Place, Newport, NSW 2016. The fieldwork was completed on 24th September 2025 by ESWNMAN staff under the supervision of an experienced Geotechnical Engineer.

The purpose of investigation was to assess the feasibility of site in geotechnical prospective for a proposed alteration & addition to an existing dwelling.

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 “Alterations and Additions to Existing House, No. 4 Belinda Place, Newport, NSW 2106” prepared by RPDC, referenced Project No. 2426-048, including drawing nos. A0 to A13 inclusive and dated 8th September 2025.

1.2 Proposed Development

Based on the information provided in Section 1.1, the proposed development will comprise the construction of a single storey addition to the front and rear of existing house.

The design plans indicate variable excavation up to 2.0m deep would be required for proposed addition near the rear corner of existing dwelling. An approximate setback of 0.9m was proposed for proposed addition from site northern boundary.

Other excavation, minor cut/fill and earthworks are likely required include the following:

- Excavations of structural footings for building and retaining walls, such as pad/strip footings and piles;
- Trench excavation for installations of services pipes;
- Foundation/subgrade preparation for pavement/footpath; 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 and visual examination 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 upon completion of fieldwork;
- 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 26.4km to the northeast of Sydney CBD, 810m to the south of Bilgola Plateau Public School and 880m to the west of Newport Beach.

The site is identified as Lot 42 in Deposited Plan (DP)218250, with an approximate area of 847.3m², At time of fieldwork, the site was occupied by a two storey brick house.

Based on the plans provided and our observations during a site walkover, the majority of site was characterised by a steep and very steep sloping ground (38°-42°) towards the east. Some sandstone outcrops and boulders were present on the slopes and retaining walls.

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 Hawkesbury Sandstone (Rh). The Hawkesbury Sandstone is described as “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 augering of boreholes 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 two(2) DCP tests, positioned next to boreholes and identified as DCP1 and DCP2 accordingly, were completed during fieldwork. The DCP tests reached refusal depth and bounce of DCP hammer occurred approximately at 4.5m and 2.1m below existing ground level (BGL) at location of DCP1 and DCP2 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

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 4, 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 plans 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 fieldwork, apart from existing house, a garage, concrete steps, retaining walls and concrete surface, the remainder of outdoor areas was covered with dense grass and vegetation. Some sandstone outcrops and boulders were present on surface of slopes.

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): Clayey SAND, fine-medium grained, grey, some topsoil near surface, some gravel, trace sandstone boulder, some colluvium, mostly 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 V-IV SANDSTONE, medium to coarse grained, brown and light grey, moderately weathered, low and medium strength, based on examination of sandstone outcrops exposed within the site (see Figure 1 attached in Appendix A and Photos, 4, 5 & 6 included in Appendix B) and interpreted results of DCP test. The classification of rock was carried out in accordance with Pells et al (Reference 10).

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
Fill (Unit 1)	Clayey SAND, poorly compacted	0	0
Residual Soils (Unit 2)	Clayey SAND, medium dense & dense	2.3	1.2
Weathered Sandstone (Unit 3)	Class V-IV SANDSTONE, low & medium strength, some high strength	>4.5	>2.1

5.3 Groundwater

No groundwater was encountered during augering of any boreholes. No indicates of water seepage or inflow on faces of retaining walls and toe areas of slopes during a site walkover.

6. GEOTECHNICAL ASSESSMENT

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

- Site classifications and characterisation;
- Excavation conditions;
- Stability of excavation/safe excavation batters;
- Earth retaining structures;
- Foundations;
- Excavation method & vibration control measures;
- Earthworks and material use; and
- **Landslide risk assessment and control measures.**

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

6.1 Site Classifications and Characterisation

(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 Class P due to presence of step and very steep sloping ground within the site with instability/landslip risk. Therefore, 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 geotechnical investigation indicate the presence of fill/colluvium and natural soils, underlain by Class V 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 Newport 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_017, Pittwater Local Environmental Plan 2014 (Reference 14), the site is 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 2.0m deep is required for proposed rear addition and associated retaining walls. Other minor excavation may include the excavation of structural footings for building and retaining walls, such as pad/strip footings and piles, trench excavation for installations of services pipes and landscaping.

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 of proposed development and associated works.**

6.3 Stability of Excavation/Safe Excavation Batters

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

The excavations should be carried out in accordance with the ‘NSW Government: Code of Practice – Excavation Works’ (Reference 9).

Temporary excavations through the underlying soils may be excavated using a safe excavation batters 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/footings;
- 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 or supported by a suitable temporary shoring measure/formworks.

We recommend a permanent safe excavation 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 in rock and soils away from site boundaries greater than 1.0m in depth, the temporary safe batters for excavated slopes in Table 2 below can be adopted:

Table 2 - Recommended Safe Excavation Batters¹

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

Notes:

¹ - Typical temporary batters of excavated slopes (Hoerner, 1990). Assume no surcharge on top of cutting batter and no major adjoining structures. Staged excavation and construction can be adopted.

² – Reinforced shotcrete with drainage, inclined/raking shores/braces/formworks or earth berms/formworks can be considered as temporary support/shoring measures for excavation over short period of time.

Based on proposed setbacks and depth of excavation as mentioned in Section 1.2, we assessed that temporary batters recommended in Table 2 are applicable for proposed excavation associated rear addition near rear corner of existing dwelling.

If excavation using safe excavation batters in Table 2 is not possible or impractical due to some reasons, including inadequate setback proposed or consideration of control lateral ground movement and safe work in front of excavation/cut, the following temporary excavation support/shoring measures **immediate after excavation** can be considered for less critical sections:

- **Reinforced shotcrete** (with adequate drainage) for upper soil profile and fractured/weak rock zones (if encountered); or
- Raking or inclined shores/**formworks** with “Staged” construction method; or
- **Earth berm** in front of shallow cut/excavation.

Other alternative shoring options and additional supports may be considered subject to the on-site assessment and approval by the project Structural and Geotechnical Engineers.

During construction excavation, observations and recording on conditions of exposed faces, safe excavation batters, support/shoring measures adopted should be carried out by a Geotechnical Engineer to determine if any additional shoring measures are required.

A dilapidation survey on adjoining properties and public infrastructure should be undertaken prior to commencement of construction.

With the recommended safe excavation batters, temporary shoring/support measures, and geotechnical inspection, construction of the proposed development and excavation in the short and long terms is expected to have no impacts on existing site structures, adjoining properties, 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 V-IV Sandstone ¹ (Unit 3)	24	100	35	100	0.20

¹ - Classification of the rock in accordance with Pells et al (Reference 10).

Table 4 - Preliminary Coefficients of Lateral Earth Pressure

Geotechnical Unit	Coefficient of Active Lateral Earth Pressure (K _a)	Coefficient of Active Lateral Earth Pressure at Rest (K _o)	Coefficient of Passive Lateral Earth Pressure (K _p)
Fill (Unit 1)	0.33	0.50	3.0
Residual Soils (Unit 2)	0.29	0.46	3.4
Class V-IV Sandstone ¹ (Unit 3)	0.27	0.43	3.7

¹ - Classification of the rock in accordance with Pells et al (Reference 10).

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:

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

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

Where:

$$P_a = \text{Active (or at rest) Earth Pressure (kN/m}^2\text{)}$$

$$P_p = \text{Passive Earth Pressure (kN/m}^2\text{)}$$

$$\gamma = \text{Bulk density (kN/m}^3\text{)}$$

$$K = \text{Coefficient of Earth Pressure (K}_a \text{ or K}_o\text{)}$$

$$K_p = \text{Coefficient of Passive Earth Pressure}$$

$$H = \text{Retained height (m)}$$

$$c = \text{Effective Cohesion (kN/m}^2\text{)}$$

6.5 Foundations

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

Based on proposed development and subsurface conditions, we assessed a footing system consisting of **piers/piles**, founded in Unit 3 – “Class V Sandstone”, are applicable for proposed addition to the front of existing house. Bored piles can be adopted. Due to presence of loose SAND, drilled pile holes typically need to be stabilised using a casing/metal liner.

It is noted that shallow rock is expected for the proposed addition near rear corner of existing house, therefore, **cast-in-situ reinforced concrete shallow foundations**, such as pad or strip footings under columns and walls, can be considered.

We recommend the suitable founding materials should be Unit 3 – “Class V Sandstone” or stronger rock(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 V Sandstone(Unit 3)	500 (Shallow footings/piles) ³	70	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 a Geotechnical Engineer during excavation. Sloping effect considered.

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 or a **geotechnical certificate** is required.

6.6 Excavation Methods & Vibration Control Measures

For this site, the majority of rock excavation will occur during excavation for proposed rear addition and associated retaining wall.

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

Note: * Rock classification to be undertaken by a Geotechnical Engineer in accordance with Pells et al (Reference 10).

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 $\pm 2\%$ 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 located on a land 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 below. 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 4×10^{-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 5×10^{-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.
- We recommend a **safety protection fence** should be built along front boundary and behind existing garage prior to construction so as capture rockfall/falling objects that may occur during construction.
- 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 V 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 sandstone boulders** on ground surface or slope if presented should be removed from site or stabilised as directed by a Geotechnical Engineer.
- **Filter type geofabric should be installed between backfill area of retaining walls and surrounding soils** to avoid soil erosion and prevent fines from entering wall drainage system.
- Footings on top of cliff/vertical cuts should be minimum 2.0m offset from edge of slope/excavation/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).

7. CONCLUSIONS AND RECOMMENDATIONS

- Results of geotechnical investigation and assessment indicate the ground conditions at this site are suitable for proposed alterations & additions and associated works.
- Based on proposed development and subsurface conditions, we assessed a footing system consisting of **piers/piles**, founded in Unit 3 – “Class V Sandstone”, are applicable for proposed addition to the front of existing house. Bored piles can be adopted. Due to presence of loose SAND, drilled pile holes typically need to be stabilised using a casing/metal liner. **Cast-in-situ reinforced concrete shallow foundations** can be considered for proposed addition and retaining wall to the rear of existing house. **We recommend the suitable founding materials should be Unit 3 – “Class V Sandstone” or stronger rock** (instead of a boulder or floater) **with a minimum 300mm footing embedment** for all structures proposed and any footing systems adopted. The details of applicable 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.
- 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. We recommend a **safety protection fence** should be built along front boundary and behind existing garage prior to construction so as capture rockfall/falling objects that may occur during construction.
- The construction, including fill & compaction, earthworks, excavations methods, safe excavation batters, temporary shoring/support measures, footing systems, retaining walls and 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.
- If the recommendations in this report are adopted during design and construction, the construction of proposed development and excavation in the short and long terms is expected to have no impacts on existing site structures, adjoining buildings, site stability, 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

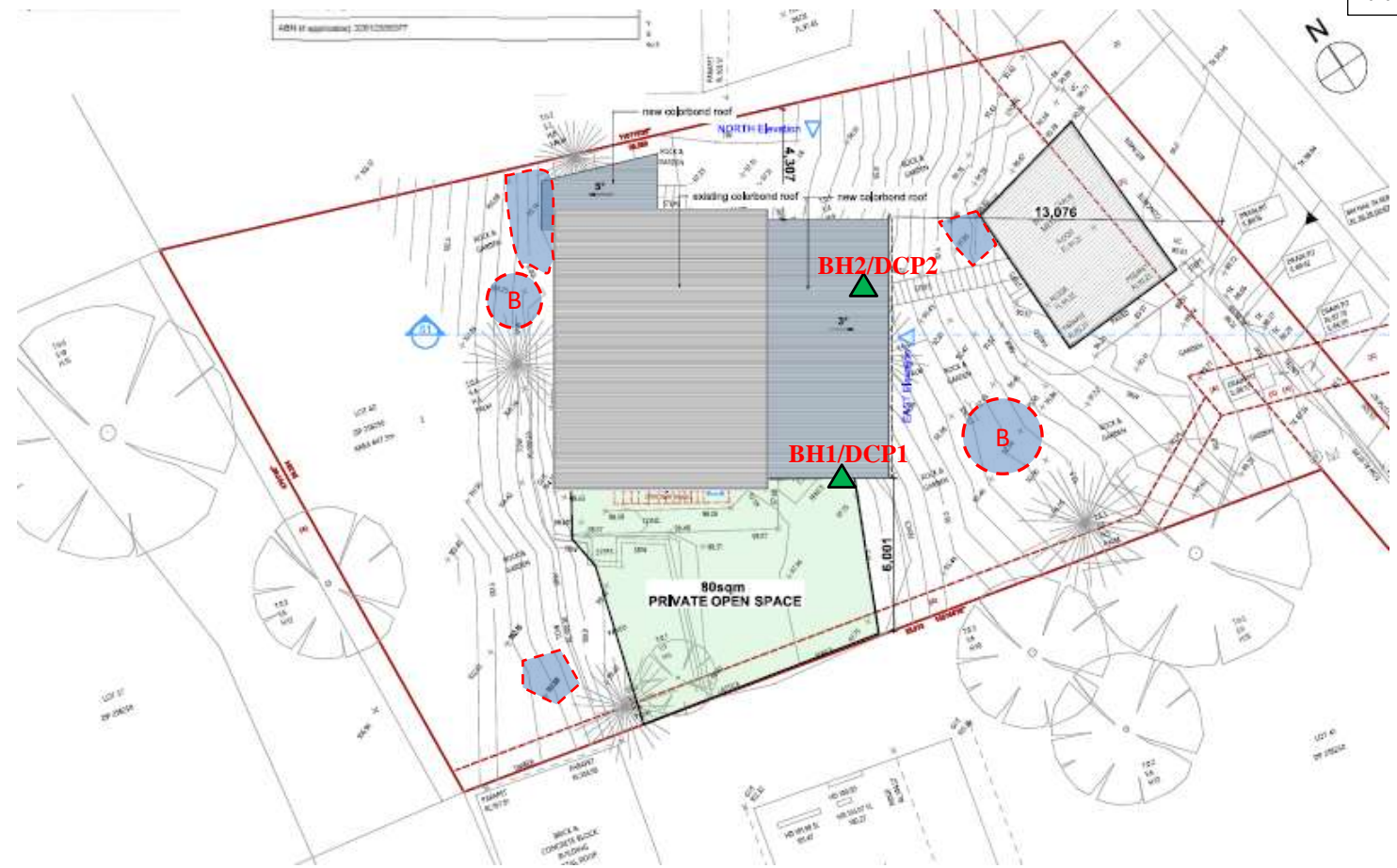


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APPENDIX A


SITE LOCATION PLAN

Image source: An architectural drawing prepared by RPDC.



LEGEND

- ▲ Approximate Location of Dynamic Cone Penetrometer (DCP) Test & Borehole (BH)
- ▭ (blue dashed) Approximate Location of Sandstone outcrops
- (blue dashed with B) Approximate Location of Sandstone Boulder

PROJECT: 4 Belinda Place, Newport, NSW 2016	DRAWN BY: J.L.		CLIENT: Mr Simon Dong
PROJECT NO: ESWN-PR-2025-2996	DATE: 29 th September 2025		TITLE: Site Location Plan

APPENDIX B

SITE PHOTOGRAPHS

29th September 2025

Ref: ESWN-PR-2025-2886 No. 4 Belinda Place, Newport, NSW 2016

Geotechnical Investigation

		
<p>Photograph 1 Dynamic Cone Penetrometer(DCP) Test at DCP1 at middle portion of site</p>	<p>Photograph 2 DCP test in progress at DCP2 within middle portion</p>	<p>Photograph 3 Sandstone boulder exposed on existing slope</p>
		
<p>Photograph 4 Sandstone outcrops exposed at rear garden</p>	<p>Photograph 5 Sandstone outcrops exposed near northern or rear corner of existing dwelling</p>	<p>Photograph 6 Sandstone outcrops exposed near existing garage</p>

Appendix B Site Photographs

APPENDIX C

ENGINEERING BOREHOLE LOGS AND EXPLANATORY NOTES



CLIENT Mr Simon Dong PROJECT NAME Geotechnical Investigation

PROJECT NUMBER ESWN-PR-2025-2886 PROJECT LOCATION No.4 Belinda Place, Newport, NSW 2016

DATE STARTED 24/9/25 COMPLETED 24/9/25 R.L. SURFACE 97.5 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 S.C. CHECKED BY J.L.

NOTES Middle portion

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations	
HA		97.0	0.5		SC	Clayey SAND, fine grained, grey & brown, some gravel, trace boulder, moist, mostly poorly compacted.		FILL	
		96.5	1.0				- encountered sandstone boulder at 1.1m-1.4m depth		
		96.0	1.5						
		95.5	2.0						RESIDUAL SOILS
		95.0	2.5			SC	SAND, medium grained, brown, moist, medium dense.		
		94.5	3.0						
		94.0	3.5						
		93.5	4.0			SC	SAND, medium grained, brown, moist, dense.		
		93.0	4.5			SC	Clayey SAND, medium grained, brown, moist, very dense.		
							Borehole BH1 terminated at 4.5m		DCP test indicates top of rock below 4.5m depth
		92.5	5.0						

BOREHOLE / TEST PIT ESWN-PR-2025-2886 GP.J GINT STD AUSTRALIA.GDT 28/9/25



CLIENT Mr Simon Dong PROJECT NAME Geotechnical Investigation

PROJECT NUMBER ESWN-PR-2025-2886 PROJECT LOCATION No.4 Belinda Place, Newport, NSW 2016

DATE STARTED 24/9/25 COMPLETED 24/9/25 R.L. SURFACE 94.9 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 S.C. CHECKED BY J.L.

NOTES Middle portion

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
HA		94.5	0.5		SC	Clayey SAND, fine grained, grey & brown, some gravel, moist, mostly poorly compacted.		FILL
	Not Encountered	94.0	1.0					
		93.5	1.5		SC	SAND, medium grained, brown, moist, medium dense.		RESIDUAL SOILS
		93.0	2.0		SC	Clayey SAND, medium grained, brown, moist, very dense.		DCP test indicates top of rock below 2.1m depth
						Borehole BH2 terminated at 2.1m		
		92.5	2.5					
		92.0	3.0					

BOREHOLE / TEST PIT ESWN-PR-2025-2886 GP1 GINT STD AUSTRALIA.GDT 28/9/25





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 μ m to 2.36 mm
	medium	200 μ m to 600 μ m
	fine	75 μ m to 200 μ m

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

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

ROCK QUALITY

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

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

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

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.
<i>Distinctly Weathered (see AS1726 Definition below)</i>		
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 I _{s(50)} (MPa)
Extremely Low	EL	<0.03
Very Low	VL	0.03 to 0.1

- 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
Very closely spaced	6 to 20 mm	Laminated
Closely spaced	20 to 60 mm	Very Thin
Moderately widely spaced	0.06 to 0.2 m	Thin
Widely spaced	0.2 to 0.6 m	Medium
Very widely spaced	0.6 to 2 m	Thick
	>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 (I_{s50}) test (AS 4133.4.1 - 1993). For Sydney Basin sedimentary rocks the uniaxial compressive strength is typically about 20 x (I_{s50}) 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

¹After 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



ESWNSMAN
25 YEARS EXPERIENCE

Client:	Mr Simon Dong	Ref No:	ESWN-PR-2025-2886
Project:	Geotechnical Investigation	Date tested:	24/09/2025
Location:	No. 4 Belinda Place, Newport, NSW 2016	Tested By:	S.C./J.L.

Depth (mm)	DCP No.				Depth (mm)	DCP No.			
	DCP1	DCP2	3	4		5	6	7	8
0-100	0	0			0-100				
100-200	1	1			100-200				
200-300	1	2			200-300				
300-400	1	3			300-400				
400-500	2	1			400-500				
500-600	5	1			500-600				
600-700	2	1			600-700				
700-800	3	1			700-800				
800-900	3	1			800-900				
900-1000	3	1			900-1000				
1000-1100	3	2			1000-1100				
1100-1200	8	2			1100-1200				
1200-1300	13	4			1200-1300				
1300-1400	5	5			1300-1400				
1400-1500	3	6			1400-1500				
1500-1600	3	7			1500-1600				
1600-1700	1	12			1600-1700				
1700-1800	1	14			1700-1800				
1800-1900	1	12			1800-1900				
1900-2000	1	20			1900-2000				
2000-2100	1	11/70mm			2000-2100				
2100-2200	2	Bounce			2100-2200				
2200-2300	2				2200-2300				
2300-2400	3				2300-2400				
2400-2500	4				2400-2500				
2500-2600	3				2500-2600				
2600-2700	4				2600-2700				
2700-2800	4				2700-2800				
2800-2900	5				2800-2900				
2900-3000	5				2900-3000				
3000-3100	6				3000-3100				
3100-3200	6				3100-3200				
3200-3300	7				3200-3300				
3300-3400	8				3300-3400				
3400-3500	7				3400-3500				
3500-3600	6				3500-3600				
3600-3700	8				3600-3700				
3700-3800	7				3700-3800				
3800-3900	7				3800-3900				
3900-4000	11				3900-4000				
4000-4100	11				4000-4100				
4100-4200	16				4100-4200				
4200-4300	16				4200-4300				
4300-4400	18				4300-4400				
4400-4500	21				4400-4500				
4500-4600	Bounce				4500-4600				
4600-4700					4600-4700				
4700-4800					4700-4800				
4800-4900					4800-4900				
4900-5000					4900-5000				
RL (m)	97.5	94.9			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

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10 ⁻³	5x10 ⁻³	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10 ⁻⁴	5x10 ⁻⁴	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10 ⁻⁵	5x10 ⁻⁵	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10 ⁻⁶	5x10 ⁻⁶	1,000,000 years	200,000 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%		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%	40%	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%	10%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%	1%	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*

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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.
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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.
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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.

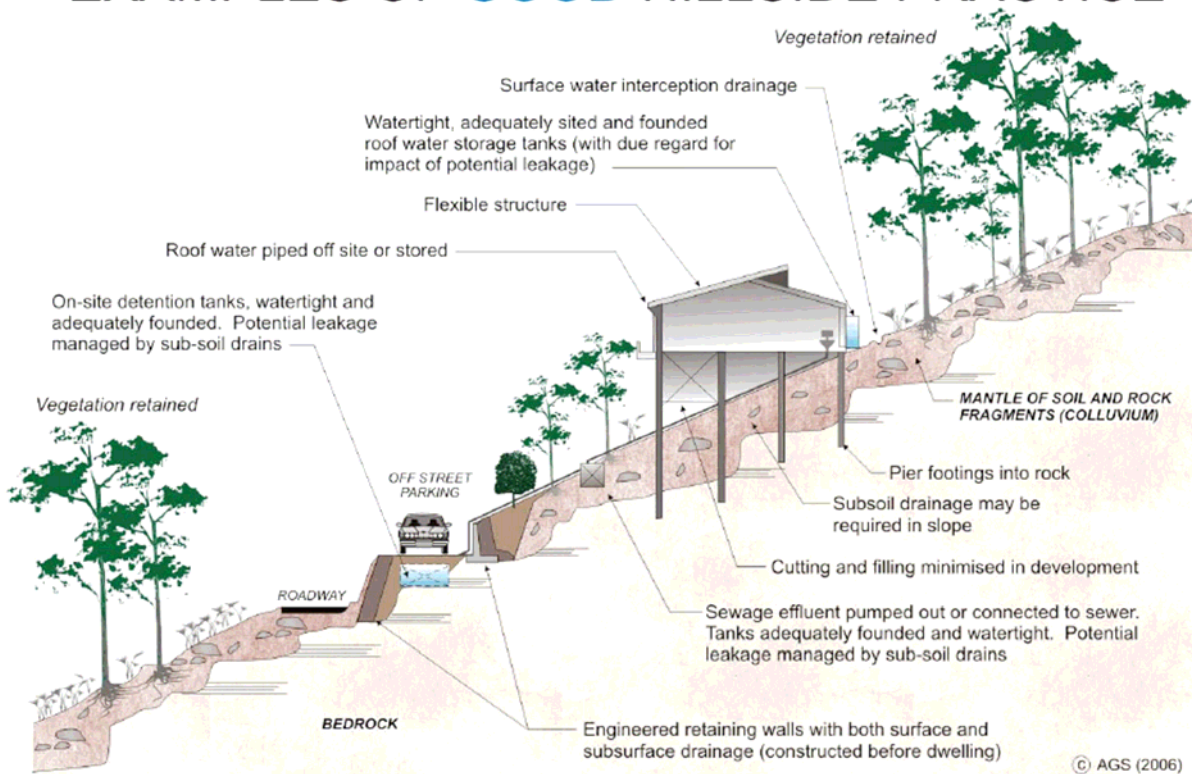
DRAWINGS AND SITE VISITS DURING CONSTRUCTION

DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	

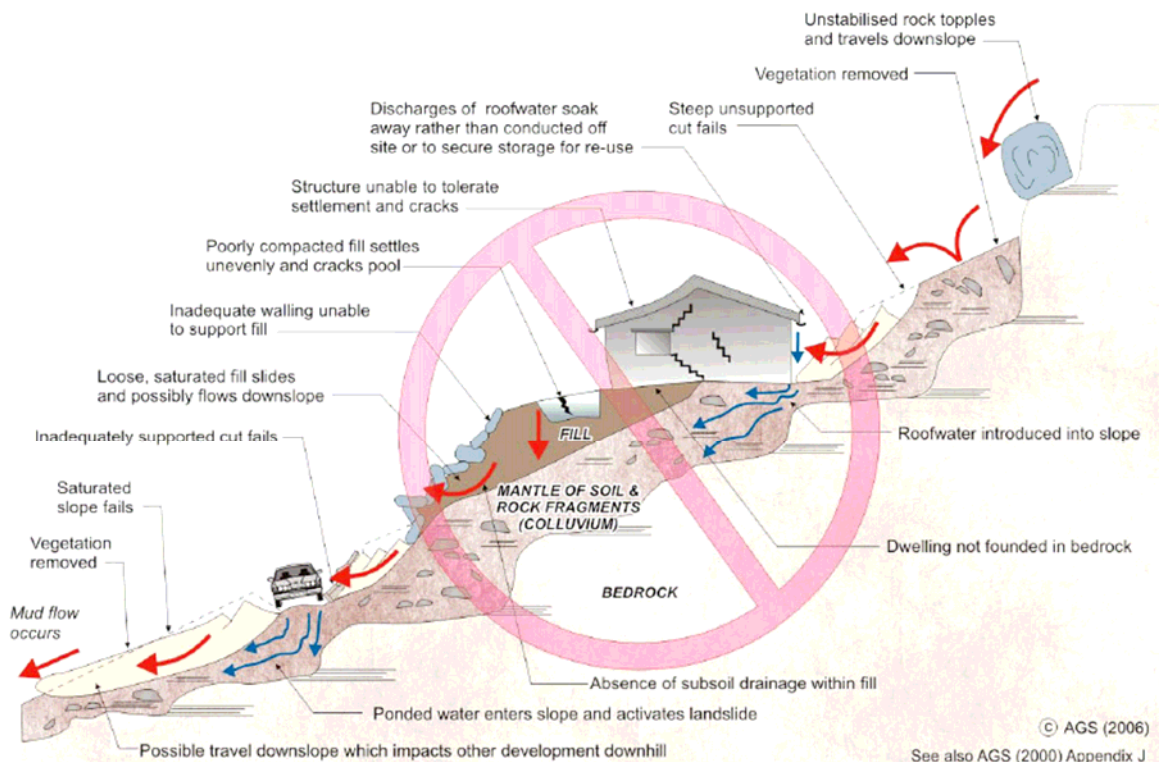
INSPECTION AND MAINTENANCE BY OWNER

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.	
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EXAMPLES OF **GOOD** HILLSIDE PRACTICE



EXAMPLES OF **POOR** HILLSIDE PRACTICE



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 apprised 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.

ESWNMAN does not accept any liability for site conditions not observed during the time of the construction or inspection.

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.