GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

GEOTECHNICAL ASSESSMENT

FOR

PRIME ENGINEERING CONSULTANTS PTY LTD

790A Barrenjoey Road, Palm Beach, New South Wales

Report No: 20/1245

Project No: 30433/3736D-G

April 2020

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1. INTRODUCTION

This report presents the results of a geotechnical assessment carried out by STS Geotechnics Pty Limited (STS) for a proposed secondary dwelling to the constructed at 790A Barrenjoey Road, Palm Beach (Lot 2 in DP838513). The assessment was undertaken at the request of Prime Engineering Consultants Pty Limited.

We understand that DA Approval was granted in 2018 for the construction of a double storey residential dwelling on the southern half of the lot under DA2018/2061, however construction of this dwelling is yet to commence. We understand that a separate DA will now be submitted for the construction of a smaller secondary residential dwelling to be constructed over the northern half of the lot.

The proposed secondary dwelling comprises a double storey structure with plan dimensions of approximately 16 metres by 8 metres. Due to the slope of the site construction of the dwelling will require excavating up to 1.5 metres below the existing ground surface.

Further details of the proposed development are provided in Section 2 of this report.

Further to the above we understand that the site is classified as H1 on the Northern Beaches Council's Geotechnical Hazard Map. As the site contains slopes in excess of 25°, a geotechnical assessment is required by Northern Beaches Council (Pittwater) in accordance with the Geotechnical Risk Management Policy.

The purpose of the investigation was to:

- review available literature for the site,
- assess the surface and subsurface conditions at the site,
- undertake a slope risk assessment of the site in accordance with the Landslide Risk Management guidelines set out by AGS, 2007,
- provide geotechnical recommendations regarding the outcomes of the slope risk assessment, and
- complete relevant council forms for DA Submission.

Our scope of works did not include a contamination assessment of the site.

2. FIELDWORK DETAILS

The fieldwork comprised a detailed site assessment together with the drilling two (2) boreholes numbered BH1 and BH2, at the locations shown on Drawing No. 20/1245. Restricted site access dictated the borehole locations, which were drilled using hand auger equipment. Soil strengths were determined by undertaking Dynamic Cone Penetrometer (DCP) tests at each borehole location.

Fieldwork activities were undertaken by one of STS's Principal Engineering Geologists who also logged the subsurface conditions encountered.

The subsurface conditions observed are recorded on the borehole logs given in Appendix A. An explanation of the terms used on the logs is also given in Appendix A. Notes relating to geotechnical reports are also attached.

3. SITE DESCRIPTION

A summary of the observations made by one of our Principal Engineering Geologists during our site visit on the 24th April 2020 are outlined below. Annotated photographs of the site are attached in Appendix B:

- The site is located on the high side of Barrenjoey Road and has a westerly aspect. The site is located approximately one third up a slope that rises from Barrenjoey Road to Beauty Drive with access via a right of carriageway battle-axe handle. From the road frontage the land surface falls at an average angle of 20 to 25 degrees. There is a cross fall of approximately 10 degrees from north to south across the property.

- The site is roughly rectangular in shape with an area of approximately 1,073m^2. At the time of the inspection the site was vacant except for a small clad shed with metal roof that has been recently constructed in the south west corner of the site.

- The ground surface across the site falls approximately 14 metres to the south from RL32 metres in the northern corner to RL 18 metres in the southern corner.

- At the front of the site is a low height sandstone block retaining wall which appears stable (Photo 1).

- The site has been recently subject to bulk earthworks which includes the construction of a 1.4-metre-high timber retaining wall towards the front of the proposed building platform (Photo 1) and cutting at the rear of the building platform (Photo 2). The retaining wall has been backfilled to create a gently sloping surface. The timber wall appeared stable, however the ground surface behind the wall is uneven with sandstone boulders and concrete blocks exposed within the wall backfill.

- The cutting at the rear of the building platform has exposed the underside of the footings of a low height coppers log retaining wall (Photo 2 and 5) and has also encountered large detached sandstone boulders. To the north of the low height wall are further large detached sandstone boulders.

- The section of slope to the south of the low height wall has been cut near vertical (Photo 6) with a height of approximately 2 metres. The cut face has exposed a colluvial material comprising a sandy clay with sandstone gravels, cobbles and boulders.

- Further up slope of the building platform is a timber post and panel type wall. The wall has a height of approximately 1.5 meters and is tilting down slope (Photo 3).

- Site vegetation comprised grass, shrubs and numerous mature trees. The trees appear near vertical with no evidence of significant bowing at their bases.

- To the north, south, east and west of the site are residential dwellings, like those proposed on the subject site. The adjoining structures have been in place for some time and there is no evidence of movement from landslides.

- There were no signs of active global slope instability noted on the subject site. Any minor slope instability noted on the site is as a result of recent earthworks or the condition of retaining structures.

The conceptual details of the proposed development are shown on the following drawings:

Architectural: David Lamb – Drawing Nos. 1 to 10 Inclusive, Dated November 2019, Revised 27th March 2020

The secondary dwelling comprises a double level residence with a suspended deck at the front. The finished floor level of the ground floor is shown as RL 23.84 meters and will comprise a concrete slab. The finished floor level of the first floor is shown as RL26.69 metres, and we expect it will be fully suspended timber construction. A series of terraced cuts are shown the rear of the site with terrace heights of up to 1.5 metres.

We understand that the construction of the terraces at the rear of the site will likely require the removal of the low height coppers log wall at the rear, however it is not clear from the drawings if the recently constructed wall at the front of the site will remain.

At the time of preparing this report STS were also provided with the following Geotechnical Report that was submitted to accompany DA2018/2061:

- Risk Analysis & Management for Proposed New Residence at 790A Barrenjoey Road, Palm Beach, Prepared by Jack Hodgson Consultants Pty Limited, Reference MT 31628, Dated 12th December 2018.

4. GEOLOGY AND SUBSURFACE CONDITIONS

The Sydney geological series sheet 9130 at a scale of 1:100,000 indicates that the site is underlain be interbedded sandstones, siltstones and shales of the Newport Formation of the upper Narrabeen Group. The Narrabeen Group Rocks are Late Permian to Middle Triassic in age with the early rocks not outcropping in the area under discussion.

The materials from which the rocks were formed consist of gravels, coarse to fine sands, silts and clays. They were deposited in a riverine type environment with larger floods causing fans of finer materials. The direction of deposition changed during the period of formation. The lower beds are very variable with the variations decreasing as the Junction with the Hawkesbury Sandstone is approached. This is marked by the highest persistent shale beds over thicker sandstone beds which are similar in composition to the Hawkesbury Sandstones shale beds.

Based on the subsurface conditions observed in the boreholes and the site observations, the site is likely to be underlain by shallow colluvial soils overlying sandstone and shale bedrock belonging to the Newport Formation.

Localised fill materials comprising a gravelly sandy clay are also expected to be encountered behind retaining walls, in particular the recently constructed wall at the front of the site. The fill encountered behind the wall at the front of the site appears poorly compacted and contains oversize materials. The maximum depth of fill is likely to be in the order of 1.5 metres

The natural soils below the site comprise a firm to stiff becoming very stiff colluvial clayey soil. The colluvial soils include sandstone gravels, cobbles and boulders. Based on the results of the DCP testing the depth of colluvial soils is likely to be up to 1.5 metres over parts of the site.

The sandstone bedrock exposed on the site is interpreted to be detached boulders within a colluvial matrix rather than in-situ sandstone bedrock.

The site is well drained with no natural water courses on the property. A drainage easement enters the north east corner of the block and then runs down the block to the street drainage system. No groundwater seepage was observed on the site.

5. LANDSLIDE RISK ASSESSMENT

5.1. Introduction

A landslide risk assessment has been undertaken for Lot 2, 790A Barrenjoey Road, Palm Beach. It is not technically feasible to assess the stability of a particular site in absolute terms such as stable or unstable, and it must be recognised by the reader that all sites have a risk of land sliding, however small. However, a risk assessment can be undertaken by the recognition of surface features supplemented by limited information on the regional and local subsurface profile, and with the benefit of experience gained in similar geological environments.

Natural hill slopes are formed by processes that reflect the site geology, environment and climate. These processes include down slope movement of the near surface soil and rock. In geological time all slopes are ‘unstable’. The area of influence of these down slope movements may range from local to regional and are rarely related to property boundaries. The natural processes may be affected by human intervention in the form of construction, drainage, fill placement and other activities.

5.2. Purpose of the Assessment

The purpose of this assessment is to enable the owner, potential owner or other parties interested in the site in question, to be aware of the level of risk associated with potential slope movements within the property, and within the area immediately surrounding the property. The risk is assessed considering the existing development of the property and proposed developments of which we have been informed of and which are summarised in this report.

The onus is on the owner, potential owner or other party to decide whether the level of risk presented in this report is acceptable in the light of the possible economic consequence of such risk.

5.3. Risk Assessment Methodology

The risk assessment in this report is based on the guidelines on Landslide Risk Management (LRM) as presented in the Australian Geomechanics publication, Volume 42, Number 1, dated March 2007. This issue presents a series of LRM guidelines and further understanding on the application of the risk assessments for the recommended use by all practitioners nationwide.

Definition of the terms used in this report with respect to the slope risk assessment and management are given in Attachment 2.

It must be accepted that the risks associated with hillside construction are greater than construction on level ground in the same geological environment. The impact of development may be adverse, and imprudent construction techniques can increase the potential for movement. Areas of instability rarely respect property boundaries and poor practices on one property can trigger instability in the surrounding area.

5.4. Hazard Identification

A landslide is defined as "the movement of a mass of rock, debris or earth down a slope". Apart from ground subsidence and collapse, this definition is open to the movement of material types including rock, earth and debris down slope. The causes of landslides can be complex. However, two common factors include the occurrence of a failure of part of the soil or rock material on a slope and the resulting movement is driven by gravity. The actual motion of a landslide is subdivided into the five kinematically distinctive types of material movement including fall, topple, slide, spread, and flow. For further information regarding types of landslides please refer to Appendix B – Landslide Terminology from Australian Geomechanics Practice Note Guidelines For Landslide Risk Management 2007.

The frequency of landslides are difficult to quantify and typically dependant on the inter-relationship between the factors influencing the stability of the slope. Some of the common factors affecting the stability of slopes include the weather (prolonged rainfall with water percolating into rock mass defects can cause washout of fines and reduction of rock mass strength), land development, vegetation removal, changes in drainage and earthquakes. One or a combination of these conditions could result in a landslide failure event. Table 4.1 below outlines the landslide hazards that have been identified Lot 2, 790A Barrenjoey Road, Palm Beach:

A) Hazards Above The site: Nil

B) Hazards Below The Site: Nil

C) Hazards Beside the Site: Nil.

D) Hazards On the Site: See Table 5.1 Below

Table 5.1: Landslide Hazard Identification – On The Site

Hazard Description	Estimated Volume (m^3)	Justification
Failure of the tiling wall up-slope of the proposed dwelling (H1)	5	The existing wall is tilting and showing signs of distress. The wall is located directly above the proposed secondary dwelling.
Failure of the recently constructed retaining wall at the front of the proposed dwelling (H2)	10	The existing wall appears stable, however the fill placed behind the wall has not been compacted during placement. Any movement or failure of this wall could have significant consequences not only for down slope receptors, but also any structures that may be supported by the retaining wall backfill.
Failure of a cut slope including toppling of boulders (H3)	5	The cut slopes at the rear of the proposed secondary dwelling have been constructed near vertical. There is evidence of minor embankment instability and the cuts have exposed the base of the foundations for a low height wall. The slopes are also supporting large detached boulders.
Deep Landslide (H4)	100	The slope rises from the west at an average angle of some 20 to 25 degrees. Slopes formed at these angles can be susceptible to deep seated landslide movements, however no evidence of significant slope instability was identified at the time of our inspection.

5.5. Risk Assessment to Property

Risk to property has been estimated by assessing the likelihood of an event and the consequences if such an event takes place. The relationship between likelihood, consequence and risk is determined by a risk matrix. The risk categories and implications are shown in Attachment 3 (taken from Practice Note Guidelines for Landslide Risk Management 2007, Appendix C). The terms used in risk assessments as defined in the above paper are presented in Attachment 1 (reproduced from AGS 2007 Appendix A).

The assessment process involved the following:

- Risk estimation (comparative analysis of likelihood of a slope failure versus consequence of the failure).
- Evaluation of the estimated (assessed) risk by comparing against acceptance criteria.

The following factors observed during the site walkover were taken into consideration when undertaking the slope risk assessment:

- Topography: The site comprises steeply sloping land over most of the site.
- Geology: The sub-surface soils is expected to comprise minor amounts of topsoil, and colluvial material overlying residual soils and weathered sandstone bedrock. Sandstone outcrops were identified on the site. Fill materials will be encountered behind retaining walls.
- Drainage: The site in general is reasonably drained. There were no signs of severe erosion across the site at the time of the inspection.
- Slope stability: There were no signs of active global slope instability noted during the site walkover.

Based on the above factors and site observations, an assessment of risk to property have been carried out as shown in Table 5.2 below:

Table 5.2: Risk to Property

Hazard		H1	H2	H3	H4
Likelihood	Descriptor	Likely	Possible	Possible	Rare
	Approximate Annual Probability	1×10^{-2}	1×10^{-3}	$1x\ 10^{-3}$	$1x\ 10^{-5}$
Consequence		Minor	Medium	Medium	Major
Risk Category		Moderate	Moderate	Moderate	Low

The assessed risk to property is assessed to be Moderate to Low risk. Based on the information provided by the AGS and presented in Attachment 1, the implications for a risk level of Moderate is that it 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. Treatment options to reduce the risk to Low are discussed in Section 6 of this report.

5.6. Risk Assessment to Loss of Life

A risk assessment for the loss of life was undertaken for the identified geotechnical hazards for the site. The risk assessment and management process adopted for this study was carried out in general accordance with AGS (2007a).

In accordance with the AGS 2007 Landslide Risk Management Guidelines for loss of life, the individual risk for loss of life can be calculated from:

$$R_{(LoL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$$

Where

- $R_{(LoL)}$ is the risk - annual probability of loss of life (death) - of an individual.
- $P_{(H)}$ is the annual probability of the landslide.
- $P_{(S:H)}$ is the probability of spatial impact of the landslide impacting on a location potentially occupied by a person.
- $P_{(T:S)}$ is the temporal spatial probability (e.g. of the location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide occurrence.
- $V_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact).

In accordance with AGS 2007, the regulator should set risk acceptance criteria. In this case, Northern Beaches Council is the regulator, and requires the risk to life post development to be 'Tolerable' for existing areas of residential subdivision, provided risk control measures are put in place to control the risk

The risk acceptance criteria consider the occurrence of the potential geotechnical hazards identified for the site and evaluate the risk against a Tolerable Risk Criteria for loss of life. In this instance, the individual risk is accepted due to being tolerable or risk mitigation measures are undertaken to reduce the risk to more tolerable levels.

The AGS 2007 guidelines indicate that the regulator, with assistance from the practitioner where required, is the appropriate authority to set the standards for risk relating to perceived safety in relation to other risks and government policy. The importance of the implementation of levels of the tolerable risk should not be understated due to the wide ranging implications, both in terms of the relative risks or safety to the community and the potential economic impact to the community. The

AGS provide recommendations in relation to tolerable risk for loss of life as shown below in the table.

Table 5.3 : Suggested Tolerable Risk for Loss of Life by AGS

Situation	Suggested Tolerable Loss of Life Risk for Person Most at Risk
Existing Slope (1) / Existing Development (2)	10^{-4}/annum
New Constructed Slope (3) / New Development (4) / Existing Landslide	10^{-5}/annum

Notes:

1. "Existing Slopes" in this context are slopes that are not part of a recognisable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.

2. "Existing Development" includes existing structures, and slopes that have been modified by cut and fill, that are not located on or part of a recognisable landslide and have demonstrated non-failure performance over at least several seasons or events of extended adverse weather, usually being a period of at least 10 to 20 years.

3. "New Constructed Slope" includes any change to existing slopes by cut or fill or changes to existing slopes by new stabilisation works (including replacement of existing retaining walls or replacement of existing stabilisation measures, such as rock bolts or catch fences).

4. "New Development" includes any new structure or change to an existing slope or structure. Where changes to an existing structure or slope result in any cut or fill of less than 1.0m vertical height from the toe to the crest and this change does not increase the risk, then the Existing Slope/Existing Structure criterion may be adopted. Where changes to an existing structure do not increase the building footprint or do not result in an overall change in footing loads, then the Existing Development criterion may be adopted.

5. "Existing Landslides" have been considered likely to require remedial works and hence would become a New Constructed Slope and require the lower risk. Even where remedial works are not required per se, it would be reasonable expectation of the public for a known landslide to be assessed to the lower risk category as a matter of "public safety".

The future development at 790A Barrenjoey Road must be considered a New Development. The AGS risk threshold provided in Table 4.3 for new developments suggests the 'Tolerable Loss of Life for the person most at risk' is 10^{-5} per annum.

The risk assessment has been based on observations made during the site visit by an experienced geotechnical engineer, and by reviewing available geotechnical data and the future geotechnical requirements for development as outlined elsewhere in this report. Departures from the recommendations in this report may change the quantification of the hazard risk. A risk assessment has been carried out for the identified geotechnical hazards and is presented in Section 5.5 of this report.

The annual probability of a failure occurring has been calculated based on engineering judgement and observations made during the site visit. The probability of spatial impact is calculated by dividing the size of the estimated landslide by the size of the building area which is approximately 160m^2.

The temporal spatial probability has been calculated based on the assumption that someone will be present in the house for 16 hours a day. This is then divided by the number of hours in a day. The vulnerability of an individual is based on values from Australian Geomechanics Vol. 42. If visitor numbers to the site were to increase, then this would change the risk to loss of life. This could affect whether the risk is considered tolerable or otherwise.

Any changes to the site will affect the risk assessment outcome, making it necessary to carry out the risk assessment again.

From our quantitative risk to life assessment we have estimated the annual probability of risk to life to be in order of the range of 1.0 x 10^{-5} to 2.0 x 10^{-7}. These values are considered tolerable using the AGS risk acceptance criteria.

6. GEOTECHNICAL RECOMMENDATIONS

6.1. Excavation Conditions and Retaining Wall Design

Any development on the site should follow good hillside building practices (refer to Attachment 4 for some examples).

The colluvial soils present on site will be very sensitive changes in slope conditions (i.e. cuts and fills). Based on the site observations it appears that the bulk earthworks required for construction of the secondary dwelling have been partially completed, and that only minor further excavation of the rear face will be required.

The further excavation works will likely result in the removal of the existing low height coppers log retaining wall and will also provide an opportunity to address the management of the cut slopes identified as Hazard 3.

The excavation works are expected to encounter minor topsoil and colluvial soils that may include large sandstone boulders or possibly in-situ sandstone bedrock. Access to the site is restricted and therefore we have assumed that the excavations works will be undertaken using small tracked excavators. Small excavators fitted with a toothed bucket attachment should be capable of removing the colluvial soils, however some form of assistance will likely be required to remove any in-situ sandstone bedrock or to break up any boulders before they can be removed using an excavator. Typically, either rock hammers or rock saws are used in these scenarios.

Given the distance of the proposed excavations from adjacent structures the risk of damage from ground vibrations generated during rock hammering are considered to be low. However, excavations methods should be adopted which limit ground vibrations at the adjoining structures to not more than 10 mm/sec. Vibration monitoring will be required to verify that this is achieved.

Temporary slopes in the colluvial soils should be limited to 1H:1V. Steeper slopes may be possible in sandstone bedrock subject to inspections by a geotechnical engineer during construction. The excavation works should be undertaken in accordance with NSW Government Code of Practice Excavation Work Dated January 2020.

It is strongly recommended that an experienced engineering geologist or geotechnical engineer observes the excavation as it progresses. At that time, they will be able to recommend any support that is required for either temporary or permanent conditions and help to finalise the design of the final cut slopes and any retaining walls that may be required.

All loosened rocks should either be stabilised or removed from the sides of the excavation as it proceeds. If floaters are encountered care will be required as they can often be sizeable in this geological environment, appearing to be part of the "solid" rock profile.

Due to the colluvial nature of the soils we strongly recommend that all cut slopes be supported in the long term by an engineer designed retaining wall.

Retaining wall design parameters for the various materials are provided in Table 6.1 below:

Table 6.1: Retaining Wall Design Parameters

Material Type	Active Earth Pressure Co-efficient (K_a)	Earth Pressure Co-efficient at Rest (K_o)	Passive Earth Pressure Co-efficient (K_p)	Bulk Unit Weight (kN/m^3)
Stiff Cohesive (Clayey) Soils & Compacted Fill	0.4	0.6	2.5	19
Sandstone Bedrock	Uniform pressure of 10 kPa		4.5	22

As with all retaining walls, the above coefficient must be adjusted for ground surface slope, groundwater and external loads, such as buildings and vehicles.

Surface water diversion drains must be constructed at the crest of any slopes including cut or fill batters and retaining walls.

Fill behind retaining walls should be non-plastic granular material placed in horizontal layers no greater than 250 mm and compacted to a density ratio at least 95% of Standard Maximum Dry Density. Fill should be progressively 'benched into' the slope with benches 250mm in height (i.e. one bench per layer).

All roof water not stored for reuse and surface runoff should be piped to a stormwater easement downslope of the property. Onsite disposal of stormwater via onsite 'soak in' pits or the like are not recommended on the basis of increased risk of landslide and reactive clay movement. Subsoil drainage is recommended on the upslope side of slab on ground structures to limit the potential for seepage to affect the structure.

To address Hazard 1, it is recommended that the tilting timber post and panel retaining wall at the rear of the site either be stabilised, or preferably demolished and re-constructed.

At the time of writing this report it was not known if the recently constructed retaining wall at the front of the site (Hazard 2) is to remain, or if it will be demolished as part of the bulk earthworks. If the wall is to remain then it is recommended that independent engineering certification for the wall be obtained. Further, the backfill of the wall appears poorly compacted, and therefore under no circumstances should footings be constructed within these backfill materials.

6.2. Site Classification to AS2870-2011

The classification has been prepared in accordance with the guidelines set out in the "Residential Slabs and Footings" Code, AS2870 – 2011.

Because there are trees present, abnormal moisture conditions (AMC) prevail at the site (Refer to Section 1.3.3 of AS2870).

Because of the AMC and fill present together with the slope of the site, the site is classified a ***Problem site (P).*** However, provided the recommendations given below are adopted and the footings bear in the underlying natural colluvial soils, the site may be reclassified as ***Moderately Reactive (M).***

6.3. Foundation Design

As it is possible that footings will be founded in talus/colluvial soil materials, any buildings must be articulated or flexible to allow for some ground movement. Given the slope of the site and the presence of colluvial talus soils, brick masonry construction is not recommended for the site.

Under no circumstances should structural loads be founded within topsoil or uncontrolled fill materials. Further, no structural loads should be founded within the zone of influence of the recently constructed retaining wall at the front of the site (Hazard 2).

Pad and/or strip footings founded in natural stiff colluvial materials below the topsoil or fill, may be proportioned using an allowable bearing pressure of 100 kPa. The minimum depth of founding must comply with the requirements of AS2870. In order to overcome the presence of trees, the foundations are to be designed in accordance with Appendices H and CH of AS2870.

Should a higher bearing pressure be required then piles can be used. Piles will also be required in the areas of deep fill. Piles that bear on weathered sandstone bedrock may be proportioned using an allowable end bearing pressure of 600 kPa. An allowable adhesion of 60 kPa may be adopted for the portion of the shaft within the weathered rock. When piles bear on weathered rock, adhesion in the overlying soils must be ignored. Care should be undertaken during pile installation to ensure that the piles are founded on in-situ sandstone bedrock, and not a detached boulder within a colluvial matrix.

In order to ensure the bearing values given can be achieved, care should be taken to ensure the base of the excavations are free of all loose material prior to concreting. To this end, it is recommended that all excavations be concreted as soon as possible, preferably immediately after excavating, cleaning, inspecting and approval. Pile excavations should not be left open overnight. The possibility of groundwater inflow needs to be considered when drilling the piers and pouring concrete.

7. FINAL COMMENTS

Based on the observations made during the site walkover and the risk assessment undertaken, it has been determined that the risk level of slope instability on this site is moderate, however recommendations have been provided in Section 6 of this report to reduce the risk.

The site is considered suitable for residential development provided good hillside building practices are followed and the recommendations of this report are incorporated into the design and construction of the development. There are no geotechnical constraints for the proposed development of the site; however, preceding sections of this report provide some advice that shall be taken into consideration and applied to any future development.

Provided the recommendations given in this report, in particular the construction of footings, monitoring and inspection of cut slopes, retaining wall construction and surface drainage are incorporated into the design and construction of the project the risk to property would become at least low.

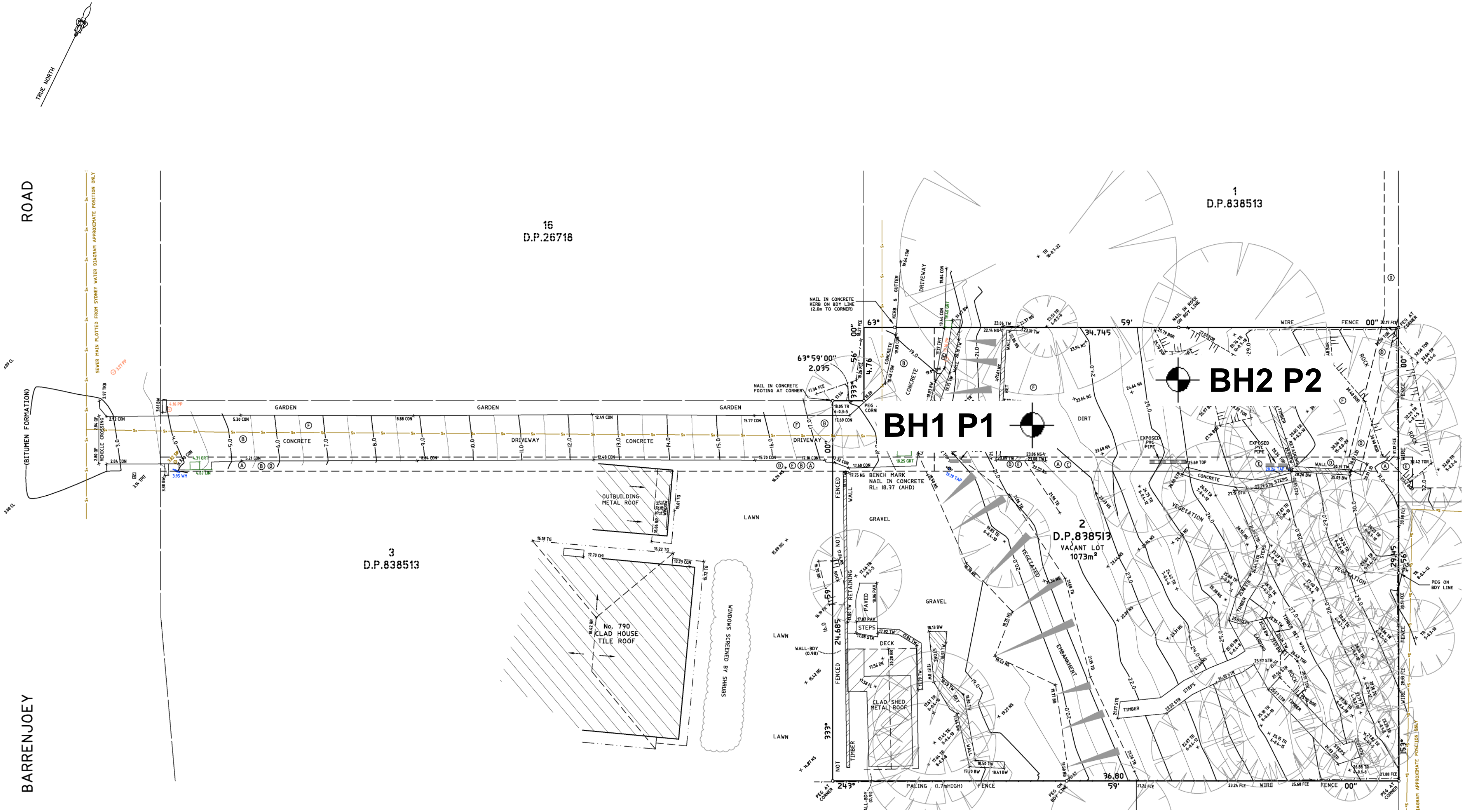
The conclusions and outcomes of this assessment are subject to the subsequent inspection of bulk earthworks, exposed cut faces and footings by this organisation. These inspections will also be required to facilitate completion of relevant forms for issue of construction certificate in accordance with council guidelines.

During construction, should the subsurface conditions vary from those inferred above, we would be contacted to determine if any changes should be made to our recommendations.

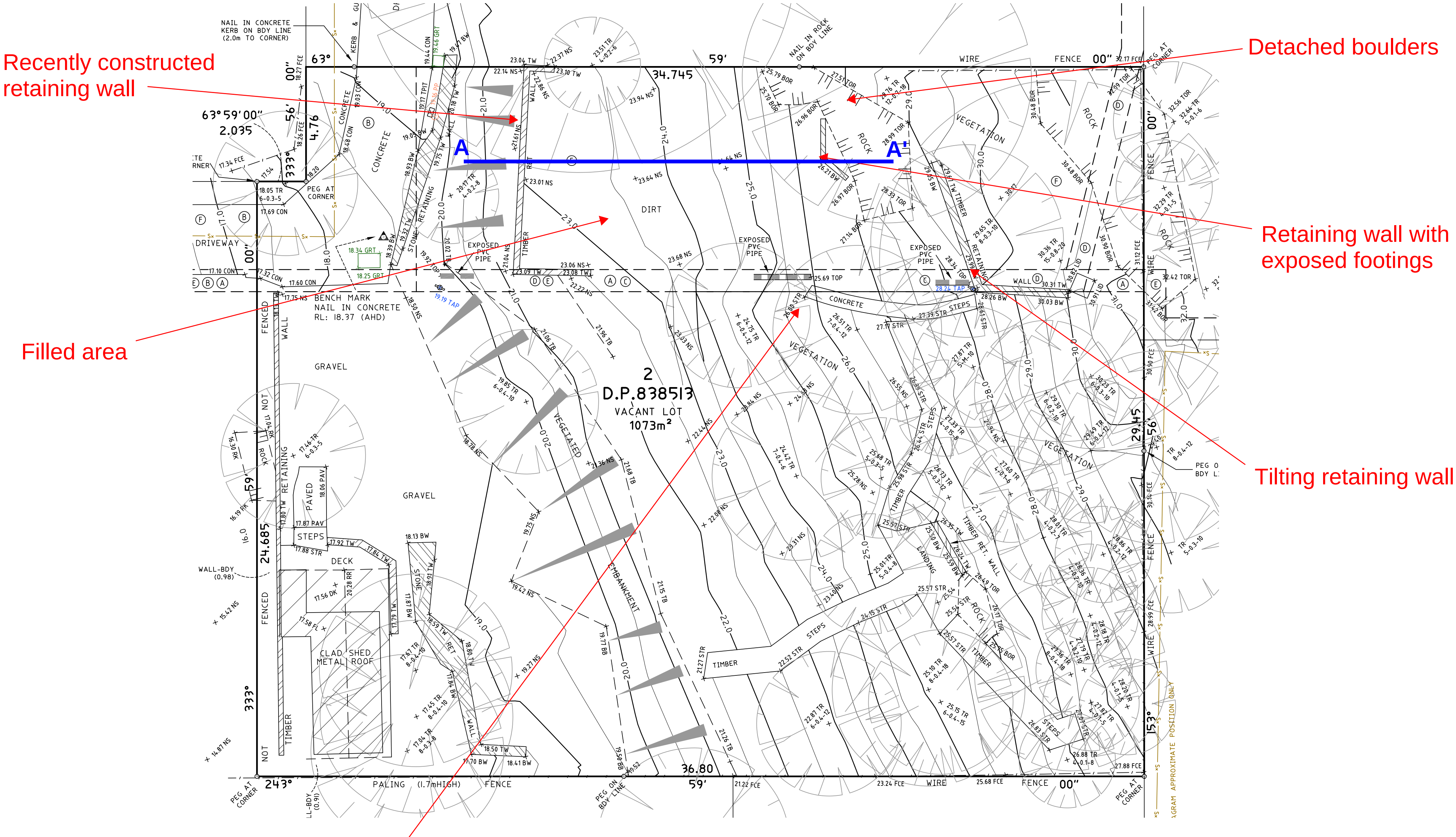
At the completion of earthworks and construction, a final inspection of the site will be required for issue of occupation certificate.

The exposed bearing surfaces for footings should be inspected by a geotechnical engineer to ensure the allowable pressure given has been achieved.

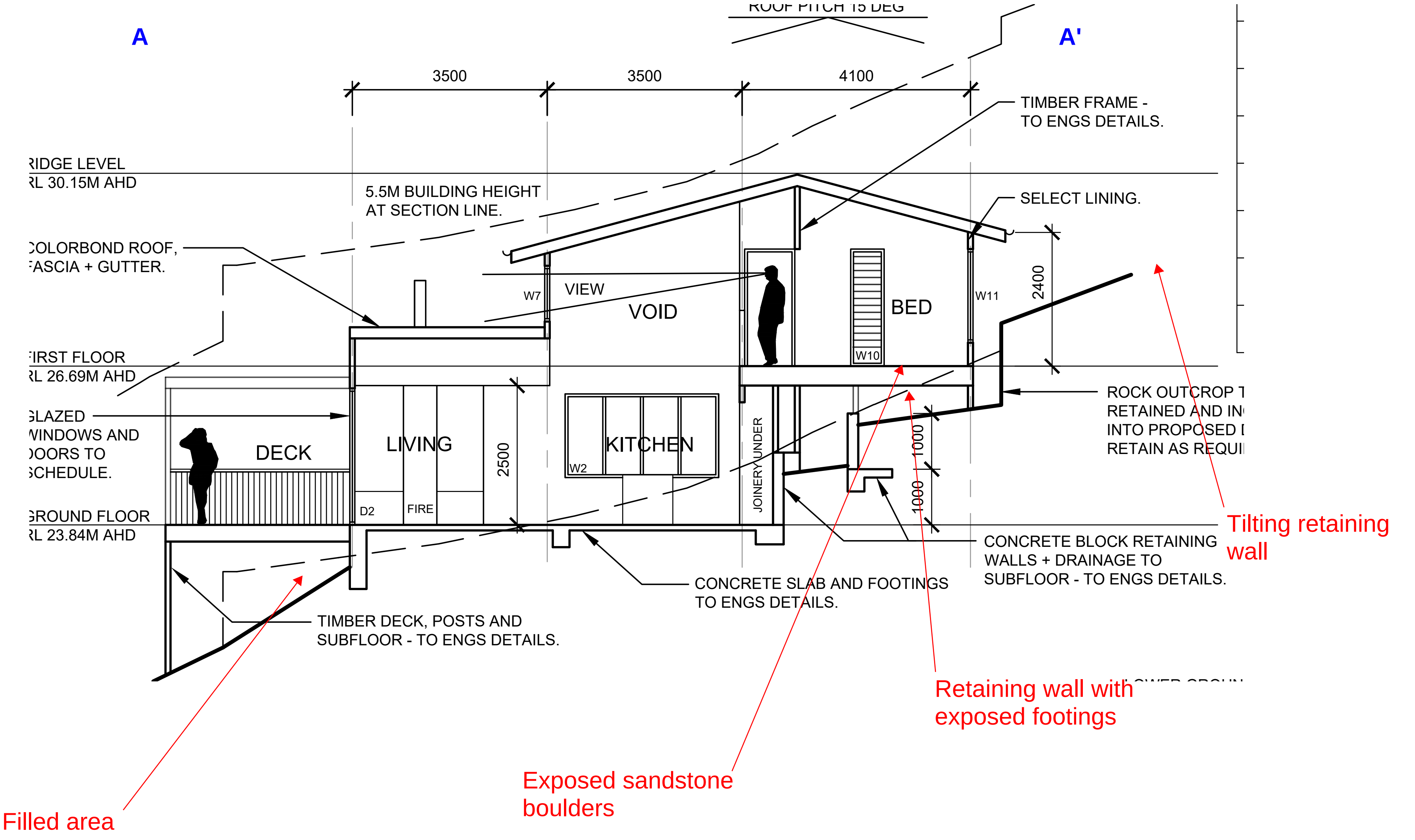
Matthew Green
Principal Engineering Geologist



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: April 2020
Client: PRIME ENGINEERING CONSULTANTS PTY LIMITED		
GEOTECHNICAL ASSESSMENT 790A BARRENJOEY ROAD, PALM BEACH BOREHOLE AND PENETROMETER LOCATIONS		Project No. 30433/3736D-G Drawing No: 20/1245



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: April 2020
Client: PRIME ENGINEERING CONSULTANTS PTY LIMITED		
GEOTECHNICAL ASSESSMENT **790A BARRENJOEY ROAD, PALM BEACH** **ANNOTATED SITE PLAN**		Project No. 30433/3736D-G Drawing No: 20/1245A



STS Geotechnics Pty. Ltd.	Scale: Unknown	Date: April 2020
Client: PRIME ENGINEERING CONSULTANTS PTY LIMITED		
GEOTECHNICAL ASSESSMENT **790A BARRENJOEY ROAD, PALM BEACH** **CROSS SECTION A-A**		Project No. 30433/3736D-G Drawing No: 20/1245B

NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

These notes have been provided to outline the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

When copies of reports are made, they should be reproduced in full.

Geotechnical Reports

Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work and is supplemented by knowledge of the local geology and experience of the range of properties that may be exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (eg. design of a three-storey building), the information and interpretation may not be appropriate if the design is changed (eg. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by STS Geotechnics Pty Limited in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, STS Geotechnics Pty Limited would be pleased to resolve the matter through further investigation, analysis or advice.

Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, STS Geotechnics Pty Limited should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

Subsurface Information

Logs of a borehole, recovered core, test pit, excavated face or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling and/or observation spacings and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume or material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements outside of specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localised perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures mask or prevent groundwater inflow.

The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

Supply of Geotechnical Information or Tendering Purposes

It is recommended tenderers are provided with as much geological and geotechnical information that is available and that where there are uncertainties regarding the ground conditions, prospective tenders should be provided with comments discussing the range of likely conditions in addition to the investigation data.

APPENDIX A – BOREHOLE LOGS & EXPLAINATION SHEETS

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Prime Engineering Consultants Pty Limited	Project / STS No. 30433/3736D-G		**BOREHOLE NO.:** **BH 1**
Project: 790A Barrenjoey Road, Palm Beach	Date: April 24, 2020		
Location: Refer to Drawing No. 20/1245	Logged: MG	Checked By: RM	Sheet 1 of 1

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
N/E			FILL: GRAVELLY SANDY CLAY: grey brown to orange brown, low plasticity, fine to coarse grained with sandstone gravel	CL	SOFT	M
		0.5	HAND AUGER REFUSAL AT 0.5 M ON WHAT APPEARS TO BE A BOULDER WITHIN THE FILL		SOFT	
		1.0				
					VERY STIFF	
		1.5				
		2.0				
		2.5				

D - disturbed sample	U - undisturbed tube sample	B - bulk sample	Contractor: STS
WT - level of water table or free water		N - Standard Penetration Test (SPT)	Equipment: Hand Auger
S - jar sample			Hole Diameter (mm): 62
NOTES:	See explanation sheets for meaning of all descriptive terms and symbols		Angle from Vertical (^{o}): 0
			Drill Bit: Mild Steel

STS Geotechnics Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Prime Engineering Consultants Pty Limited	Project / STS No. 30433/3736D-G		**BOREHOLE NO.: BH 2**
Project: 790A Barrenjoey Road, Palm Beach	Date: April 24, 2020		
Location: Refer to Drawing No. 20/1245	Logged: MG	Checked By: RM	Sheet 1 of 1

WATER TABLE	SAMPLES	DEPTH (m)	DESCRIPTION OF DRILLED PRODUCT (Soil type, colour, grain size, plasticity, minor components, observations)	SYMBOL	CONSISTENCY (cohesive soils) or RELATIVE DENSITY (sands and gravels)	MOISTURE
			FILL: GRAVELLY SANDY CLAY: grey brown, low plasticity, fine to coarse grained	CL	SOFT	M
N/E			SILTY SANDY CLAY: orange brown, low plasticity, sandstone cobbles and boulders (colluvial)	CL	FIRM TO STIFF	D-M
			HAND AUGER REFUSAL ON SANDSTONE FLOATER AT TWO LOCATIONS AT 0.25 M		FIRM TO STIFF	
		0.5			STIFF	
					VERY STIFF	
		1.0				
		1.5				
		2.0				
		2.5				

D - disturbed sample	U - undisturbed tube sample	B - bulk sample	Contractor: STS
WT - level of water table or free water		N - Standard Penetration Test (SPT)	Equipment: Hand Auger
S - jar sample			Hole Diameter (mm): 62
NOTES:	See explanation sheets for meaning of all descriptive terms and symbols		Angle from Vertical (^{o}): 0
			Drill Bit: Mild Steel

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

Dynamic Cone Penetrometer Test Report

Project: 790A BARRENJOEY ROAD, PALM BEACH — Project No.: 30433/3736D
Client: PRIME ENGINEERING CONSULTANTS PTY LIMITED — Report No.: 20/1245
Address: 2G Auburn Road, Auburn — Report Date: April 27, 2020
Test Method: AS 1289.6.3.2 — Page: 1 of 1

Accredited for compliance with ISO/IEC 17025 - Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards
NATA Accreditation Number 2750

Site No.	P1	P2				
Location	Refer to Drawing No. 20/1245	Refer to Drawing No. 20/1245				
Date Tested	24/4/2020	24/4/2020				
Starting Level	Surface Level	Surface Level				
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	1	1				
0.15 - 0.30	2	3				
0.30 - 0.45	1	7				
0.45 - 0.60	1	4				
0.60 - 0.75	2	8				
0.75 - 0.90	2	>25				
0.90 - 1.05	3	Bouncing				
1.05 - 1.20	7					
1.20 - 1.35	>25					
1.35 - 1.50	Bouncing					
1.50 - 1.65						
1.65 - 1.80						
1.80 - 1.95						
1.95 - 2.10						
2.10 - 2.25						
2.25 - 2.40						
2.40 - 2.55						
2.55 - 2.70						
2.70 - 2.85						
2.85 - 3.00						
3.00 - 3.15						
3.15 - 3.30						
3.30 - 3.45						
3.45 - 3.60						
3.60 - 3.75						

Remarks: * Pre drilled prior to testing

Approved Signatory...
Technician: MG — Orlando Mendoza - Laboratory Manager

E1. CLASSIFICATION OF SOILS

E1.1 Soil Classification and the Unified System

An assessment of the site conditions usually includes an appraisal of the data available by combining values of engineering properties obtained by the site investigation with descriptions, from visual observation of the materials present on site.

The system used by STS Geotechnics Pty Ltd (STS) in the identification of soil is the Unified Soil Classification system (USC) which was developed by the US Army Corps of Engineers during World War II and has since gained international acceptance and has been adopted in its metricated form by the Standards Association of Australia.

The Australian Site Investigation Code (AS1726-1981, Appendix D) recommends that the description of a soil includes the USC group symbols which are an integral component of the system.

The soil description should contain the following information in order:

Soil composition

- SOIL NAME and USC classification symbol (IN BLOCK LETTERS)
- plasticity or particle characteristics
- colour
- secondary and minor constituents (name estimated proportion, plasticity or particle characteristics, colour

Soil condition

- moisture condition
- consistency or density index

Soil structure

- structure (zoning, defects, cementing)

Soil origin

interpretation based on observation eg FILL, TOPSOIL, RESIDUAL, ALLUVIUM.

E1.2 Soil Composition

(a) Soil Name and Classification Symbol

The USC system is summarised in Figure E1.2.1. The primary division separates soil types on the basis of particle size into:

- Coarse grained soils - more than 50% of the material less than 60 mm is larger than 0.06 mm (60 µm).
- Fine grained soils - more than 50% of the material less than 60 mm is smaller than 0.06 mm (60 µm).

Initial classification is by particle size as shown in Table E1.2.1. Further classification of fine grained soils is based on plasticity.

TABLE E1.2.1 - CLASSIFICATION BY PARTICLE SIZE

NAME	SUB-DIVISION	SIZE
Clay (1)		< 2 µm
Silt (2)		2 µm to 60 µm
Sand	Fine Medium Coarse	60 µm to 200 µm 200 µm to 600 µm 600 µm to 2 mm
Gravel (3)	Fine Medium Coarse	2 mm to 6 mm 6 mm to 20 mm 20 mm to 60 mm
Cobbles (3)		60 mm to 200 mm
Boulders (3)		> 200 mm

Where a soil contains an appropriate amount of secondary material, the name includes each of the secondary components (greater than 12%) in increasing order of significance, eg sandy silty clay.

Minor components of a soil are included in the description by means of the terms “some” and “trace” as defined in Table E1.2.2.

TABLE E1.2.2 - MINOR SOIL COMPONENTS

TERM	DESCRIPTION	APPROXIMATE PROPORTION (%)
Trace	presence just detectable, little or no influence on soil properties	0-5
Some	presence easily detectable, little influence on soil properties	5-12

The USC group symbols should be included with each soil description as shown in Table E1.2.3

TABLE E1.2.3 - SOIL GROUP SYMBOLS

SOIL TYPE	PREFIX
Gravel	G
Sand	S
Silt	M
Clay	C
Organic	O
Peat	Pt

The group symbols are combined with qualifiers which indicate grading, plasticity or secondary components as shown on Table E1.2.4

TABLE E1.2.4 - SOIL GROUP QUALIFIERS

SUBGROUP	SUFFIX
Well graded	W
Poorly Graded	P
Silty	M
Clayey	C
Liquid Limit <50% - low to medium plasticity	L
Liquid Limit >50% - medium to high plasticity	H

(b) Grading

"Well graded"	Good representation of all particle sizes from the largest to the smallest.
"Poorly graded"	One or more intermediate sizes poorly represented
"Gap graded"	One or more intermediate sizes absent
"Uniformly graded"	Essentially single size material.

(c) Particle shape and texture

The shape and surface texture of the coarse grained particles should be described.

Angularity may be expressed as "rounded", "sub-rounded", "sub-angular" or "angular".

Particle **form** can be "equidimensional", "flat" or elongate".

Surface texture can be "glassy", "smooth", "rough", pitted" or striated".

(d) Colour

The colour of the soil should be described in the moist condition using simple terms such as:

Black	White	Grey	Red
Brown	Orange	Yellow	Green
Blue			

These may be modified as necessary by "light" or "dark". Borderline colours may be described as a combination of two colours, eg red-brown.

For soils that contain more than one colour terms such as:

- Speckled Very small (<10 mm dia) patches
- Mottled Irregular
- Blotched Large irregular (>75 mm dia)
- Streaked Randomly oriented streaks

(e) Minor Components

Secondary and minor components should be individually described in a similar manner to the dominant component.

E1.3 ***S****oil Condition*

(a) Moisture

Soil moisture condition is described as "dry", "moist" or "wet".

The moisture categories are defined as:
Dry (D) - Little or no moisture evident. Soils are running.
Moist (M) - Darkened in colour with cool feel. Granular soil particles tend to adhere. No free water evident upon remoulding of cohesive soils.

In addition the moisture content of cohesive soils can be estimated in relation to their liquid or plastic limit.

(b) Consistency

Estimates of the consistency of a clay or silt soil may be made from manual examination, hand penetrometer test, SPT results or from laboratory tests to determine undrained shear or unconfined compressive strengths. The classification of consistency is defined in Table E1.3.1.

TABLE E1.3.1 - CONSISTENCY OF FINE-GRAINED SOILS

TERM	UNCONFINED STRENGTH (kPa)	FIELD IDENTIFICATION
Very Soft	<25	Easily penetrated by fist. Sample exudes between fingers when squeezed in the fist.
Soft	25 - 50	Easily moulded in fingers. Easily penetrated 50 mm by thumb.
Firm	50 - 100	Can be moulded by strong pressure in the fingers. Penetrated only with great effort.
Stiff	100 - 200	Cannot be moulded in fingers. Indented by thumb but penetrated only with great effort.
Very Stiff	200 - 400	Very tough. Difficult to cut with knife. Readily indented with thumb nail.
Hard	>400	Brittle, can just be scratched with thumb nail. Tends to break into fragments.

Unconfined compressive strength as derived by a hand penetrometer can be taken as approximately double the undrained shear strength ($q_u = 2\ c_u$).

(c) Density Index

The insitu density index of granular soils can be assessed from the results of SPT or cone penetrometer tests. Density index should not be estimated visually.

TABLE E1.3.2 - DENSITY OF GRANULAR SOILS

TERM	SPT N VALUE	STATIC CONE VALUE q_c (MPa)	DENSITY INDEX (%)
Very Loose	0 - 3	0 - 2	0 - 15
Loose	3 - 8	2 - 5	15 - 35
Medium Dense	8 - 25	5 - 15	35 - 65
Dense	25 - 42	15 - 20	65 - 85
Very Dense	>42	>20	>85

E1.4 Soil Structure

(a) Zoning

A sample may consist of several zones differing in colour, grain size or other properties. Terms to classify these zones are:

Layer - continuous across exposure or sample
Lens - discontinuous with lenticular shape
Pocket - irregular inclusion
Each zone should be described, their distinguishing features, and the nature of the interzone boundaries.

(b) Defects

Defects which are present in the sample can include:

- fissures
- roots (containing organic matter)
- tubes (hollow)
- casts (infilled)

Defects should be described giving details of dimensions and frequency. Fissure orientation, planarity, surface condition and infilling should be noted. If there is a tendency to break into blocks, block dimensions should be recorded

E1.5 Soil Origin

Information which may be interpretative but which may contribute to the usefulness of the material description should be included. The most common interpreted feature is the origin of the soil. The assessment of the probable origin is based on the soil material description, soil structure and its relationship to other soil and rock materials.

Common terms used are:

“Residual Soil” - Material which appears to have been derived by weathering from the underlying rock. There is no evidence of transport.

“Colluvium” - Material which appears to have been transported from its original location. The method of movement is usually the combination of gravity and erosion.

“Landslide Debris” - An extreme form of colluvium where the soil has been transported by mass movement. The material is obviously distributed and contains distinct defects related to the slope failure.

“Alluvium” - Material which has been transported essentially by water. usually associated with former stream activity.

“Fill” - Material which has been transported and placed by man. This can range from natural soils which have been placed in a controlled manner in engineering construction to dumped waste material. A description of the constituents should include an assessment of the method of placement.

E1.6 Fine Grained Soils

The physical properties of fine grained soils are dominated by silts and clays.

The definition of clay and silt soils is governed by their Atterberg Limits. Clay soils are characterised by the properties of cohesion and plasticity with cohesion defines as the ability to deform without rupture. Silts exhibit cohesion but have low plasticity or are non-plastic.

The field characteristics of clay soils include:

- dry lumps have appreciable dry strength and cannot be powdered
- volume changes occur with moisture content variation
- feels smooth when moist with a greasy appearance when cut.

The field characteristics of silt soils include:

- dry lumps have negligible dry strength and can be powdered easily
- dilatancy - an increase in volume due to shearing - is indicted by the presence of a shiny film of water after a hand sample is shaken. The water disappears upon remoulding. Very fine grained sands may also exhibit dilatancy.
- low plasticity index
- feels gritty to the teeth

E1.7 Organic Soils

Organic soils are distinguished from other soils by their appreciable content of vegetable matter, usually derived from plant remains.

The soil usually has a distinctive smell and low bulk density.

The USC system uses the symbol Pt for partly decomposed organic material. The O symbol is combined with suffixes “O” or “H” depending on plasticity.

Where roots or root fibres are present their frequency and the depth to which they are encountered should be recorded. The presence of roots or root fibres does not necessarily mean the material is an “organic material” by classification.

Coal and lignite should be described as such and not simply as organic matter.

APPENDIX B – SITE PHOTOGRAPHS

PROJECT: 790A BARRENJOEY ROAD, PALM BEACH
PROJECT No: 30433/3736D-G
REPORT No: 20/1245
TITLE: PHOTO 1 - FRONT OF SITE

Recently construvted retaining wall

PROJECT: 790A BARRENJOEY ROAD, PALM BEACH
PROJECT No: 30433/3736D-G
REPORT No: 20/1245
TITLE: PHOTO 2 - BUILDING PLATFORM AREA

STS GEOTECHNICS PTY LTD
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Retaining wall footings exposed

Detached sandstone boulders

PROJECT: 790A BARRENJOEY ROAD, PALM BEACH
PROJECT No: 30433/3736D-G
REPORT No: 20/1245
TITLE: PHOTO 3 - RETAINING WALL AT REAR

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

Tilting Wall

PROJECT: 790A BARRENJOEY ROAD, PALM BEACH
PROJECT No: 30433/3736D-G
REPORT No: 20/1245
TITLE: PHOTO 4 - BH1 AREA

Filled Ground

BH1

PROJECT: 790A BARRENJOEY ROAD, PALM BEACH
PROJECT No: 30433/3736D-G
REPORT No: 20/1245
TITLE: PHOTO 5 - BH2 AREA

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Oversteepened embankment

BH2

PROJECT: 790A BARRENJOEY ROAD, PALM BEACH
PROJECT No: 30433/3736D-G
REPORT No: 20/1245
TITLE: PHOTO 6 - OVERSTEEPENED EMBANKMENT

STS GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

PVC Pipe Exposed

Cut slope

APPENDIX C – GEOTECHNICAL RISK MANAGEMENT POLICY FORMS 1 & 1A

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for____

Name of Applicant

Address of site 790A Barrenjoey Road, Palm Beach

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

I, Matthew Green *on behalf of* STS Geotechnics Pty Limited
(Insert Name) (Trading or Company Name)

on this the 28th April 2020 certify that I am a geotechnical engineer or engineering geologist or coastal engineer as defined by the Geotechnical Risk Management Policy for Pittwater - 2009 and I am authorised by the above organisation/company to issue this document and to certify that the organisation/company has a current professional indemnity policy of at least $2million.
I:

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 Assessment - 790A Barrenjoey Road, Palm Beach

Report Date: 28th April 2020
:
Author: Matthew Green

Author's Company/Organisation: STS Geotechnics Pty Limited

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

Architectural Drawings Prepared by David Lamb, Drawing Nos 1 to 10, dated
November 2019

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

Signature …………………………………………………………..

Name Matthew Green

Chartered Professional Status MAIG

Membership No. 7337

Company STS Geotechnics Pty Limited

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

Development Application for____
Name of Applicant
Address of site 790A Barrenjoey Road, Palm Beach

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: 790A Barrenjoey Road, Palm Beach
Report Date: 28th April 2020
Author: Matthew Green
Author's Company/Organisation: STS Geotechnics Pty Limited

Please mark appropriate box

- ☑ Comprehensive site mapping conducted 24/4/2020 (date)
- ☑ Mapping details presented on contoured site plan with geomorphic mapping to a minimum scale of 1:200 (as appropriate)
- ☑ Subsurface investigation required
  - ☐ No Justification …………………………………………………...
  - ☑ Yes Date conducted 24/4/2020……………………………………
- ☑ Geotechnical model developed and reported as an inferred subsurface type-section
- ☑ Geotechnical hazards identified
  - ☐ Above the site
  - ☑ On the site
  - ☐ Below the site
  - ☐ Beside the site
- ☑ Geotechnical hazards described and reported
- ☑ Risk assessment conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
  - ☑ Consequence analysis
  - ☑ Frequency analysis
- ☑ Risk calculation
- ☑ Risk assessment for property conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☑ Risk assessment for loss of life conducted in accordance with the Geotechnical Risk Management Policy for Pittwater - 2009
- ☑ Assessed risks have been compared to "Acceptable Risk Management" criteria as defined in the Geotechnical Risk Management Policy for Pittwater - 2009
- ☑ Opinion has been provided that the design can achieve the "Acceptable Risk Management" criteria provided that the specified conditions are achieved.
- ☑ Design Life Adopted:
  - ☑ 100 years
  - ☐ Other …………………………………………… specify
- ☑ Geotechnical Conditions to be applied to all four phases as described in the Geotechnical Risk Management Policy for Pittwater - 2009 have been specified
- ☑ Additional action to remove risk where reasonable and practical have been identified and included in the report.
- ☐ Risk assessment within Bushfire Asset Protection Zone.

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

Signature ……………………………………………………..
Name Matthew Green
Chartered Professional Status MAIG
Membership No. 7337
Company STS Geotechnics Pty Limited

GEOTECHNICS PTY LTD
CONSULTING GEOTECHNICAL ENGINEERS

ATTACHMENTS 1, 2, 3, 4

ATTACHMENT 1 - DEFINITION OF TERMS AND LANDSLIDE RISK

(Australian Geomechanics Vol 42 No 1 March 2007)

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

Annual Exceedance Probability (AEP) – The estimated probability that an event of specified magnitude will be exceeded in any year.

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

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

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

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

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

Landslide Activity – The stage of development of a landslide; pre failure when the slope is strained throughout but is essentially intact; failure characterised by the formation of a continuous surface of rupture; post failure which includes movement from just after failure to when it essentially stops; and reactivation when the slope slides along one or several pre-existing surfaces of rupture. Reactivation may be occasional (e.g. seasonal) or continuous (in which case the slide is “active”).

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

Landslide Risk – The AGS Australian GeoGuide LR7 (AGS, 2007e) should be referred to for an explanation of Landslide Risk.

Landslide Susceptibility – The classification, and volume (or area) of landslides which exist or potentially may occur in an area or may travel or retrogress onto it. Susceptibility may also include a description of the velocity and intensity of the existing or potential landsliding.

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

Probability – A measure of the degree of certainty. This measure has a value between zero (impossibility) and 1.0 (certainty). It is an estimate of the likelihood of the magnitude of the uncertain quantity, or the likelihood of the occurrence of the uncertain future event.

There are two main interpretations:

(i) Statistical – frequency or fraction – The outcome of a repetitive experiment of some kind like flipping coins. It includes also the idea of population variability. Such a number is called an “objective” or relative frequentist probability because it exists in the real world and is in principle measurable by doing the experiment.

(ii) Subjective probability (degree of belief) – Quantified measure of belief, judgment, or confidence in the likelihood of an outcome, obtained by considering all available information honestly, fairly, and with a minimum of bias. Subjective probability is affected by the state of understanding of a process, judgment regarding an evaluation, or the quality and quantity of information. It may change over time as the state of knowledge changes.

Qualitative Risk Analysis – An analysis which uses word form, descriptive or numeric rating scales to describe the magnitude of potential consequences and the likelihood that those consequences will occur.

Quantitative Risk Analysis – An analysis based on numerical values of the probability, vulnerability and consequences and resulting in a numerical value of the risk.

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

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

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

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

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

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

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

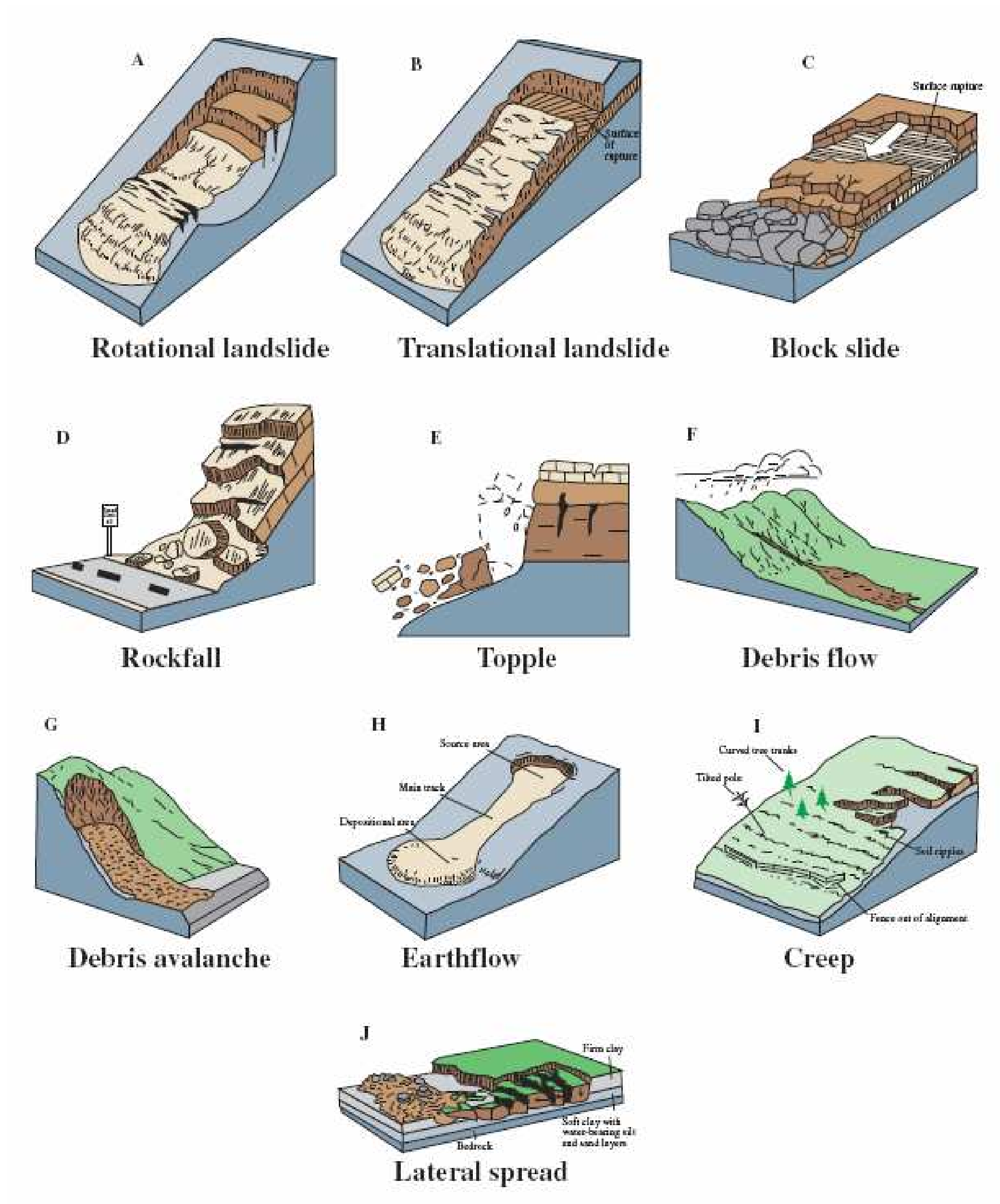
Societal Risk – The risk of multiple fatalities or injuries in society as a whole: one where society would have to carry the burden of a landslide causing a number of deaths, injuries, financial, environmental and other losses.

Susceptibility – see Landslide Susceptibility

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

Tolerable Risk – A risk within a range that society can live with so as to secure certain net benefits. It is a range of risk regarded as non-negligible and needing to be kept under review and reduced further if possible.

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



ATTACHMENT 2 MAJOR TYPES OF LANDSLIDES

ATTACHMENT 3: 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%	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

ATTACHMENT 3: – 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.

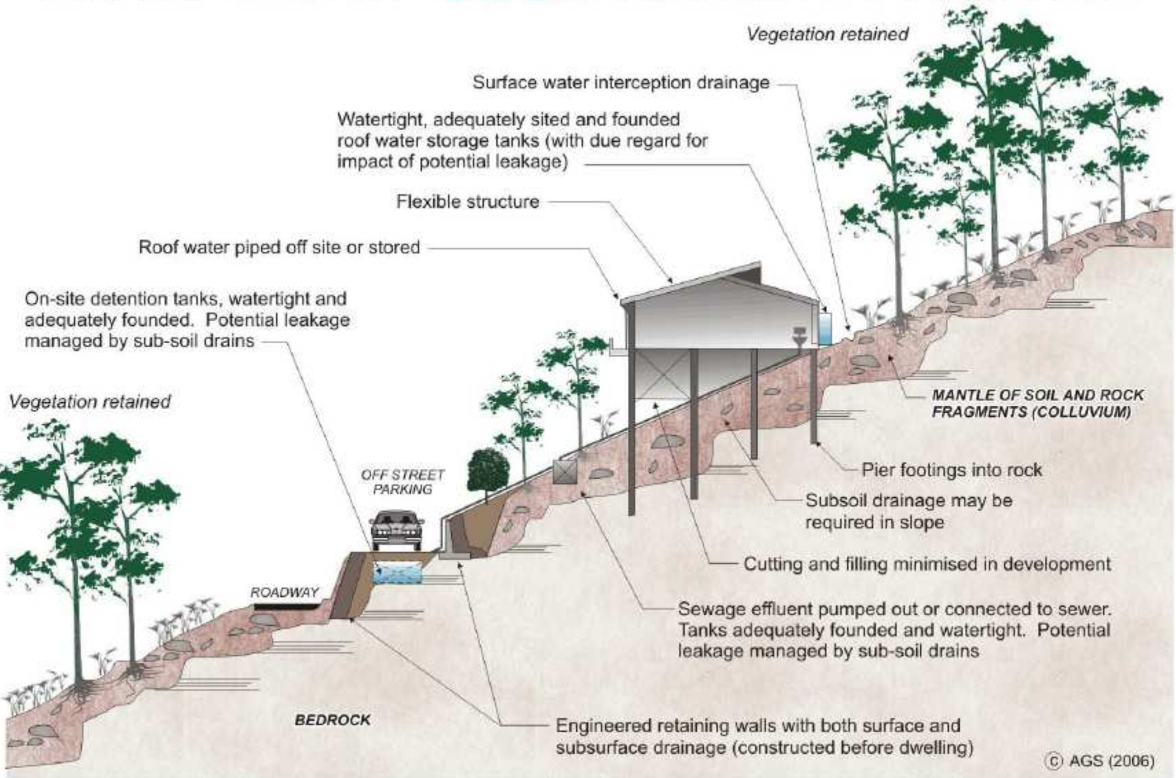
Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

ATTACHMENT 4

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant 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.	Indiscriminant 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



EXAMPLES OF POOR HILLSIDE PRACTICE