DAVIES GEOTECHNICAL
CONSULTING ENGINEERS

29 January 2018 17-049.A

Aveo Group
61 Parry St
NEWCASTLE WEST NSW 2302

Attention: Clare Brennock

**re: GEOTECHNICAL ASSESSMENT / LANDSLIDE RISK APPRAISAL
PROPOSED INDEPENDENT LIVING DEVELOPMENT
PENINSULA GARDENS RETIREMENT VILLAGE, 79 CABBAGE TREE RD BAYVIEW NSW**

In response to your request, please find enclosed our report R/17-049.A, for your dealing with Northern Beaches Council, in regard to a DA submission for the proposed Independent Living Development.

The enclosed report provides the results of our geotechnical assessment and landslide risk appraisal for the site of the proposed development.

The appraisal concludes that the risks in relation to potential slope instability for this site, having regard for both risk to property and risk to life, are within or can be brought within acceptable levels as determined by the Geotechnical Risk Management Policy for Pittwater, subject to the recommendations of the report being properly implemented.

We trust the enclosed report is adequate for your needs at this time. Please contact the undersigned if you require further information or assistance.

Yours faithfully
DAVIES GEOTECHNICAL Pty Ltd

Warwick N Davies MIEAust CPEng NER (Civil)
Principal Geotechnical Engineer

a17049R.docx

encl.
report R/17-049.A, dated 29/11/18

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DAVIES GEOTECHNICAL

CONSULTING ENGINEERS

REPORT ON
GEOTECHNICAL ASSESSMENT / LANDSLIDE RISK APPRAISAL

PROPOSED INDEPENDENT LIVING DEVELOPMENT
PENINSULA GARDENS RETIREMENT VILLAGE
No.79 CABBAGE TREE RD BAYVIEW NSW

29 January 2018 report ref: R/17-049.A

Submitted to:

Aveo Group
61 Parry St
NEWCASTLE WEST NSW 2302

Attention: Clare Brennock

Distribution:

PDF version	- Aveo Group
PDF version	- Jackson Teece Architects
1 copy (master)	- Davies Geotechnical Pty Ltd (Library)

GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

FORM NO. 1 – To be submitted with Development Application

Development Application for Aveo Group
(*Name of Applicant*)

Address of site No.79 Cabbage Tree Rd Bayview NSW

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

I, Warwick Davies on behalf of Davies Geotechnical Pty Ltd
(Insert Name) *(Trading or Company Name)*

on this the 29 January 2018 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.

Please mark appropriate box

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

☐ I 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

☐ I 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.

☐ I 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.

☐ I 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.

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

Geotechnical Report Details:

Report Title: DA-Stage Geotechnical Assessment, Independent Living Development, Peninsula Gardens Retirement Village, No. 79 Cabbage Tree Rd Bayview NSW

Report Date: R/17-049.A, dated 29 January 2018

Author: Warwick Davies

Author's Company/Organisation: Davies Geotechnical Pty Ltd

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

DA stage drawings prepared by Jackson Teece Architects, Details supplied by Northrop Consulting Engineers, and Site Survey by Waterview Surveying Services, all as referenced in the accompanying report.

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 Northern Beaches 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: Davies

29 January 2018

Name: Warwick Davies

Chartered Professional Status: MIEAust CPEng NER (Civil)

Membership No. 385078

Company: Davies Geotechnical Pty Ltd

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

Development Application for Aveo Group
(*Name of Applicant*)

Address of site No.79 Cabbage Tree Rd Bayview NSW

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

Geotechnical Report Details:

Report Title: DA-Stage Geotechnical Assessment, Independent Living Development, Peninsula Gardens Retirement Village, No. 79 Cabbage Tree Rd Bayview NSW

Report Date: R/17-049.A, dated 29 January 2018

Author: Warwick Davies

Author's Company/Organisation: Davies Geotechnical Pty Ltd

Please mark appropriate box

- ☑ Comprehensive site mapping conducted *30 October 2017* *(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 …[verify at time of construction by engineering inspections]
  - ☑ Yes ~~Date conducted~~ …to be undertaken for engineering design prior to construction
- ☑ 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 (as qualified in report)
  - ☐ 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 actions 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 Northern Beaches 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: WDavies

29 January 2018

Name: Warwick Davies

Chartered Professional Status: MIEAust CPEng NER (Civil)

Membership No. 385078

Company: Davies Geotechnical Pty Ltd

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Cover photograph: General view looking northwest on entry road to intersection with vehicular track at base of northern hillslope.

1.0 INTRODUCTION

1.1 Scope of the Assessment

At the request of the Aveo Group, Davies Geotechnical Pty Ltd has undertaken a geotechnical assessment of the land at No.79 Cabbage Tree Rd in Bayview NSW, for the purpose of forming an opinion on the risk of slope instability of the site.

Our opinions on the risks of slope instability are required in connection with a Development Application (DA) to the Northern Beaches Council for an Independent Living Development to be undertaken on the site.

The report addresses the requirements of the Geotechnical Risk Management Policy for Pittwater (2009), in particular Section 6 of the Policy, associated with the Development Application. Where interpretation of the policy meaning has been made for the purposes of this report, explanation is provided.

The appraisal presented in the following report was carried out in accordance with our letter dated 12 October 2017, ref. P/17-1002.A. Approval to proceed with the work was provided by Aveo Group on 16 October 2017.

Drawings/details for the work and site survey information were supplied to us for the purposes of our assessment. The information provided is referenced in appropriate sections of the report. The comments and recommendations in the report are based on the details provided.

1.2 Basis of the Assessment

The opinions provided in the following report are based on a visual inspection of the property and also the immediately adjoining land. Geotechnical inspection and slope mapping of the site were undertaken by Warwick Davies (Principal Geotechnical Engineer) and Michael Doherty (Senior Geotechnical Engineer) on 30 October 2017.

Subsurface exploration of the property at No.79 has not been carried out as part of the geotechnical site assessment. However, information is available on our files from previous geotechnical assessments, investigations and construction-stage inspections on residential and commercial developments in the locality. Information on subsurface conditions from those previous projects has been used for the assessment at Peninsula Gardens.

Detailed slope monitoring has not been carried out within or adjacent to this site for the purposes of this appraisal. However, we have observed the slopes in the general area, and as noted above have undertaken geotechnical investigations and carried out slope stability risk appraisals on other properties in the locality with similar geotechnical and geological context, over a period in excess of 35 years. The opinions expressed in this report are based on our relevant local experience.

Our opinions and conclusions on the stability of the land are presented in the framework of the Australian Geomechanics Society's publication *Practice Note Guidelines for Landslide Risk Management 2007* (reference 1), described and referenced in the report.

The property is within an area where landslip and/or subsidence have occurred, or where there are risks that slope instability may occur. Important factors relating to slope conditions and the impact of development, which commonly influence the risks of slope instability, are discussed in the report.

An owner's decision to acquire, develop or build on land within an area such as this involves the acceptance of a level of risk. It is important to recognise that soil and rock movements are an ongoing geological process, which may be affected by development and land management within the site or on adjoining land. Soil or rock movements may cause visible damage to structures even where the risk of slope failure is considered low. This report is intended to assess the risk of slope failure, apparent at the time of inspection.

Our opinion is provided on the risk of slope instability for the land specifically referenced in the title to this report. Foundations suitable for development on this site may be discussed in relation to slope stability considerations and the anticipated subsurface conditions. However, this report is not intended as, is not suitable for, and must not be used in lieu of a detailed foundation investigation for final design or costing of foundations, retaining walls or other structures associated with a future development of the property.

2.0 GEOLOGY

2.1 General Geology

The subject property is located on a south-facing hillslope formed on sedimentary sandstone and shale bedrock of the Hawkesbury Sandstone and the Narrabeen Group Newport Formation. The site location is indicated on the Locality Plan provided in Figure 1.

The natural soil overburden in this area typically comprises a cover of colluvial and residual soils formed by the weathering and transport of the bedrock over a period of several million years.

For this geological sequence, the colluvium (mixtures of rock and soil debris) which blankets the rock and any residual soils is sandy and clayey, and has varying permeability and a generally stiff to very stiff consistency. Areas of gravelly colluvial soils with cobbles and boulders occur on these slopes. The colluvial soil (where present) has varying thickness according to the position on the slope.

The colluvial slopes in this locality, and in similar areas elsewhere within the Sydney Basin region, are derived by the build up of soil and rock transported down the slopes. These naturally occurring colluvial and residual slopes have a history of slope failures and may be unstable and may move at varying rates. Some slopes may move at rates that have an obvious and significant effect on the land and on houses. Such slope failures have occurred on relatively flat slopes, sometimes as flat as 10^{o} from the horizontal.

2.2 Site Geology and Stability in Vicinity of No.79 Cabbage Tree Rd

The geology in the vicinity of No.79 is shown on the 1:100,000 scale geology map published by the NSW Geological Survey (reference 2). The site is located on the south-facing side-slope of a ridge which plunges roughly eastwards, veering to the north at lower elevations.

The upper elevations of the ridge and side-slope are formed on Hawkesbury Sandstone, with the underlying Narrabeen Group Newport Formation forming the lower elevations. The slope continues to an incised watercourse flowing to the east through the Peninsula Gardens property.

There are no exposures of bedrock on the slope within the site. However, Hawkesbury Sandstone is exposed uphill on the adjoining properties fronting on Cabbage Tree Rd and in road cuttings along Cabbage Tree Rd further uphill. Sandstone is also seen on the narrow “handle” part of the Peninsula Gardens property that extends over the ridge and through to a frontage on Cabbage Tree Rd. Where viewed on the property, the profile of the exposed sandstone at this higher elevation extends at the same typical slope angle to the ridge and a prominent steep-faced cliff is not present.

An interpretation of the bedrock profile on No.79 and upslope to the ridge line is shown on the geotechnical slope section provided in this report.

Mapping in reference 3 indicates the northern hillside portion of the site is located on the Watagan colluvial soil landscape, and the lower eastern portion of the site may be within the Erina erosional soil landscape.

The site lies within the mapped Hazard Zone H1(slope), in accordance with GHD Geotechnics – Geotechnical Hazard Mapping of Pittwater LGA, 2007 (reference 7). The hazard mapping for this locality does not show any area influenced by past landsliding ("*interpreted previous slope movement*") within proximity to the site.

3.0 SITE CONDITIONS

3.1 Topographic Situation and Slope Features

The Peninsula Gardens retirement village complex is located within a gully to the south of Cabbage Tree Road. The subject area of the proposed development is situated on the northern hillslope flanking the gully and comprises an area of some 240m east-west by 60m north-south.

Figure 2 provides a site plan of the property.

Developed residential properties fronting onto Cabbage Tree Road border the northern side of the Peninsula Gardens site. A narrow portion of land, part of the Aveo property, extends northwards connecting the broader northern hillslope area to Cabbage Tree Road. This area is undeveloped but has been improved with a lawn area, gardens and landscaping.

The base of the gully and a small golf course adjoin the southern side of the of the proposed development site and natural bushland is present at the western end of the site, continuing to and beyond the western property boundary.

The access to the retirement village is via a concrete road that winds down off Cabbage Tree Rd within the easten portion of the property. The road grades steeply downhill to the south and at the base of the gully continues to the established part of the village on the southern valley flank.

The landform of the development site comprises a relatively uniform slope of the south-facing valley hillside. Typical slope angles calculated from the site survey plan are 15° to 20° degrees. Measured slope angles from our walk-over of the site are within this range and are indicated on the attached plan in Figure 3 and the slope sections presented as Figures 4A – 4C.

The internal access road divides the proposed development site into two portions, comprising the major area of the northern hillslope to the west of the access road, and a smaller area on the footslope of the hillside to the east.

Within the area of the proposed development, the access road has been formed by cutting on the uphill side to depths of about 3m below the original ground level. This has formed a steep batter of about 8m overall height on the western side, as shown on Section 4 in Figure 4C. Surface evidence of the batter materials was not seen due to leaf litter and vegetation.

A number of east/west orientated tracks formed by minor cut to fill earthworks are evident on the hillside. The extent of vegetation re-growth shows these tracks to be likely 30 years or older since formed. A "BMX" track of more recent construction is located on the slope.

Observation of the overall slope contours from our walk-over traversing (making allowance for the past track works) display no signs of large-scale instability.

The features described above from our geotechnical mapping and general observations are marked up on the survey plan presented as Figure 3 and on the geotechnical slope sections provided in Figures 4A – 4D.

Survey information was supplied electronically by Waterview Surveying Services, Ref.No.593-B dated 6 Jan 2017, comprising Sheets 1 – 6.

Figures 5A – 5D, and the cover page to the report, provide selected photographs illustrating the slope features and site development.

3.2 Vegetation

Most of the subject site of the proposed development has a tree cover of mature native species, predominantly turpentine but with several very old angophora.

The ground cover over the northern hillside is generally thin to moderate but with some areas of very thick cover, and comprises various native shrub, fern and grass types. Isolated infestations of introduced weed species with patches of thin lantana are also present, particularly along the northern side downhill from the adjoining residential developments on Cabbage Tree Rd.

The eastern-most portion of the site comprises a mown grassy slope.

3.3 Drainage

The overall drainage of the northern hillslope site is directly southwards downhill to the watercourse gully. Minor variation or concentrations of this general flow may occur as a result of the historical tracks present on the hillside.

Drainage for the gully area and stormwater from the retirement village complex is directed eastward off the site by the watercourse, which is piped through sections of the existing development. The concrete access road off Cabbage Tree Rd incorporates kerb and gutter with drainage pits, presumably piped to the gully.

A half- round concrete surface batter drain extends down the face of the cut batter adjacent to the access road, and terminates at the roadside kerb. Erosion has occurred at the uphill end of the batter drain from runoff along an unlined drainage channel on the adjacent land. This has undermined the entry to the batter drain with the result that no flow enters the drain and the concentrated surface water at that point flows uncontrolled and appears to disperse over the batter face or continues to channel beneath the batter drain.

The site was viewed after an extended period of dry weather. At the time of inspection, no apparent problems with surface water were evident on the broad extent of the northern hillslope area traversed. Similarly, we observed no areas of natural seepages or spring activity.

3.4 Existing Development

The majority of the property at Peninsula Gardens is developed with brick dwellings, concrete roads and recreational facilities providing for the retirement living community.

The site of the proposed new development on the northern hillside within Peninsula Gardens is undeveloped, except for a gravelled access track along the toe of the slope flanking the watercourse, some improvements to the watercourse and landscaping maintenance facilities including a shed.

The narrow “handle” to the property fronting onto Cabbage Tree Rd is undeveloped but has been improved with well-maintained landscaped gardens, lawn areas and pathways.

4.0 SUBSURFACE CONDITIONS

Subsurface investigation within the proposed development area on No.79 has not been undertaken for the geotechnical assessment.

The slope sections in Figures 4A – 4C indicate our interpretation of the geotechnical slope model and the anticipated subsurface conditions at the site, based on the mapped slope features and site geology.

Information is available from work undertaken nearby to this site in the Narrabeen Group Newport Formation geology in 2012 (Park St Mona Vale, about 1.25km to the south-east), and in Barkala Rd about 670m to the north-east).

The subsurface conditions we have observed at those locations, and elsewhere about the Bayview and Mona Vale localities, including sites in the Hawkesbury Sandstone geology, are helpful for indicating expectations of the range of typical subsurface conditions anticipated at Peninsula Gardens on the northern hillslope site.

Figures 6A and 6B illustrate the observed subsurface conditions at these two sites, comprising:-

- a profile of sandy and gravelly/sandy clay, mostly colluvial soil, 1m – 2m thick, overlying
- variably/extensively weathered inter-bedded sandstone and claystone/shale/siltstone bedrock, dominated by the fine grained lithologies of the Newport Formation.

The northern hillside at Peninsula Gardens is capped by Hawkesbury Sandstone upslope from the site of the proposed development. Lower down in the area of the proposed development the slope is formed on bedrock of the Newport Formation. Consequently, it is anticipated the soil profile and bedrock conditions there will be similar to the exposures at the Barkala Rd and Park St sites.

Variations in the bedrock lithology across the hillside may result in local variations of the subsurface conditions where stronger sandstone strata or weaker siltstone or shale/claystone strata are present.

It is recommended (refer 6.1 and 6.2 below) that investigation of the subsurface conditions should be undertaken for the engineering design, to provided data and confirmation of the subsurface conditions along the loop road excavation and elsewhere as necessary.

5.0 SLOPE STABILITY

5.1 General

The slope instability risk appraisal for No.79 Cabbage Tree Rd, presented in this report, is based on procedures outlined in the Australian Geomechanics Society's (AGS) *Practice Note Guidelines for Landslide Risk Management* (reference 1).

Since publication of the original AGS (2000) Guidelines, the Geotechnical Risk Management Policy for Pittwater has been modified for submission of geotechnical assessments in relation to slope instability risk (reference 4). The slope instability risk assessment reported herein addresses the requirements of the Geotechnical Risk Management Policy (2009).

Our opinions provided in this report, with regard to the risk assessment undertaken, rely on interpretation of certain components of the Geotechnical Risk Management Policy. Further explanation of these matters is provided in Section 7.0 below.

5.2 Risk Assessment

Discussion is presented in Appendix A of this report, regarding the assessed geotechnical hazards, our assessment for frequency analysis, consequences to property, and risk to property and life, for the existing and anticipated future slope conditions, and the proposed development. Reference should be made to Table A1 and Table A2, and to discussion in Appendix A.

The risk assessment is intended for management of geotechnical risk, rather than as an engineering design tool. The geotechnical hazards discussed herein are determined from experience, and from any specific knowledge of the site (from published data, site observations and/or subsurface investigation and slope monitoring) and/or known slope history.

The assessment of hazards and analysis of risk, as presented in the report, aim to identify where risk reduction measures are either necessary, or appropriate, or desireable. The risk analyses presented in Appendix A do not necessarily treat each and every possible hazard or combinations of factors. Rather, the aim generally is to determine upper and lower bounds, typical situations or defining cases as a “framework” for the assessment.

For the Peninsula Gardens project, the risk assessment process examines the existing slope conditions separately from the proposed development. In the latter case, the rationale adopted is to consider risk levels associated with: (i) a “poorly engineered” approach to the works, both during and following construction, and (ii) for the completed development assuming a “properly engineered approach”. For reasons noted above, not all examples and hazards are necessarily analysed.

For each identified hazard/event, the elements of the existing conditions and the new development at this site that would be considered to be at risk are residential and associated structure(s), services, and landscaping improvements. Table A1 and Table A2 provide a risk analysis for the proposed development.

In summary, the outcome of the risk analysis undertaken is as follows (refer table below):-

	Hazards	***Risk to Property*** (Table A1)	***Risk to Life*** ***(for person most at risk)*** (Table A2)
Existing Conditions	***H1, H2, H4***	***Very Low to Low***	***$<10^{-6}$***
Proposed Development			
▪ Non-engineered or poorly-engineered	**H3A, H3B**	***Moderate to High***	***Up to 1.5×10^{-4}***
▪ Engineered, with Risk Management	**H3C**	***Very Low to Low***	***$<10^{-6}$***

The above risks for non-engineered or poorly-engineered work are unacceptable. However, with appropriate engineering investigation, design and construction controls, the assessed risks for the development (up to Low Risk for property, and $\leq 10^{-6}$ for Loss of Life) are **"acceptable"** as defined in the Geotechnical Risk Management Policy.

It should be noted that site-specific data are not available to permit a quantitative analysis of the frequency of hazard events for this site. A limited regional study of landslide likelihood for the Pittwater area been carried out and published (MacGregor et al 2007, reference 5). The assessment of risk to property reported herein is based on qualitative methods as permitted in the Geotechnical Risk Management Policy. To the extent that the assessment of hazard occurrence frequency for this site is partly based on qualitative methods, the assessment of risk to life is limited to semi-quantitative methodology.

The assessed risks are subject to maintenance and/or improvement of the present site conditions as discussed elsewhere in the report, and to further geotechnical review should these conditions alter significantly in the future.

Examples of recommended hillside development and construction practice are provided in the attachments to this report. Where relevant, the examples provide guidance for future development on this site, and should be incorporated in the development.

Recommendations are provided in Section 6.2 below, to *"remove foreseeable risk from the site"*, as required by the Geotechnical Risk Management Policy, for the current and future development.

5.3 Additional Risk Issues

There is potential for increased overall risks on this project, where multiple dwellings within the development complex may be impacted by a large-scale failure event, with an increased level of consequence in regard to loss of life.

The risk analysis and assessment, and appropriate acceptance criteria for the purposes of the DA for this development, do not extend to this level under the guidelines of the Pittwater Risk Management Policy. Further discussion is provided in Section A3 (Appendix A), which directs the reader to commentary in the AGS 2007 Guidelines (reference 1) for consideration or assessment of "societal" risk. These issues are beyond the scope of this report.

6.0 DEVELOPMENT & RECOMMENDATIONS

6.1 General

The proposed development is for a residential dwelling cluster on the northern hillslope, with vehicular access from a loop road running westward along the slope contour, off the existing entry road from Cabbage Tree Rd. A smaller dwelling cluster will be located on the open grassed area to the east of the existing entry road, served by a separate loop road.

Twenty four 2-bedroom dwellings are to be constructed in total, comprising nine detached buildings housing various single, double and multiple dwellings. Vehicular access to garages for each dwelling is directly off each loop road.

The current design (alignment, level and grades) prepared by Northrop Consulting Engineers for the proposed western loop road requires a continuous excavation of some 4m depth on centreline along the upslope portion of the road, and approximately at grade (only minor excavation or fill) for the downslope portion. The design is illustrated in the plan provided as Figure 7, and details from the design are used for developing part of Section 3 (Figure 4B).

A design batter slope for the road excavation has not been advanced at the time of writing. However, an appreciation of the extent of earthworks can be estimated using a notional 45^{o} (1H:1V) typical batter angle for weak rock, with a bench at the top, and a flatter 2H:1V batter slope above the bench, substantially in the soil profile.

Alternatives to the suggested batter design can be considered for support of the loop road excavation, for example:-

- structural or gravity retaining walls,
- soil nailing,
- anchored shotcrete.

An example of a structural support wall is provided in Figure 4C, comprising a soil nailed shotcrete facing for the lower 5m height, and a bench with a low landscaping wall and 2H:1V trimmed batter above. Construction staging for such a design can be determined so as to maintain stable slope conditions during construction.

Engineering design for the access road and associated earthworks (yet to be undertaken) will need to balance sensible limits for: (a) batter heights and slope angles in the bedrock underlying this slope, (b) the aesthetics for residents associated with the “streetscape”, and (c) costs.

Geotechnical investigation is necessary for the engineering design, to provided data and confirmation of the subsurface conditions along the loop road excavation and elsewhere as necessary (refer 6.2(a) below).

Low retaining walls or re-shaped slope batters may be adopted for support of the downhill side of the loop road. Details provided by the project architect are shown in Figure 8.

Subject to the recommendations of this report being implemented through the design and construction phases of the project, it is our opinion that the proposed development can be undertaken within the framework of the assessed degree of risk in relation to slope instability, as discussed in Section 5.0 above.

Further, we consider an acceptable risk outcome in regard to property and life at this site can be achieved for the development, in accordance with requirements of the Northern Beaches Council.

The recommendations provided below are to assist in maintaining or improving the slope conditions and geotechnical risk.

6.2 Recommendations – The Subject Development

Building and Development Matters

a) A geotechnical investigation using boreholes, test pits or other suitable means is to be scoped by a geotechnical engineer and undertaken as part of the engineering design stage, to provided data on the subsurface conditions in areas of proposed excavation for the loop road and building footprints.

   The data from the investigation is to be reviewed by a geotechnical engineer and recommendations assessed for excavation support systems or batter slopes as appropriate, for the purposes of the engineering design.

b) All building footings are to be taken to a bearing in undisturbed bedrock, to be verified by a geotechnical engineer at the time of construction.

c) Engineering details for the proposed works are to be prepared by a suitably experienced consulting structural or civil engineer, and reviewed by a geotechnical engineer in regard to geotechnical aspects, prior to issue of the Construction Certificate (ie prior to commencement of site works). Refer Item (h) below.

   Of particular relevance, as part of the design, a construction methodology is to be prepared for the road excavation component of the works, with emphasis on temporary support, staging and monitoring of the excavation, with geotechnical input as appropriate to the design for the excavation support systems.

d) Particular attention is required in the stormwater design to capture and manage water flows and seepage along the existing drainage line emanating from the property at No.83 Cabbage Tree Rd (to be confirmed by survey) and which currently flows onto and down the existing road batter.

e) It is not normally expected that the proposed building construction, and other elements of the development, would be able to sustain a design life of 100 years (refer to the Geotechnical Risk Management Policy). In order that the proposed structures can perform a satisfactory function after expiry of their normal design lives, the structural designer and the manufacturer must specify either the construction requirements for the desired life span, or the remedial action necessary at the end of the normal design life.

f) Roofwater and surface drainage captured by paved or landscaped areas in and around the development should be directed via sealed pipes to discharge into the natural drainage line at the base of the slope, or to the existing stormwater system, in accordance with requirements of the Northern Beaches Council.

g) All aspects of the design and construction for the development should be in accordance with the guidelines provided in the attached *Some Guidelines for Hillside Construction* (refer to Appendix A of this report).

h) In regard to Clause 6.5(g)(i) and (ii) of the Geotechnical Risk Management Policy (geotechnical design parameters and design for Construction Certificate), the following details are to be provided from the engineering design, for review by a geotechnical engineer:

- footings for building structures, retaining walls
- retaining walls and other slope support systems, including construction methodology
- retaining wall drainage systems, stormwater.

i) In regard to Clause 6.5(g)(iii) of the Geotechnical Risk Management Policy (conditions applying to the construction), geotechnical inspections are required for the following stages of the proposed construction works:

- excavation exposures, for verification of anticipated ground conditions;
- monitoring of temporary excavation support structures/systems;
- assessment of the ground conditions for footings;
- other aspects of the development arising from the engineering design

Risk Reduction and Risk Management

j) In regard to Clause 6.5(g)(iv) of the Geotechnical Risk Management Policy (conditions regarding ongoing management of the site/structure), the following measures are recommended (further details in Appendix A):-

- maintenance and/or improvements (as necessary) for surface drainage about the site and roof water disposal, in accordance with the approved design;
- monitoring of the performance of drainage systems about the site, particularly during and following rainfall events;

7.0 GEOTECHNICAL RISK MANAGEMENT POLICY FOR PITTWATER

The above report is intended to satisfy the requirements of Geotechnical Risk Management Policy (reference 4). Table 1 below provides a cross-reference between the Policy and this report, indicating relevant sections of the report that address appropriate requirements of the Policy.

TABLE 1 – Policy Cross Reference

Policy Section	Item/Description	Report Reference
6.5 (a)	Assessment of risk	5.0, Appendix A
6.5 (b)	Plan(s) and section(s)	Figures 1 – 4, Figure A1
6.5 (c)	Details of inspections/investigations	1.2, 4.0, Figures 6A, 6B
6.5 (d)	Photographs/drawings	Figures 1 – 8
6.5 (e)	Geological/geotechnical model	2.1, 2.2, Figures 4A – 4C
6.5 (f)	Conclusion and conditions	6.1 – 6.2
6.5 (g)	Geotechnical Conditions	6.2
6.5 (h)	Impact of Asset Protection Zones (Bushfire Risk mitigation)	Not Applicable
6.5 (i)	Coastal bluff	Not Applicable
6.5 (j)	Statement	8.0
6.5 (k)	Forms 1 & 1(a)	Attached to report
6.6(a) – (h)	Building Certificate	Addressed at 6.5 (a) – (j)
6.7	Construction Certificate	Not Applicable

9 (a)	Separate site analysis	Not Required
10.1	Form 1 and Form 1(a)	Not Applicable
10.2	Form 2	Not Applicable
10.3	Form 3	Not Applicable
10.4	Form 4	Included in report

Opinions provided in this report with regard to the risk assessment undertaken rely on interpretation of certain components of the Policy in accordance with the Section 4.0 of the Policy (Definitions).

In this regard, it is particularly noted that words in the Policy, and the Forms, which (in various ways) state, imply, or refer to a requirement to *"remove risk,"* are taken to have the meaning intended by the Policy as defined under **Remove Risk** in Section 4.0 of the Policy (Definitions).

References in the Policy and/or Forms to a *"design project life, taken to be 100 years"* or to *"the life of the structure, taken as at least 100 years"*, or to *"design life adopted … 100 years"*, are taken to have the meaning intended by the Policy as defined under **Life of the Structure** in Section 4.0 of the Policy (Definitions). No opinion, statement or implied statement contained in this report should be taken to provide any warranty at all, in regard to the existing or future development on the site, for any period of time.

Extracts from the Policy, providing the definitions for **Remove Risk** and **Life of the Structure**, are attached herewith in Appendix D to this report.

8.0 SUMMARY & LIMITATIONS

The above report provides the results of a geotechnical assessment for landslide risk on part of the land within the Peninsula Gardens Retirement Village property at Bayview NSW.

The assessment and report are for the purposes of a development application to Northern Beaches Council concerning a proposed Independent Living Development within the property. The assessment concludes that:

- the proposed works can be undertaken at the site, and
- the proposed works can achieve an **Acceptable Risk Level**, under the Geotechnical Risk Management Policy for Pittwater, provided that all the recommendations of the report are properly implemented during and following development.

The current design for the development involves construction of an internal loop road for access to the new residential dwellings. The proposed dwellings and loop road are to be constructed on a moderate to steep hillslope and require excavations across the slope and some filling.

Accordingly, strict engineering controls are necessary to ensure **Acceptable Risk Levels** can be achieved. These controls are to be embraced in the detailed design and construction phases of the development, and are to be reviewed for geotechnical purposes prior to commencement of construction, as discussed in the report.

Normal slope management and maintenance are required for the longer term over the life of the development. Recommendations are provided and discussed.

Reasonable and practical steps are available, and are identified in the report, to “remove foreseeable risk from the site”, as required by the Geotechnical Risk Management Policy for Pittwater.

The owner, potential owner or interested party in regard to this site should assess whether the risk levels determined in Table A1 (risk to property) and Table A2 (risk to life) are acceptable for the site in its present state, taking into account the possible economic and societal consequences associated with the risks.

The risk of slope instability within this property may be affected by changes in land management or development on this or adjacent property. Review of the risk appraisal is recommended if significant changes occur to the natural site features or to the development, outside the scope of this report.

If any conditions are encountered that vary significantly from those described in the above report, or that might affect the probability of occurrence, and/or the consequences of the defined geotechnical hazards, it is a condition of the report that we be advised so that those conditions, and the conclusions discussed in the report, can be reviewed and alternative recommendations assessed, if appropriate.

The appendices, which are attached to this report, are important in understanding the basis of the assessment undertaken, and the conclusions reached. This report must be read in conjunction with these appendices.

DAVIES GEOTECHNICAL Pty Ltd

REFERENCES

1. *Practice Note Guidelines for Landslide Risk Management 2007 [and Commentary],* Australian Geomechanics, Vol.42, No.1, March 2007.
2. Geol. Sur. NSW, Dept Min Resources (1983). *Geological Series Sheet 9130 (Sydney) 1:100,000*
3. Chapman, G.A. and Murphy, C.L. (1989), *Soil Landscapes of the Sydney 1:100,000 sheet*. Soil Conservation Service of NSW, Sydney
4. *Geotechnical Risk Management Policy for Pittwater - 2009,* Pittwater Council P21 DCP Appendix 5, Policy No.178 amended 21 September 2009.
5. MacGregor, P., Walker, B.F., Fell, R., and Leventhal, A.R., (2007). *Assessment of Landslide Likelihood in the Pittwater Local Government Area*, Australian Geomechanics, Vol.42, No.1, March 2007.
6. Walker, B.F. (2002). *An Example of Semi Quantitative Landslide Risk Management for an Individual Lot in Northern Sydney,* Australian Geomechanics, Vol.37, No.2, May 2002.
7. GHD Geotechnics. *Geotechnical Hazard Mapping of the Pittwater LGA, 20*07. Pittwater Council's Geotechnical Risk Management Map P21CDP-BC-MDCP083.

Image Source - NSW Land & Property Information SIX Maps

DAVIES GEOTECHNICAL
CONSULTING ENGINEERS

Project No: 17-049
Scale: NTS
Drawn: wnd
Date: 28 Nov 17

LOCALITY PLAN
PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW
(Aveo Group)

Figure 1

- ❑ Geotechnical slope sections shown on Figures 4A - 4D.
- ❑ Survey prepared by Waterview Surveying Services, Ref.No.593-B dated 6 Jan 2017 (Sheet 1 of 6).

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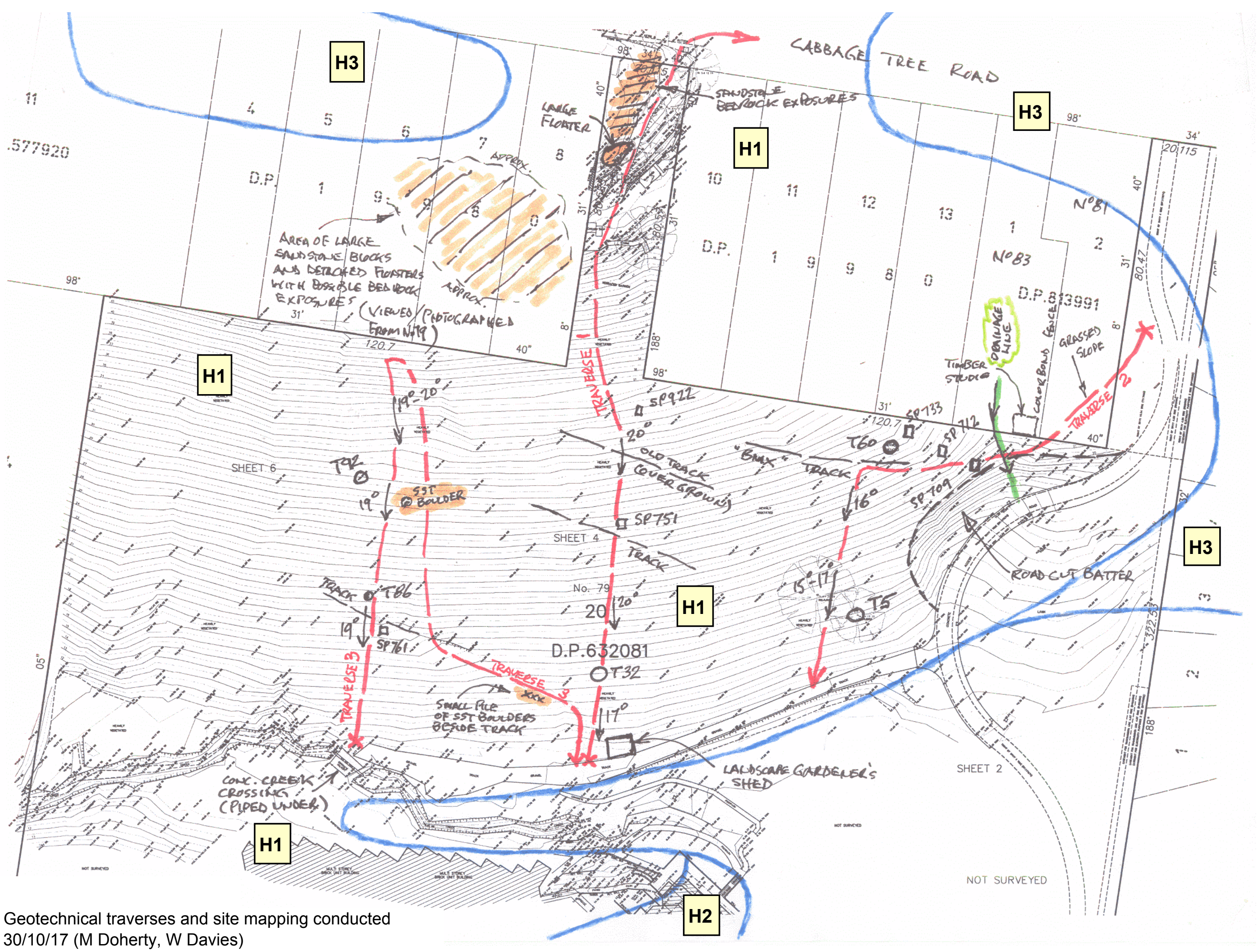
Scale: as shown
Drawn: wnd
Date: 29 Jan 18

SURVEY BASE PLAN
PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW
(Aveo Group)

Figure 2



NORTH

NOTES:

1. Start points for traverses marked by "X". End points marked by "arrow head".
2. Traverse alignments and features marked along traverses are plotted approximately only.
3. Slope angles measured by hand-held clinometer.
4. Area of sandstone boulders and floaters indicated on Lots 6 - 8, west of No.79 narrow access "handle" onto Cabbage Tree Rd, is schematic only, as viewed from No.79. Refer photographs in Figure 5A.
5. Numbered trees noted hereon [T5, T32, T60, T86, T92] are indicative locations only, and subject to accurate survey.
6. Numbered survey pegs "SP" noted hereon [709, 712, 733, 751, 761, 922] are indicative locations only, and subject to accurate survey details.
7. H1, H2, H3 .... GHD Hazard mapping zones (ref. 7).

❑ Geotechnical traverses and site mapping conducted 30/10/17 (M Doherty, W Davies)

❑ Survey prepared by Waterview Surveying Services, Ref.No.593-B dated 6 Jan 2017 (Sheet 1 of 6)

DAVIES GEOTECHNICAL

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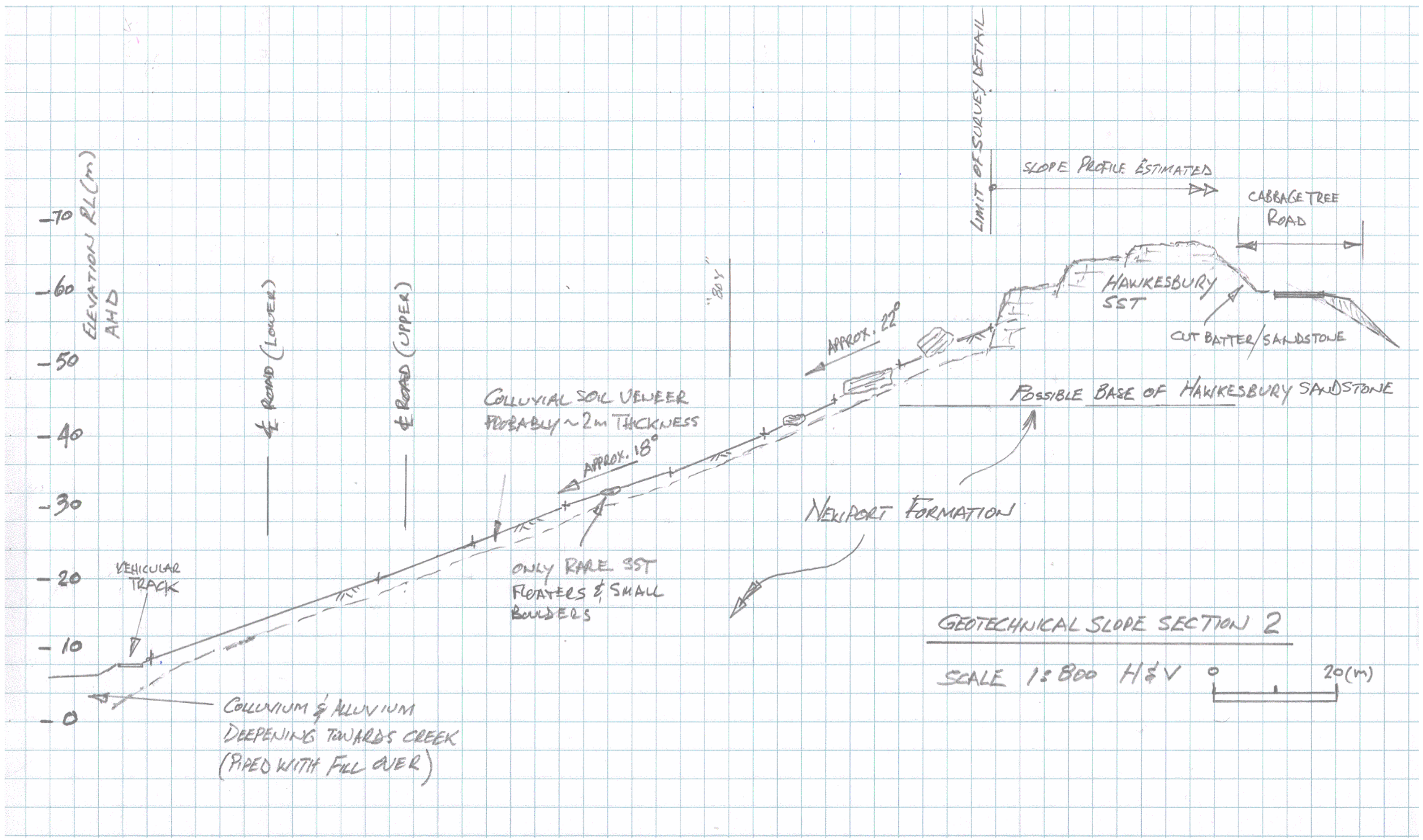
Project No:	17-049	**Scale:**	as shown	GEOTECHNICAL SITE PLAN PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	**Figure 3**
Drawn:	wnd	**Date:**	18 Dec 17		



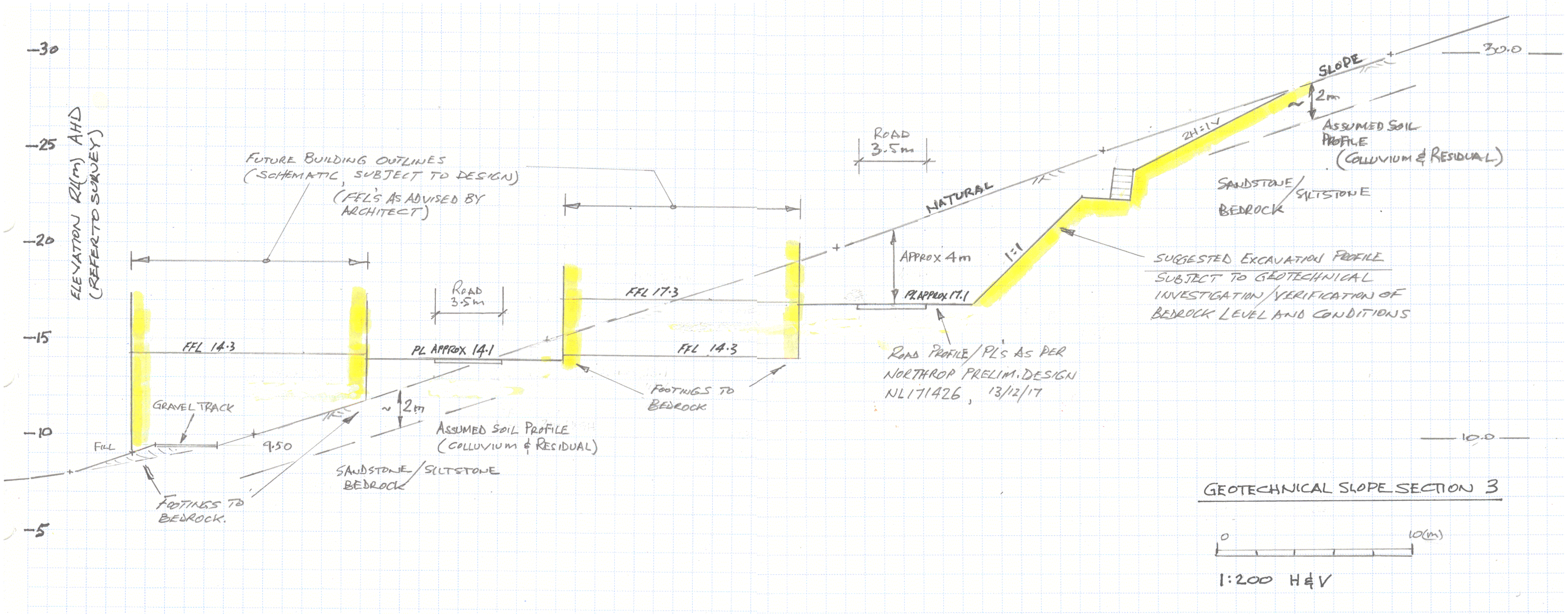
- ☐ Section location shown on Figure 2.
- ☐ Refer to survey prepared by Waterview Surveying Services, as referenced in report.
- ☐ Road (upper & lower) as per Northrop Consulting Engineers' design NL171426_CIVIL BASE-DA.171213-Model.

DAVIES GEOTECHNICAL
CONSULTING ENGINEERS

Project No:	17-049	**Scale:**	as shown	GEOTECHNICAL SLOPE SECTION 2 PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	**Figure 4A**
Drawn:	wnd	**Date:**	18 Dec 17		

PRELIMINARY - CONCEPT ONLY

FOR DA PURPOSES
Subject to investigation, engineering design and geotechnical
review prior to finalising for construction



- ❑ Section location shown on Figure 2.
- ❑ Refer to survey prepared by Waterview Surveying Services, as referenced in report.
- ❑ Road (upper & lower) as per Northrop Consulting Engineers' design NL171426_CIVIL BASE-DA.171213-Model.

DAVIES GEOTECHNICAL
CONSULTING ENGINEERS

Project No: 17-049
Drawn: wnd
Scale: as shown
Date: 18 Dec 17

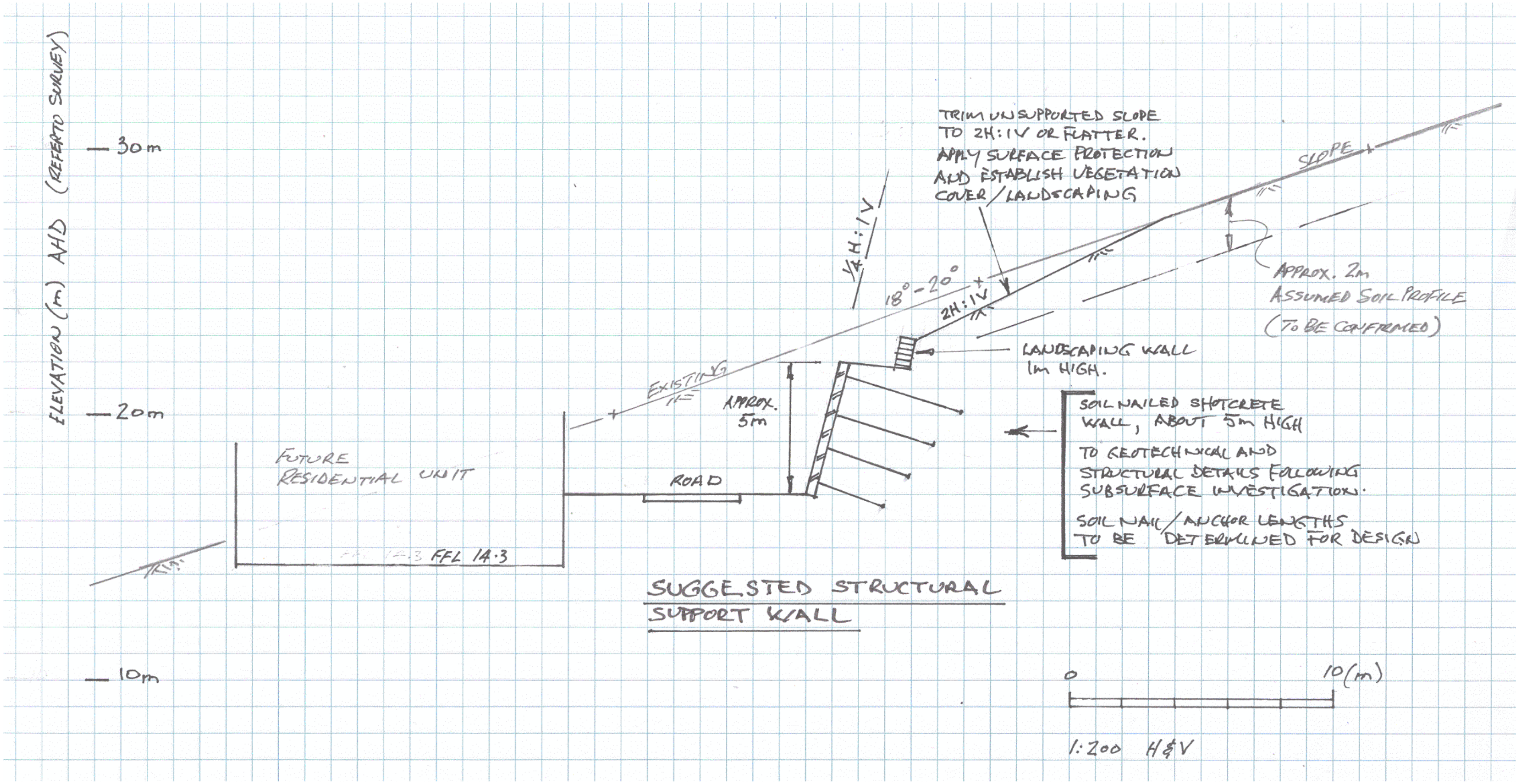
GEOTECHNICAL SLOPE SECTION 3
PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW
(Aveo Group)

Figure 4B

PRELIMINARY - CONCEPT ONLY

FOR DA PURPOSES

Subject to investigation, engineering design and geotechnical review prior to finalising for construction

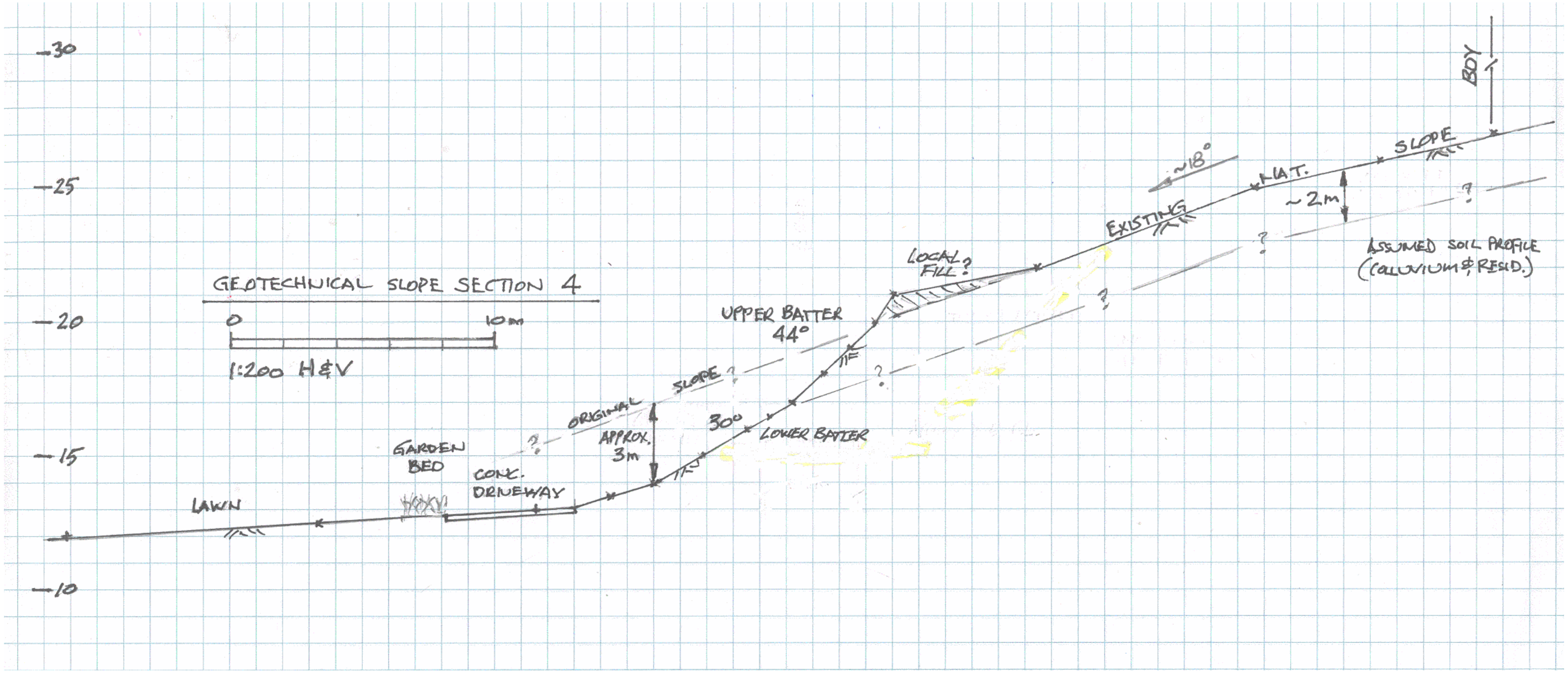


- ❑ Section location shown on Figure 2.
- ❑ Refer to survey prepared by Waterview Surveying Services, as referenced in report.
- ❑ Road as per Northrop Consulting Engineers' design NL171426_CIVIL BASE-DA.171213-Model.

DAVIES GEOTECHNICAL

CONSULTING ENGINEERS

Project No:	17-049	**Scale:**	as shown	GEOTECHNICAL SLOPE SECTION 3 - SUGGESTED STRUCTURAL SUPPORT WALL PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	**Figure 4C**
Drawn:	wnd	**Date:**	29 Jan 18		



- ☐ Section location shown on Figure 2.
- ☐ Refer to survey prepared by Waterview Surveying Services, as referenced in report.

DAVIES GEOTECHNICAL
CONSULTING ENGINEERS

Project No:	17-049	**Scale:**	as shown
Drawn:	wnd	**Date:**	18 Dec 17

GEOTECHNICAL SLOPE SECTION 4
PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW
(Aveo Group)

Figure 4D

View west from No.79

Large sandstone floaters

Large sandstone floaters

View west from No.79

View north within No.79

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Project No: 17-049

Drawn: wnd

Scale: NTS

Date: 28 Nov 17

SITE PHOTOGRAPHS
PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW
(Aveo Group)

Figure 5A

[Traverse T2] Drainage line emanating from No.83

[Traverse T2]
Half-round concrete batter drain eroded beneath
by water from drainage line off No.83

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Project No:	17-049	**Scale:**	NTS	SITE PHOTOGRAPHS PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	**Figure 5B**
Drawn:	wnd	**Date:**	28 Nov 17		

[Traverse T2] View west along "BMX" track

View west along vehicular access track at base of northern hillslope

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Project No:	17-049	**Scale:**	NTS	SITE PHOTOGRAPHS PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	**Figure 5C**
Drawn:	wnd	**Date:**	28 Nov 17		

Cut batter on western side of internal access road

View north across lower grassed footslope area east of internal access road (site for eastern residential units)

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Project No: 17-049	**Scale:** NTS	SITE PHOTOGRAPHS PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	**Figure 5D**
Drawn: wnd	**Date:** 28 Nov 17		

- Photos by Davies Geotechnical Pty Ltd, Barkala Rd Bayview, April - July 2008.
- Subsurface conditions for Newport Formation. sandstone stratigraphy, RL range 22m - 32m AHD.

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Project No: 17-049
Drawn: wnd
Scale: NTS
Date: 24 Nov 17

ANTICIPATED SUB-SURFACE CONDITIONS
PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW
(Aveo Group)

Figure 6A

- Photos by Davies Geotechnical Pty Ltd, Park St Mona Vale, August 2012.
- Subsurface conditions for Newport Formation sandstone stratigraphy, RL range 18m - 22m AHD.

DAVIES GEOTECHNICAL

CONSULTING ENGINEERS

Project No: 17-049

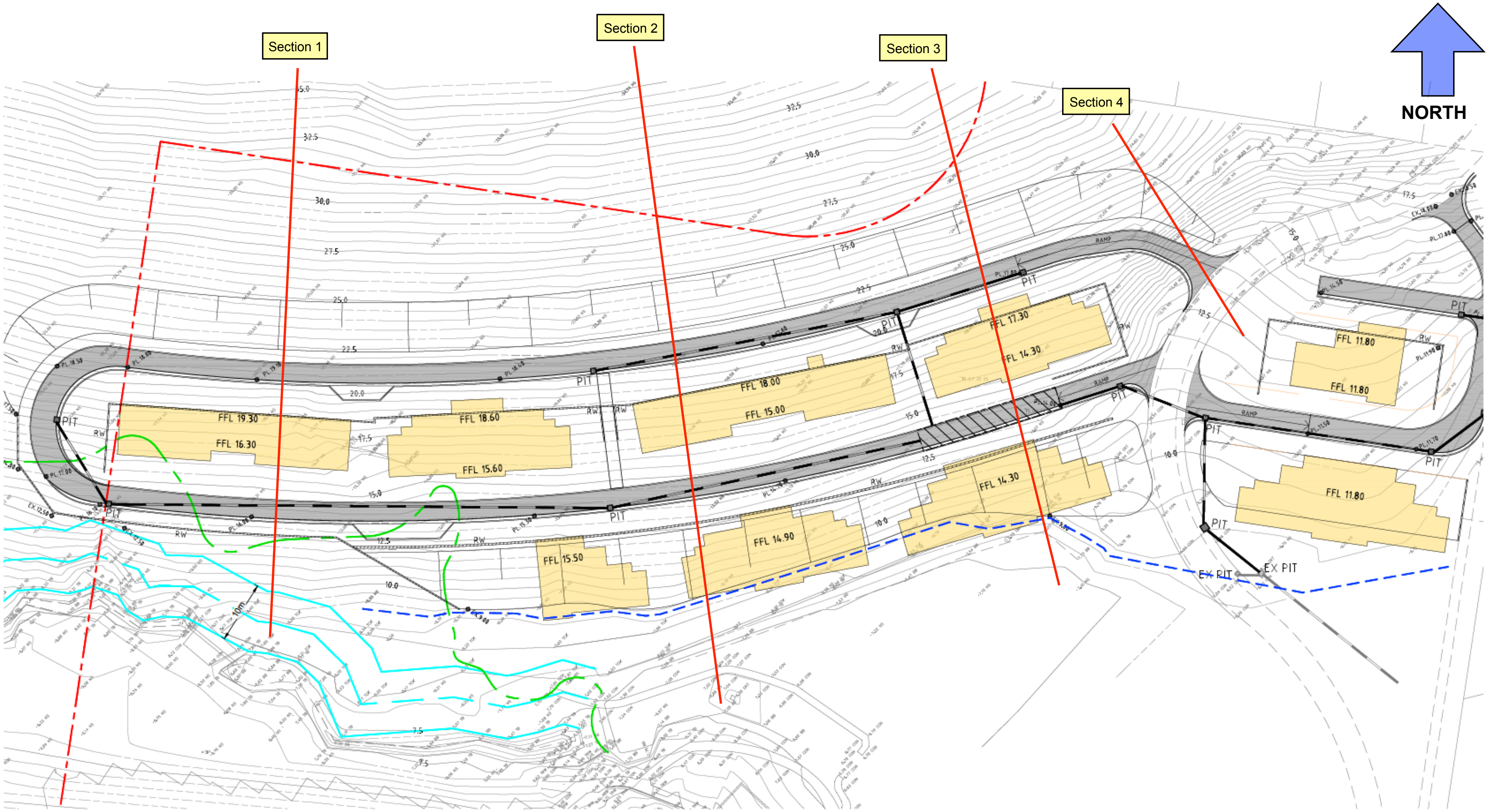
Scale: NTS

Drawn: wnd

Date: 24 Nov 17

ANTICIPATED SUB-SURFACE CONDITIONS
PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW
(Aveo Group)

Figure 6B



- ❑ Geotechnical slope sections shown on Figures 4A - 4D.
- ❑ Architect's sections 1 & 2 shown on Figure 8.
- ❑ Base plan / road design by Northrop Consulting Engineers, NL171426_CIVIL BASE-DA.171213-Model

DAVIES GEOTECHNICAL
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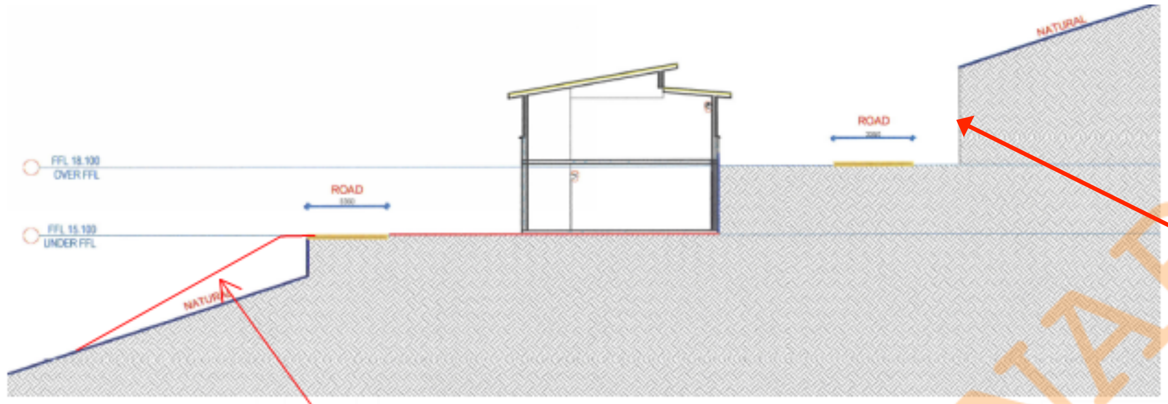
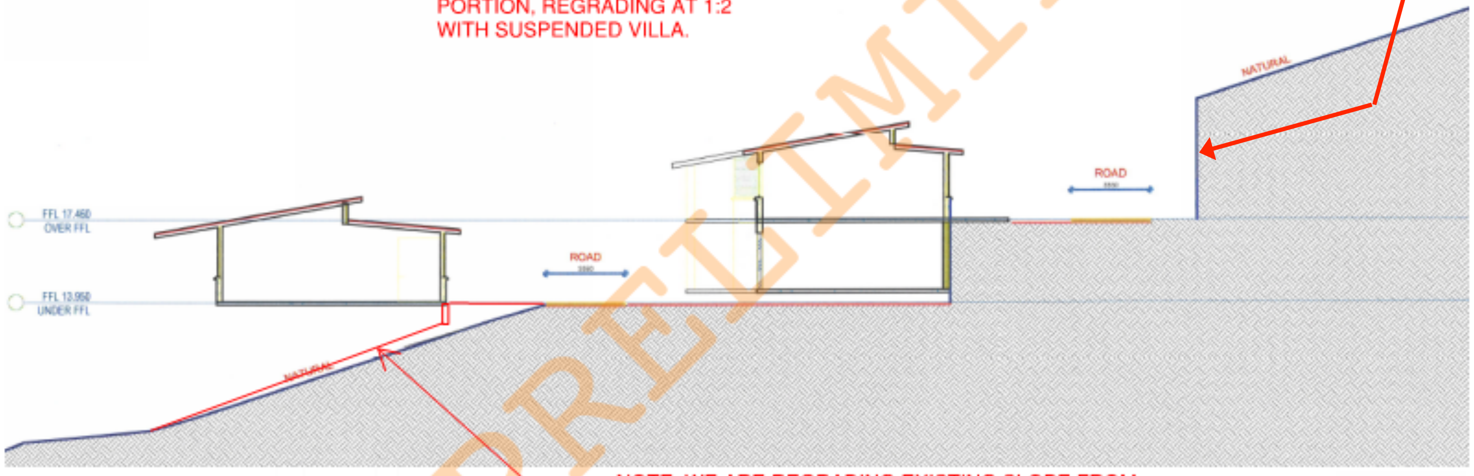
Project No:	17-049	**Scale:**	as shown	PROPOSED DEVELOPMENT - PLAN PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	Figure 7
Drawn:	wnd	**Date:**	29 Jan 18		



Road excavation support and batter geometry indicative only.
Subject to geotechnical appraisal following detailed investigation, engineering design and geotechnical review prior to construction

SECTION 1

ASSUME THIS IS FOR EASTERN PORTION. SIMILAR TO WESTERN PORTION, REGRADING AT 1:2 WITH SUSPENDED VILLA.



NOTE; WE ARE REGRADING EXISTING SLOPE FROM APPROX 1:3 to 1:2. ALSO IMPLEMENTING nom 1m RW TO REDUCE CUT TO NORTHERN ROAD.

SECTION 2

- ❑ Architectural details provided by Jackson Teece 15 Dec 2017 (subject to amendment as design progresses)
- ❑ Section locations shown on Figure 2 and Figure 7
- ❑ Refer also to geotechnical slope sections shown on Figures 4A - 4C

DAVIES GEOTECHNICAL
CONSULTING ENGINEERS

Project No: 17-049	**Scale:** as shown	PROPOSED DEVELOPMENT - SECTIONS PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	**Figure 8**
Drawn: wnd	**Date:** 18 Dec 17		

APPENDIX A

Landslide Risk Assessment

APPENDIX A

LANDSLIDE RISK ASSESSMENT AND MANAGEMENT

PROPOSED INDEPENDENT LIVING DEVELOPMENT
PENINSULA GARDENS RETIREMENT VILLAGE
No.79 CABBAGE TREE RD BAYVIEW NSW

A1 GEOTECHNICAL CONSTRAINTS/SUITABILITY OF DEVELOPMENT

The geotechnical constraints assessed for residential development on this site comprise hazards related to slope instability risk and foundation/footing conditions for building structures. These are discussed below.

A2 RISK ANALYSIS

The risk of slope instability for this site has been assessed using the methods of the AGS March 2007 publication *Practice Note Guidelines for Landslide Risk Management 2007* (reference 1), as shown on the attached flow chart, and in accordance with Geotechnical Risk Management Policy for Pittwater (reference 4). Definitions of the terminology used are also provided in the attachments herewith.

Important factors relating to slope conditions and the impacts of development, which commonly influence the risks of slope instability, are discussed in Appendix B attached to this report.

The assessment has been carried out by:

- consideration of the likely slope failure mechanisms and likely initiating circumstances which could affect the elements at the site. The type or mode of landslide failure has also been classified.
- for each case, the potential consequences with respect to any existing or future development have been considered. The current assessed probability of occurrence of each event has been estimated on a qualitative basis. The consequences and probability of occurrence have been combined for each case to provide the risk assessment.

The terms used to describe the consequences, probability of occurrence and risk are defined in the attached Appendix C extract from AGS 2007 "Landslide Risk Assessment – Qualitative Terminology for Use in Assessing Risk to Property". Reference is also made to geotechnical risk assessment procedures and background presented by Walker (2002) (reference 6).

Potential hazards or slope/structure failure mechanisms for the site have been considered in two groups: (a) existing conditions and (b) future development, limited to the northern hillside area of the site. The more gently sloping lower portion of the site east of the existing access driveway is not considered to have significant plausible hazards requiring evaluation.

The hazards are described below and are illustrated schematically on Figure A1 below.

EXISTING CONDITIONS

- ☐ **Type 1** – r*otational/translational earth slide failure within natural hillside*

  The ground surface on the subject south-facing hillside is characterised by a uniform slope of 15° to 20° with some noted inclusion of minor historical cut and fill tracks and a recent BMX course. Whilst obvious signs of large scale slope instability were not observed at the time of our site visit, such ground slopes are typical for earth creep or earth slide movement in this geological environment.

The assessed likelihood of failure is POSSIBLE for the smaller to medium scale failures of this type. As there is no development on the northern hillslope area, the consequence for property damage due to a failure in this manner is assessed to be INSIGNIFICANT. The likelihood of larger scale failures is assessed to be UNLIKELY with MINOR consequence, possibly limited to clean-up and slope restoration.

- ❑ **Type 2** – *rotational or planar failure of excavated batter adjoining western side of access driveway*

  This batter has been excavated as part of the earthworks formation of the internal access road. Batter angles are as steep as 44° and reduce to 30° over the extent of the cut face. Excavated slopes at such steep angles within this geology are prone to various levels of failure ranging from surface slumping to slides or planar failure. Whilst the scoured surface profile around the concrete surface drain on this batter is likely to be primarily from concentrated water flows, the scouring shows that unprotected batters at this angle will degrade with further potential for failure.

  The assessed likelihood of continuing degradation and failure is LIKELY for this batter. The consequence for property damage due to a failure in this manner is assessed to be INSIGNIFICANT, possibly limited to debris clean-up.

FUTURE DEVELOPMENT

- ❑ **Type 3A** – *collapse of temporary earthworks batters or temporary support structures for the proposed roadworks and building platforms (construction stage).*

  The bedrock level and conditions of the slope are uncertain without prior investigation. If poor engineering standards were adopted (eg a low level of geotechnical investigation or no investigation, little to no engineering supervision), and given the potential height of unsupported temporary batters (5m plus), a failure in these circumstances is assessed as LIKELY.

  The consequence for property damage during construction due to failure is assessed to be MINOR to MEDIUM, comprising damage to partly completed construction work, or partly completed dwellings, and debris clean-up and removal from site.

- ❑ **Type 3B** – *collapse of permanent unsupported earthworks batters for the roadworks (as-constructed)*

  As for Hazard 3A, the bedrock level and conditions of the slope are uncertain without prior investigation, although they would be assessed to a degree during construction. If poor engineering standards were accepted during construction, and given the potential height of unsupported temporary batters (5m plus), a failure in these circumstances is assessed as POSSIBLE.

  Due to the height of these batters (5m plus) there is potential for a larger scale of a failure and thus the consequence for property damage during construction is assessed to be MEDIUM to MAJOR, including damage to one or multiple residential buildings on the downhill side of the road.

  Attention is drawn to comments in A3 below regarding the potential for higher overall risks on a “societal” basis where multiple dwellings may be involved in the consequences of a large-scale failure event.

- ☐ **Type 3C** – *collapse of support structures constructed for the roadworks design.*

  It should be assumed that work involving structural support for the road excavation will be undertaken in accordance with the engineering procedures and controls as recommended herein. Accordingly, the assessed likelihood of failure for Hazard 3C is RARE.

  As for Hazard Type 3B, there is potential for a larger scale of a failure and thus the consequence for property damage during construction should be assessed as MEDIUM to MAJOR (similar to 3B), including damage to one or multiple residential buildings on the downhill side of the road.

  The structural design in this case may have a controlling or modifying effect on the scale and nature of failure and hence the level of potential consequence might be reduced. However, this would depend on the design.

  Attention is drawn to comments in A3 below regarding the potential for higher overall risks on a "societal" basis where multiple dwellings may be involved in the consequences of a large-scale failure event.

- ☐ **Type 4 –** *boulder roll from higher elevations.*

  The landform at the higher elevations above the site does not include a prominent cliff face. This is confirmed from viewing the slope across the Peninsula Gardens handle of land and across to the west on the rear slope areas of the private properties fronting onto Cabbage Tree Rd.

  However, there are numerous surface exposures of sandstone and some large detached floaters on the slope in this area. Boulder roll hazards would require a release mechanism to initiate the hazard occurrence, eg, a severe event of surface water erosion removing support from below a boulder.

  Our limited slope mapping and general observations along the traverse lines did not reveal evidence of boulders on the lower slopes, such that otherwise might indicate a rock fall and run-out hazard for the future development.

  The assessed likelihood of a boulder roll initiating and travelling downslope to affect the development is considered to be BARELY CREDIBLE. This has been determined by:

(i)	annual probability of an insitu boulder releasing to travel downslope	10^{-2}
(ii)	conditional probability that the boulder will actually travel downslope rather than stop its movement and remain at the general elevation where it started from	10^{-1}
(iii)	having commenced travel downslope, conditional probability the boulder reaches the elements at risk (the dwellings)	$<10^{-2}$
(iv)	further conditional probability that the boulder impacts a dwelling causing loss of life, rather than just causing damage, or passing through without impacting anything	10^{-1}
	combined probability – product of (i) to (iv)	**10^{-6} or lower**

  The potential consequence for property damage (impact with a dwelling) due to failure is assessed as possibly up to MAJOR, and certainly has potential to cause loss of life.

Failure of footings/retaining walls constructed as part of the building works (rotation, collapse, loss of bearing capacity) were considered as part of the risk analysis. It is reasonable to assume that these elements of the proposed development will be designed to sound engineering principles and will be constructed under engineering supervision, with a consequently reduced uncertainty of the natural slope conditions being responsible for a failure of the structural elements.

The likelihood of a failure from these components of the development occurring is RARE or lower, with consequence level for property damage assessed at no higher than MAJOR, ie a LOW RISK outcome, or lower. Risk to life assessed for other projects resulting from this group of hazards has typically been found to be well below the acceptable threshold level of 10^{-6} per annum.

A3 SUMMARY OF RISK OUTCOMES

For each identified hazard/event, the elements of the existing conditions and the new development at this site that would be considered to be at risk are residential and associated structure(s), services, and landscaping improvements. Table A1 and Table A2 provide a risk analysis for the proposed development.

In summary, the outcome of the risk analysis undertaken is as follows:-

	Hazards	***Risk to Property*** (Table A1)	***Risk to Life (for person most at risk)*** (Table A2)
Existing Conditions	***H1, H2, H4***	***Very Low to Low***	***$<10^{-6}$***
Proposed Development			
▪ Non-engineered or poorly-engineered	**H3A, H3B**	***Moderate to High***	***Up to 1.5 x 10^{-4}***
▪ Engineered, with Risk Management	**H3C**	***Very Low to Low***	***$<10^{-6}$***

The above risks for non-engineered or poorly-engineered work are unacceptable. However, with appropriate engineering investigation, design and construction controls, the assessed risks for the development (up to Low Risk for property, and $\leq 10^{-6}$ for Loss of Life) are **“acceptable”** as defined in the Geotechnical Risk Management Policy.

It is noted that the risk assessment and analyses presented for this report, and consideration of the outcome in terms of acceptance criteria, are based on the usual requirements of the Geotechnical Risk Management Policy for Pittwater, and in accordance with recommendations of AGS 2007, namely for “*the person most at risk*”.

Risk levels for non-engineered practices are higher as demonstrated by outcomes for some hazards considered in tables A1 & A2. These would be avoided by adherence to the recommendations of this report, consistent with the requirements of the Pittwater Geotechnical Risk Management Policy for managing foreseeable risk.

There is potential for increased overall risks on this project, where multiple dwellings within the development complex may be impacted by a large-scale failure event, with an increased level of consequence in regard to loss of life. The analyses for the assessment reported above (table A2) include a calculation for “*total risk”* for each hazard type.

The overall "*individual risk*" (AGS 2007, 7.4) is determined by summing the risks for "*the person most at risk*" for all the assessed hazards. This value (1.72 x 10^{-4} per annum) is shown at the bottom of the column for $\mathbf{R}_{\mathbf{(DI)}}$. For the hazards and consequence levels assessed in table A2, the "*individual risk*" is practically unchanged from the dominant risk level for "*persons most at risk*" (namely 1.5 x 10^{-4} per annum).

However, if the multiple dwellings case is considered for impact of the larger-scale hazards 3B or 3C, and the number of persons exposed to the risk is increased from 2 to (say) 24, the "*total risk*" increases roughly by an order of magnitude (eg to 3.6 x 10^{-3} for Hazard 3B).

The risk analysis and assessment, and appropriate acceptance criteria for the purposes of the DA for this development, do not extend to this level under the guidelines of the Pittwater Risk Management Policy. Further discussion is provided in 7.4(b) of the AGS 2007 Guidelines (reference 1) for assessment of "societal" risk.

The assessed risks are subject to maintenance and/or improvement of the present site conditions as discussed in the attached report, and to further geotechnical review should these conditions alter significantly in the future.

The engineering design and construction controls for the development must have regard for the potential that higher risks than accepted may result from a poor standard of design or a failure during construction to follow and implement minimum standards and requirements discussed in the report for safety and risk reduction.

Examples of recommended hillside development and construction practice are provided in the attachments to this report. Where relevant, the examples provide guidance for future development on this site, and should be incorporated in the development.

A4 FOOTINGS

All structural footings for buildings, retaining walls and other structural components of the work are to be taken to a bearing in undisturbed bedrock, to be verified by a geotechnical engineer at the time of construction (refer 6.2(b), (c), (h) and (i) in body of report).

A5 ONGOING SITE MANAGEMENT / GENERAL SLOPE MAINTENANCE / RISK REDUCTION

1. Drainage structures, retaining walls and general slope conditions within the property are to be inspected and maintained by the owner/proprietor in accordance with the recommendations in the table below.

Recommended Maintenance and Inspection Programme

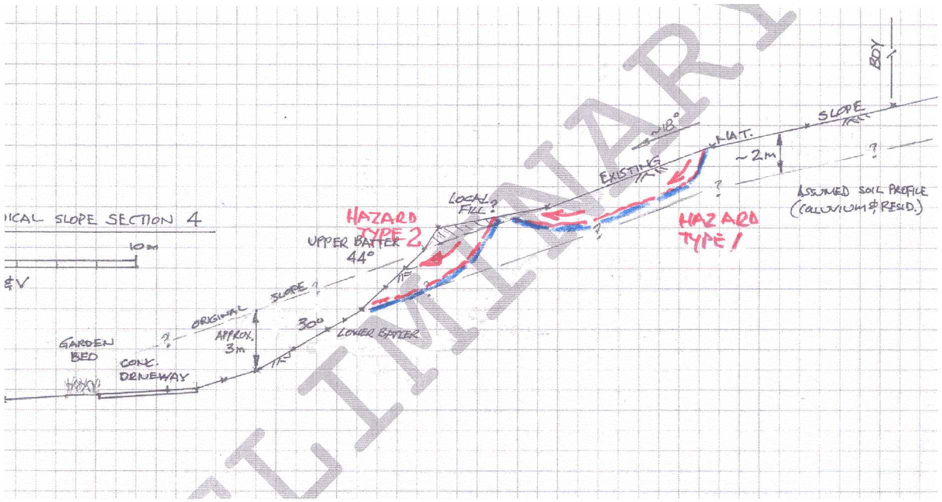
Structure/Feature	Maintenance/Inspection Task	Frequency
Drainage Lines	Inspect to ensure line is flowing and not blocked	Every year or during and following each significant rainfall event
Drainage Pits	Inspect to ensure that pits are free of debris and sediment build-up. Clear surface grates of vegetation and litter	During normal grounds maintenance and during and following each significant rainfall event, but not less frequently than every year
Retaining Walls	Inspect walls for deviation from as-constructed condition (tilting, rotation, lateral movement), and for signs of structural distress	Every 5 years or following each significant rainfall event

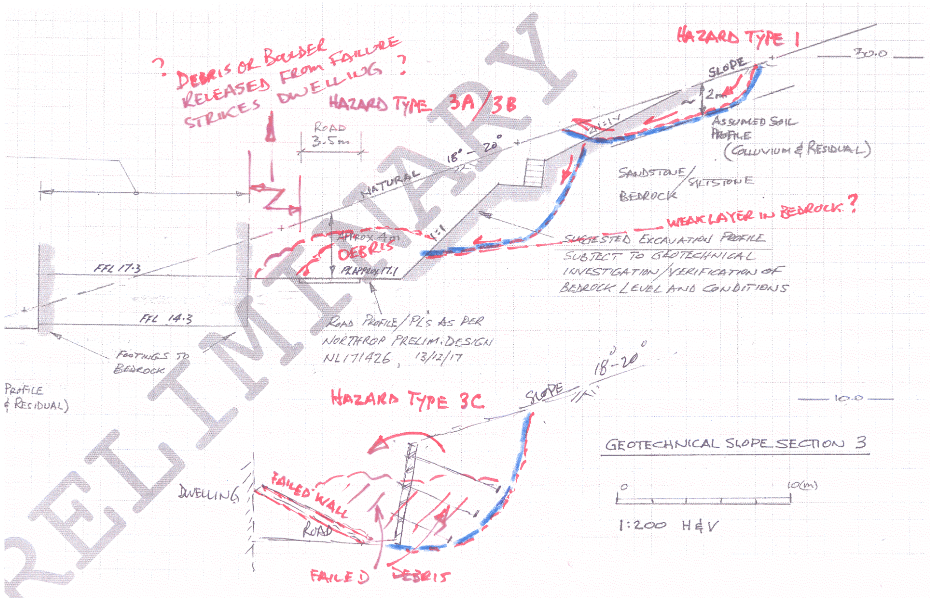
	Inspect and flush drainage lines behind wall	
	Maintain collector drain along top of wall	Every year or during and following each significant rainfall event
	Maintain sealed ground surface at top of wall to prevent infiltration of surface water into drainage behind wall	
General slope areas	Inspect for possible erosion, tension cracks, fretting of rock faces or block rotation on ledges or cliff lines	Every 5 years or following each significant rainfall event

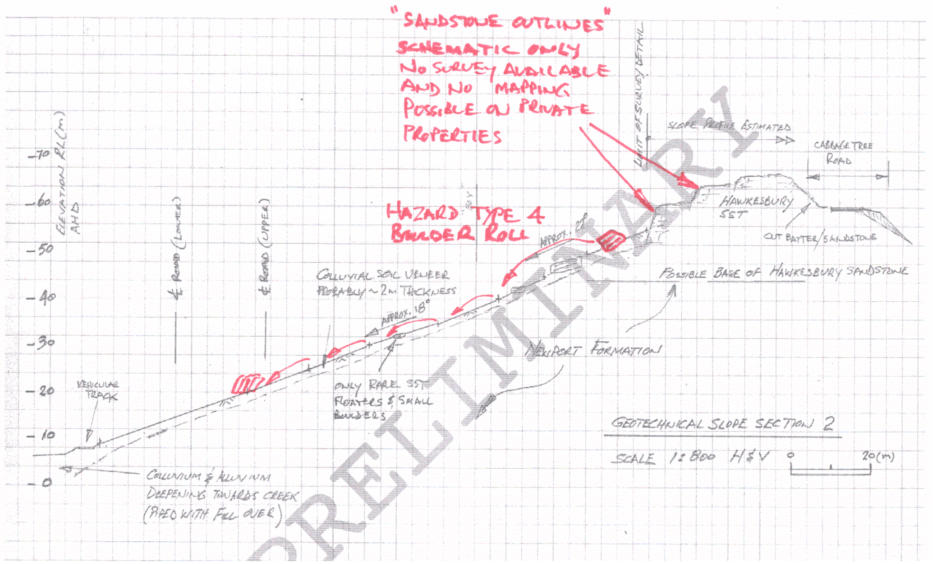
2. Maintain the functional performance of all retaining walls, and their associated drainage components, in general in accordance with the design requirements and maintenance specified on the structural drawings or other supplied details.

3. In the case of (a) retaining walls or their essential components, (b) drainage essential to slope stabilisation, or (c) other components of the development that determine the geotechnical hazards, where the structural or civil engineer responsible for design has indicated a design life of less than 100 years, the structure and/or its structural elements must be inspected by a structural or civil engineer (as appropriate) at the end of the design life. The engineer shall issue a written report identifying the required remedial measures to extend the design life of the structure and its essential components over the remaining portion of the 100 year period.

4. A Geotechnical Engineer should be engaged to undertake an assessment relating to slope instability risk, in accordance with the requirements of the Northern Beaches Council, should changes occur to the natural site features or to the development on this or adjoining property that adversely affect the risk of slope instability of the land or the development thereon.







- ☐ Section locations as shown on Figure 2/Figure 7.
- ☐ Hazards are indicative / schematic, and illustrate failure mechanisms.
- ☐ Scales / magnitude of failures may vary according to local slope conditions
- ☐ Refer to Appendix A of report for discussion / explanation of failure mechanisms and associated risk issues

DAVIES GEOTECHNICAL
CONSULTING ENGINEERS

Project No:	17-049	**Scale:**	as shown	GEOTECHNICAL SLOPE FAILURE HAZARDS PENINSULA GARDENS RETIREMENT VILLAGE, BAYVIEW NSW (Aveo Group)	**Figure A1**
Drawn:	wnd	**Date:**	25 Jan 18		

TABLE A1
LANDSLIDE RISK ASSESSMENT – RISK TO PROPERTY
Northern Hillslope, Peninsula Gardens Retirement Village, No.79 Cabbage Tree Rd Bayview NSW

(page 1 of 2)

POSSIBLE HAZARD				CONSEQUENCES (note 3)		ASSESSED LIKELIHOOD	RISK (note 1)	RISK TREATMENT, RISK REDUCTION AND COMMENTS
FAILURE ENVISAGED (note 2)		FAILURE MODE	INITIATING CIRCUMSTANCES					
1	Failure of natural slope	Rotational slump (small to medium volume)	– unsupported excavation across slope – seepage or surface water introduced to slope – fill surcharge placed on slope	Small to med. scale	INSIGNIFICANT	POSSIBLE	VERY LOW	▪ do not add water to slope. ▪ avoid unsupported excavations across slope ▪ do not surcharge slope
				Larger scale	MINOR	UNLIKELY	LOW	
2	Failure of existing excavated batter adjoining western side of access driveway.	Rotational slump or planar sliding (small volume)	– unsupported excavation across batter or steepening of batter – seepage or surface water introduced to slope – surcharge on slope	INSIGNIFICANT		LIKELY	LOW	▪ do not add water to slope. ▪ avoid unsupported excavations across batter ▪ do not surcharge slope ▪ do not steepen batter without engineered design and construction, as required , to ensure a stable batter configuration (refer to risk treatment for Hazard 3 below.
3A	Collapse of temporary earthworks batters or temporary support structures	Rotational slump, planar sliding.	– undetected weak zones or layers within batter. – inadequate design or construction of earthworks batters and support structures. – Inadequate surface and subsurface drainage provisions. – excavation in front of batters or structures – surcharge behind batters or structures.	Non/poorly-engineered	MINOR to MEDIUM	LIKELY	MODERATE to HIGH	▪ geotechnical engineer to provide design for earthworks batters and associated support structures. ▪ geotech design to be based upon borehole investigation of hillside as basis for determining slope model and geotechnical design parameters. ▪ structural engineer to provide design input as required for support structures. ▪ engineering supervision to ensure construction is compliant with design. ▪ manage surface and subsurface water, avoid excavation and surcharge as per Hazard 1 above
3B	Collapse of permanent unsupported earthworks batters for the roadworks	Rotational slump, planar sliding.			MEDIUM to MAJOR	POSSIBLE	MODERATE to HIGH	
3C	Collapse of support structures constructed for the roadworks design	Rotation, collapse, loss of bearing capacity		Engineered	MEDIUM to MAJOR	RARE	LOW	

TABLE A1
LANDSLIDE RISK ASSESSMENT – RISK TO PROPERTY
Northern Hillslope, Peninsula Gardens Retirement Village, No.79 Cabbage Tree Rd Bayview NSW

(page 2 of 2)

4	Boulder roll from higher elevations	Rock fall/boulder roll down slope	– adverse joint features, undercutting – tree root jacking – surcharge in crestal area – significantly altered drainage conditions at higher elevations – natural geological processes gradual attrition due to weathering or arising from sudden collapse of previously intact stratum	MAJOR	BARELY CREDIBLE	VERY LOW	▪ periodically check condition of higher elevations of site, in particular, observing for man-made or natural degradation of the area resulting in unsupported rock/boulder elements. ▪ carry out maintenance repairs as required.

Notes

1. The above risk assessment addresses the consequences to property from potential landslide events considered relevant to the subject site and the proposed development. The risk assessment is based on a visual appraisal and limited subsurface investigation only (where undertaken), as discussed in the attached report. Further assessment or quantification of the assessed geotechnical risks for the subject property would require additional data and/or investigation.

2. Refer above in Appendix A and to Figure A1 of this report for description and illustration of possible hazards/slope failure mechanisms.

3. The consequences assessed for the proposed development assume the structure is designed, constructed and maintained in accordance with all relevant recommendations of this report.

4. Refer to report and attachments for definition and explanation of terms used in the risk assessment.

TABLE A2
LANDSLIDE RISK ASSESSMENT – RISK TO LIFE
Northern Hillslope, Peninsula Gardens Retirement Village, No.79 Cabbage Tree Rd Bayview NSW

29-Jan-18
R/17-049.A

ACCEPTANCE CRITERION

(page 1 of 1)

Hazard (note 2)	**Likelihood**	**Indicative Annual Probability** (note 3) $P_{(H)}$	**Use of Affected Structure**	**Probability of Spacial Impact** $P_{(S:H)}$	**Occupancy** N	**Case**	**Proportion of Time** (refer below) $P_{(T:S)}$	**Probability of Not Evacuating** $P_{(NE:S)}$	**Vulnerability** (note 4) $V_{(D:T)}$	**Risk Outcome** (note 5)				**Risk Evaluation** (note 6)
										Person Most at Risk $R_{(DI)}$	Total Risk $R_{(T)}$	Sum of Total Risks	Average of Persons Most at Risk $R_{(AV)}$	
1	Possible	1.00E-03	outdoors	0.01	2	(a1)	0.01	0.1	0.1	1.00E-09	2.00E-09	2.00E-09	1.00E-09	**acceptable**
2	Likely	1.00E-02	outdoors	0.01	2	(a1)	0.01	0.2	0.1	2.00E-08	4.00E-08	1.24E-06	2.07E-07	**acceptable**
		1.00E-02	road	0.1	2	(b1)	0.02	0.2	0.1	4.00E-07	8.00E-07			**acceptable**
		1.00E-02	road/vehicle	0.2	2	(c1)	0.01	0.1	0.1	2.00E-07	4.00E-07			**acceptable**
3A	Likely	1.00E-02	construction	0.1	5	(d1)	0.2	0.2	0.5	2.00E-05	1.00E-04	1.00E-04	2.00E-05	
3B	Possible	1.00E-03	outdoors	0.1	2	(a1)	0.01	0.1	0.1	1.00E-08	2.00E-08	3.01E-04	3.77E-05	
		1.00E-03	road	0.1	2	(f1)	0.02	0.2	0.8	3.20E-07	6.40E-07			
		1.00E-03	road/vehicle	0.2	2	(g1)	0.01	0.2	0.9	3.60E-07	7.20E-07			
		1.00E-03	dwelling	1	2	(e1)	0.3	1	0.5	1.50E-04	3.00E-04			
3C	Rare	1.00E-05	outdoors	0.1	2	(a1)	0.01	0.1	0.1	1.00E-10	2.00E-10	6.14E-07	7.67E-08	**acceptable**
		1.00E-05	road	0.1	2	(f1)	0.02	0.2	0.8	3.20E-09	6.40E-09			
		1.00E-05	road/vehicle	0.2	2	(g1)	0.01	0.2	0.9	3.60E-09	7.20E-09			**acceptable**
		1.00E-05	dwelling	1	2	(e1)	0.3	1	0.1	3.00E-07	6.00E-07			**acceptable**
4	Barely credible or lower	1.00E-06	outdoors	0.5	2	(a1)	0.01	0.5	1	2.50E-09	5.00E-09	6.58E-08	8.22E-09	**acceptable**
		1.00E-06	road	0.05	2	(f1)	0.02	0.2	1	2.00E-10	4.00E-10			
		1.00E-06	road/vehicle	0.1	2	(g1)	0.01	0.2	0.9	1.80E-10	3.60E-10			
		1.00E-07	dwelling	1	2	(e1)	0.3	1	1	3.00E-08	6.00E-08			
									Individual Risk (total for all hazards)	1.72E-04				

Occupancy	**Proportion of Time**	**Persons**	**Comments**
EXISTING CONDITIONS			
a) outdoors garden and recreation activity, on the slope			
a1)	0.01	2	Person gardening, casual activities, outdoor recreation, 2 hours per week
b) persons on existing access road			
b1)	0.02	2	Persons on road , 30 minutes per day
c) persons in vehicle on existing access road			
c1)	0.01	2	Persons driving on road,100 journeys per day, 10 seconds per journey
FUTURE DEVELOPMENT			
d) persons on slope at time of construction works			
d1)	0.2	2	10 hrs per day, six days per week, for 6 mths over 1 year
e) persons in dwelling			
e1)	0.3	2	assume 8 hrs per day presence in affected zone of dwelling.
f) persons on new internal loop road			
f1)	0.02	2	Persons on road , 30 minutes per day
g) persons in vehicle on new internal loop road			
g1)	0.01	2	Persons driving on road,100 journeys per day, 10 seconds per journey

Notes

1. The risk assessment addresses potential for fatality from possible landslide events considered relevant to the subject site. The risk assessment is based on a visual appraisal, as discussed in the attached report. Further assessment or more detailed quantification of the assessed risks to life would require additional data and/or further investigation.
2. Refer to Table A1 for description of hazards. Refer to Figure A1 for illustration of possible slope failure mechanisms.
3. $P_{(H)}$ based on values in table “Qualitative Measures of Likelihood” in Appendix C of AGS 2007.
4. Vulnerability factors derived from AGS 2007, Appendix F.
5. $R_{(DI)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times P_{(NE:S)} \times V_{(D:T)}$; $R_{(T)} = R_{(DI)} \times N$; $R_{(AV)} = \Sigma R_{(T)}/\Sigma N$
6. Refer to Council’s Geotechnical Risk Management Policy (for the Person Most at Risk).
   Acceptable $\leq 10^{-6}$
   x (tolerable) $\leq 10^{-5}$
   xxx not tolerable - treatment options to be assessed and implemented
7. Refer to report and attachments for definition and explanation of terms used in the risk assessment.
8. The hazard/failure mechanisms adopted for the risk analysis may vary when detailed subsurface investigation is carried out. Probability and scale of failure, and conditional probabilities should the event occur, are likely to change and affect the risk outcomes. The above risk analyses should be reviewed in the light of any investigations being undertaken, or any new data becoming available.

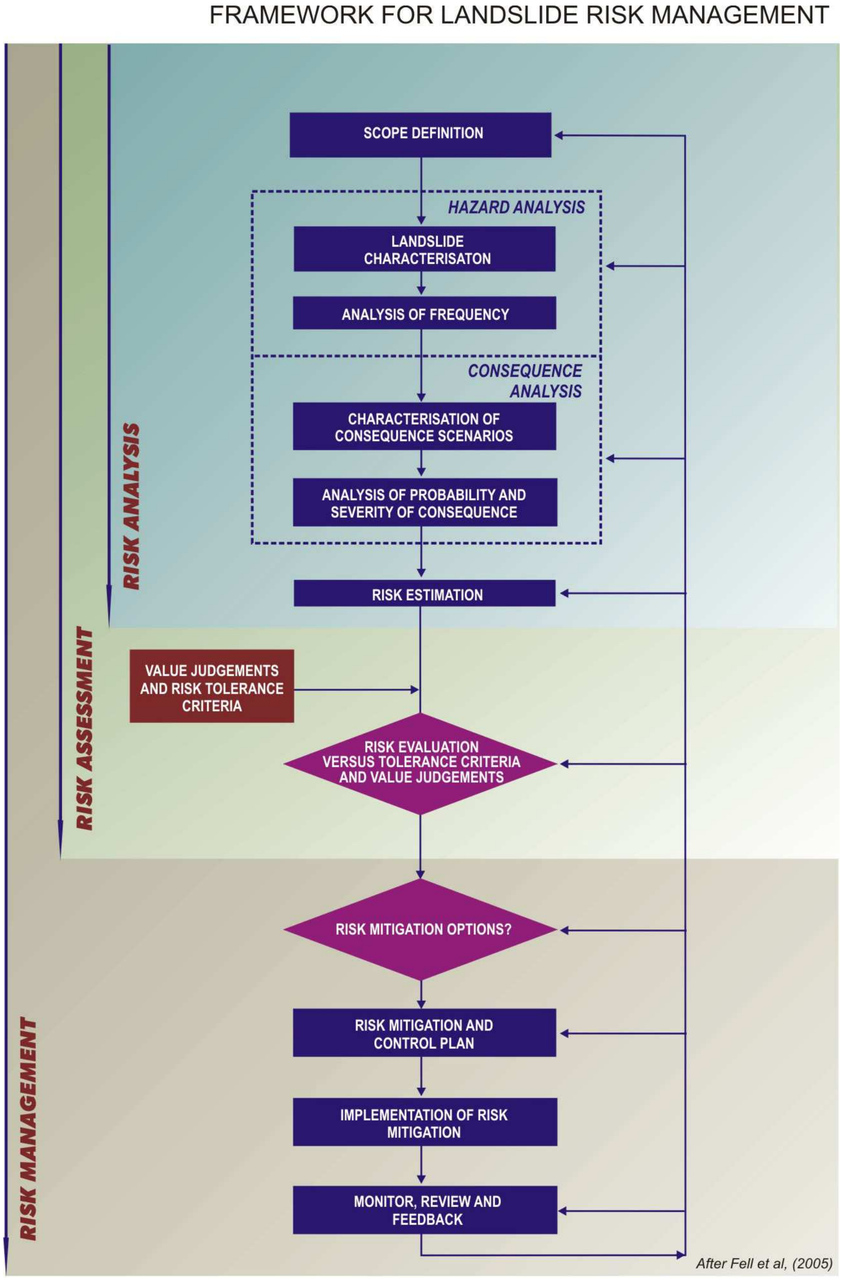


Figure 1.

The Framework for LRM presented in Figure 1 is similar to the flow chart in AGS (2000). However, it has been simplified in presentation and has been amended slightly from AGS (2000) to reflect the inclusion of Frequency Analysis as part of Hazard Analysis (in accordance with the abovementioned definition of hazard and as defined in AGS 2000).

Definitions for associated terminology have also been included in Appendix A together with an explanation of Landslide Risk as presented in AGS Australian GeoGuide LR7.

PART B GUIDELINES FOR REGULATORS

3 GUIDELINES FOR REGULATORS

3.1 BACKGROUND

The term landslide denotes *"the movement of a mass of rock, debris or earth down a slope"*. The phenomena described as landslides are not limited to either "land" or to "sliding" and usage of the word has implied a much more extensive meaning than its component parts suggest. The rates of movement cover the full range from very rapid to extremely

Picarellei, L., Oboni, F., Evans, S.G., Mostyn, G. and Fell, R., (2005) *"Hazard characterization and quantification"* Proc Int Conf on Landslide Risk Management, Vancouver, 31 May-3 June 2005, AA Balkema Publ, O. Hungr, R. Fell, R. Couture and E. Eberhardt eds., pp681

Varnes, D.J. and The International Association of Engineering Geology Commission on Landslides and other Mass Movements (1984). Landslide Hazard Zonation: A review of principles and practice. Natural Hazards, Vol 3, Paris,France. UNESCO, 63p.

Standards Australia (1996) *"Residential Slabs and Footings"* Australian Standard AS2870

Standards Australia (2001) *"Concrete Structures"* Australian Standard AS3600

Standards Australia (2001) *"Steel Structures"* Australian Standard AS4100

Standards Australia (2002) *"Earth Retaining Structures"* Australian Standard AS4678.

APPENDIX A - DEFINITION OF TERMS AND LANDSLIDE RISK

RISK TERMINOLOGY

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 (eg 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.

ASSOCIATED TERMINOLOGY

Importance Level – of a building or structure is directly related to the societal requirements for its use, particularly during or following extreme events. The consequences with respect to life safety of the occupants of buildings are indirectly related to the Importance Level, being a result of the societal requirement for the structure rather than the reason *per se* of the Importance Level.

Authority or **Council** having statutory responsibility for community activities, community safety and development approval or management of development within its defined area/region.

The **Regulator** will be the responsible body/authority for setting Acceptable/Tolerable Risk Criteria to be adopted for the community/region/activity, which will be the basis for setting levels for Acceptable and Tolerable Risk in the application of the risk assessment guidelines.

Importance Level of Structure	**Explanation**	**Examples** (Regulatory authorities may designate any structure to any classification type when local conditions make such desirable)
1	Buildings or structures generally presenting a low risk to life and property (including other property).	Farm buildings. Isolated minor storage facilities. Minor temporary facilities. Towers in rural situations.
2	Buildings and structures not covered by Importance Levels 1, 3 or 4.	Low-rise residential construction. Buildings and facilities below the limits set for Importance Level 3.
3	Buildings or structures that as a whole may contain people in crowds, or contents of high value to the community, or that pose hazards to people in crowds.	Buildings and facilities where more than 300 people can congregate in one area. Buildings and facilities with primary school, secondary school or day-care facilities with capacity greater than 250. Buildings and facilities for colleges or adult education facilities with a capacity greater than 500. Health care facilities with a capacity of 50 or more residents but no having surgery or emergency treatment facilities. Jails and detention facilities. Any occupancy with an occupant load greater than 5,000. Power generating facilities, water treatment and waste water treatment facilities, any other public utilities not included in Importance Level 4. Buildings and facilities not included in Importance Level 4 containing hazardous materials capable of causing hazardous conditions that do not extend beyond property boundaries.
4	Buildings or structures that are essential to post-disaster recovery, or with significant post-disaster functions, or that contain hazardous materials.	Buildings and facilities designated as essential facilities. Buildings and facilities with special post-disaster functions. Medical emergency or surgery facilities. Emergency service facilities: fire, rescue, police station and emergency vehicle garages. Utilities required as back-up for buildings and facilities of Importance Level 4. Designated emergency shelters. Designated emergency centres and ancillary facilities. Buildings and facilities containing hazardous (toxic or explosive) materials in sufficient quantities capable of causing hazardous conditions that extend beyond property boundaries.

(from BCA Guidelines)

Practitioner – A specialist Geotechnical Engineer or Engineering Geologist who is degree qualified, is a member of a professional institute and who has achieved chartered professional status – being either Chartered Professional Engineer (CPEng) within the Institution of Engineers Australia, Chartered Professional Geologist (CPGeo) within the Australasian Institute of Mining & Metallurgy, or Registered Professional Geoscientist (RPGeo) within the Australian Institute of Geoscientists – specifically with Landslide Risk Management as a core competency.

A Practitioner will include persons qualified under the Institution of Engineers Australia NPER – LRM register.

It would normally be required that the Practitioner can demonstrate an appropriate minimum period of experience in the practice of landslide risk assessment and management in the geographic region, or can demonstrate relevant experience in similar geological settings.

Regulator – The regulatory authority [Federal Government/ State Government/ Instrumentality/ Regional/Local.

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}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

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

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

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

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

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

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

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

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

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

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

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

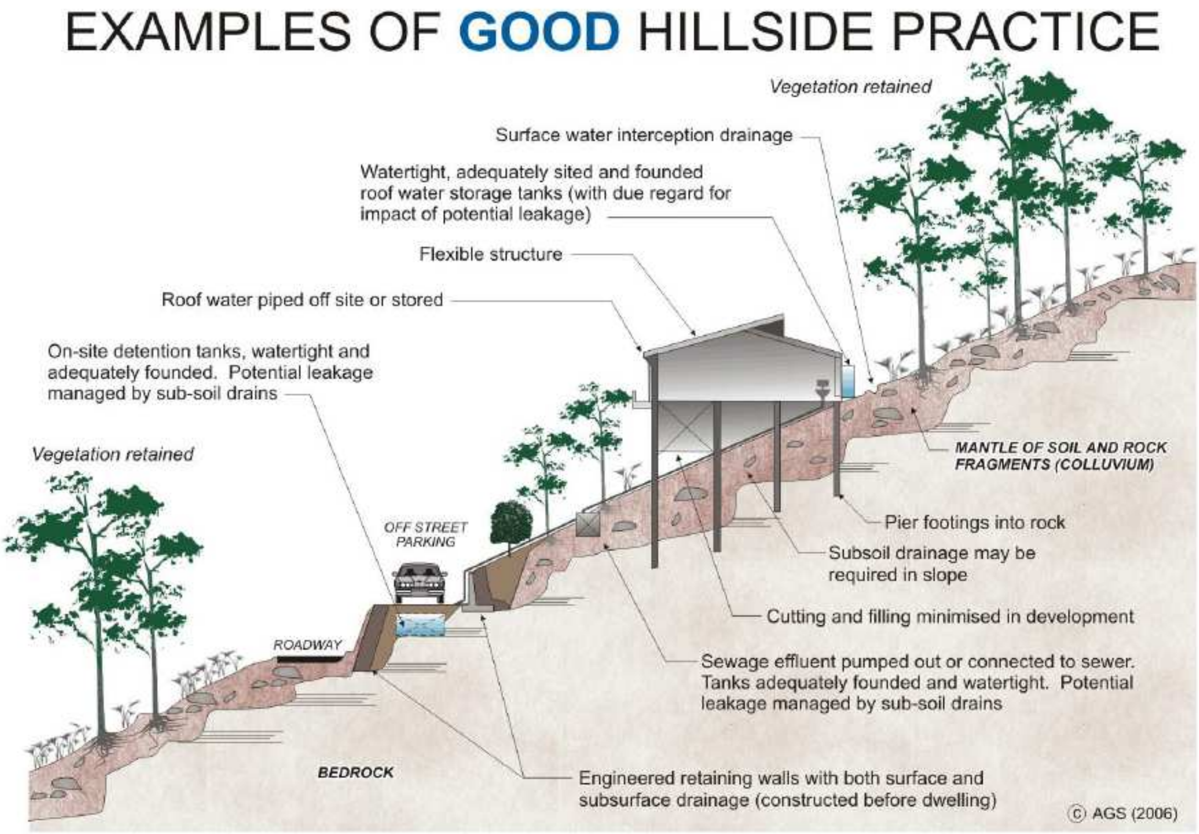
RISK LEVEL IMPLICATIONS

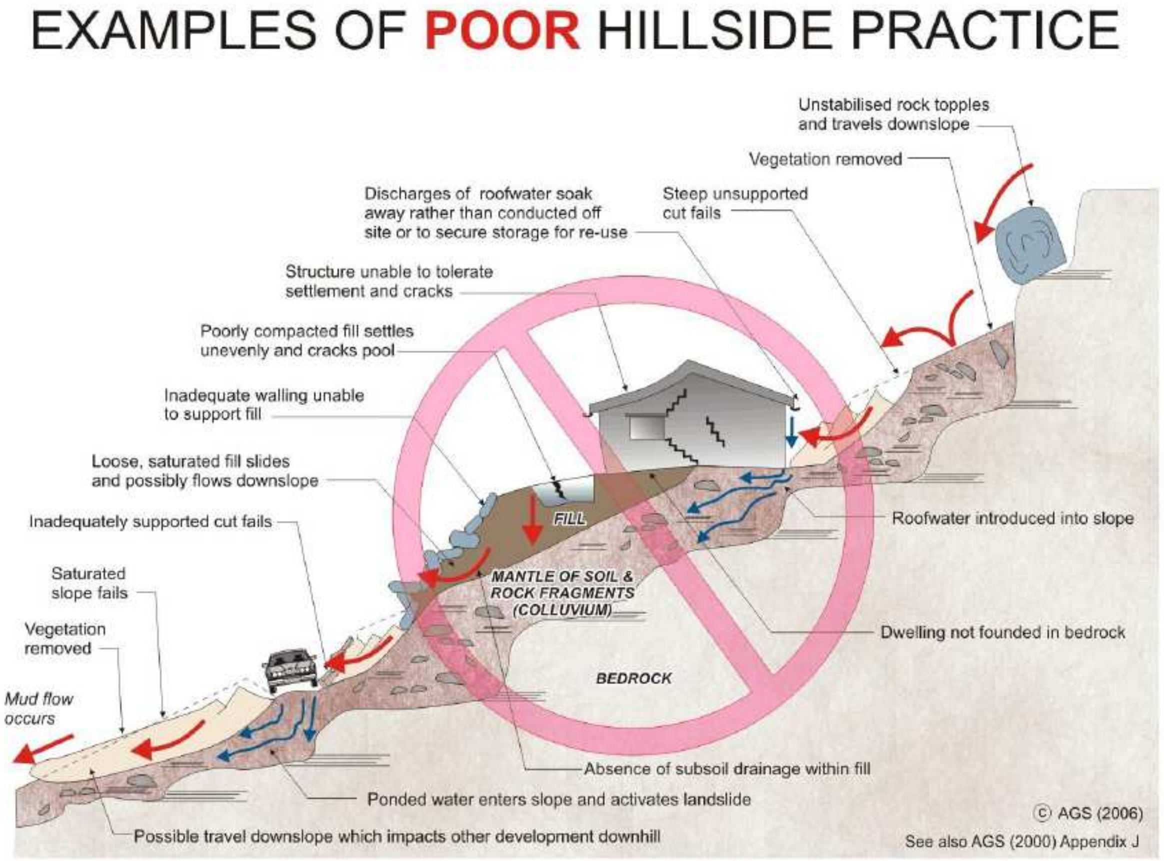
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.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

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

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

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


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


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

APPENDIX B

Important Factors Influencing the Stability of Slopes for Urban/Residential Development

(2 pages)

APPENDIX B

IMPORTANT FACTORS INFLUENCING ASSESSMENT OF STABILITY OF SLOPES FOR URBAN/RESIDENTIAL DEVELOPMENT

B1. Limitations of the Assessment Procedure

The assessment procedures carried out for this appraisal are in accordance with the recommendations of the AGS Risk Classification System described in Appendix A, and with accepted local practice. The following limitations must be acknowledged:-

◊ the assessment of the stability of natural slopes requires a great degree of judgment and personal experience, even for experienced practitioners with good local knowledge;

◊ the assessment must be based on development of a sound geological model; slope processes and process rates influencing landsliding or landslide potential will vary according to geomorphological influences;

◊ the likelihood that landsliding may occur on a given slope is generally hard to predict and is associated with significant uncertainties;

◊ different practitioners may produce different assessments of risk;

◊ actual risk of landsliding cannot be determined; risk changes with time;

◊ consequences of landsliding need to be considered in a rational framework of risk acceptance;

◊ acceptable risk in relation to damage to property from landslide activity is subjective; it remains the responsibility of the owner and/or local authority to decide whether the risk is acceptable; the geotechnical practitioner can assist with this judgement;

◊ the extent and methods of investigation for assessment of landslide risk will be governed by experience, by the perceived risk level, and by the degree to which the risk or consequences of landsliding are accepted for a specific project.

◊ the assessment may be required at a number of stages of the project or development; frequently (due to time or budget constraints imposed by the client) there will be no opportunity for long-term monitoring of the slope behaviour or groundwater conditions, or for on-going opportunity for the slope processes and performance of structures to be reviewed during and after development; such limitations should be recognised as relevant to the assessment.

B2. Slope Instability

In the Sydney Basin region, natural slope instability is mostly confined to the talus or colluvial material, but in some cases occurs in the residual clay soil overburden. The underlying bedrock on natural slopes, even in highly weathered form, is generally stable. Exceptions can occur and are known, particularly in the Illawarra and Newcastle regions.

In most of the reported slope failures in the Sydney Basin region, the cause of failure may be traced to one of the following factors:

(i) interference with natural drainage features,

(ii) introduction of additional water to the area,

(iii) excavation or removal of soil or rock from the toe (bottom) of the slope,

(iv) addition of soil or rock to the top of the slope.

There have been some slope failures with no immediately apparent cause and it is our opinion that these failures resulted from natural changes in the groundwater conditions in the slope during or some time after very heavy or prolonged periods of rainfall.

Continuing or intermittent downslope soil movement is an on-going natural geological process. It may be modified (accelerated or slowed) by the activities of man. Such movements become of concern when their magnitudes or rates have the potential to threaten the integrity of man-made improvements or threaten life or safety. A broad assessment of slope stability risk is presented in this report and it should be recognised that there is always a possibility that unpredicted slope movements can occur.

Developments can be designed to tolerate, or be isolated from, the effects of minor slope movements. Geotechnical assessment and design input, and monitoring will usually be required for such purposes.

In the case of creeping hillslopes, design that isolates the structure from the effects of slope creep is preferable. For example, retaining walls should be separated from the house structure so that if they move as a result of soil creep or other slope influences, the movements are not transmitted to the house. Where this cannot be achieved for the design, significant strengthening of the structure and/or its foundations, or other measures to modify the potential for slope movements, or the capacity of the structure to accommodate slope movements, will be required.

B3 **Development on Slopes**

B3.1 **General**

Some risk of slope instability is always attached to the development of land on slopes formed on talus and colluvium, and on residual soils. Appendix A explains the various levels of risk normally expected for development of land on such slopes and gives some guidelines for hillside construction.

B3.2 **Effects of Construction on Slope Stability**

The stability of apparently stable land may be adversely affected by various activities on the land or in the vicinity, as follows:

- the diversion of surface water onto the land by new roads, houses, landscaping, or other construction activities,
- the placing of filling either above or beside the land,
- the excavation or removal of soil or rock from the area below (downhill) of the land,
- the construction of absorption areas for stormwater or effluent, or other systems whereby liquids are introduced into the soil and rock.

B3.3 **Effects of Drainage on Slope Stability**

Good surface and subsurface drainage will almost always improve the stability of a slope. Where a new structure, modifications to an existing structure or landscaping is proposed on a slope, it is highly likely that some form of surface or subsurface drainage will be required to maintain or improve the stability of the slope.

A geotechnical engineer should review all proposed construction, developments or alterations on slopes, to assess the effect on slope stability and any required drainage.

APPENDIX C

Extracts from

Geotechnical Risk Management Policy for Pittwater - 2009

(Originally Pittwater Council P21 DCP Appendix 5, Policy No.178 amended 21 September 2009)

(3 pages)

Planning and Assessment Act requiring the lodgement of a Development Application.

(iv) for Excavation and Landfill activities for all development on land in the Pittwater LGA that includes:
- excavations greater than 1 metre deep, the edge of which is closer to the site boundary or a structure to be retained on the site, than the overall depth of the excavation and/or
- any excavation greater than 1.5 metres deep below the existing surface and/or
- any excavation that has the potential to destabilize a tree capable of collapsing in a way that any part of the tree could fall onto adjoining structures (proposed or existing) or adjoining property and/or
- any fill greater than 1.0 metre high and/or
- any works that may be affected by geotechnical processes or which may affect geotechnical processes including but not limited to construction on sites with low bearing capacity soils.

4.0 Definitions

Any terms which are defined in the Environmental Planning & Assessment Act 1979 (E.P & A) or the E.P & A Regulations 2000 there under have the same meaning when used in this Policy.

In this Policy, the following terms have the meanings set out below:

Acceptable Risk Management – The complete process of risk assessment and control of risk to the level defined as “acceptable” in this Policy.

Acceptable Risk – Acceptable Risk includes the risk to life and the risk to property, both must be considered. The guidance for the establishment of acceptable risk criteria in this Policy has been based on the contents of AGS 2007(c & d). Acceptable Risk for Loss of Life for the person(s) most at risk, per annum is taken as having a probability of 10^{6} per annum. Acceptable Risk for Loss of Property is taken as “Low” as defined in AGS 2007.

Risk levels for both loss of life and property should be determined in accordance with the methodologies presented in AGS 2007(c). Risk of loss of life should be determined quantitatively. Risk of loss of property can be determined quantitatively or in accordance with the qualitative terminologies and matrices presented in AGS 2007(c).

AGS – Australian Geomechanics Society.

Application - means any development application which relates to land in the Pittwater LGA

BCA - means the Building Code of Australia.

Building Certificate Geotechnical Risk Assessment – means a Geotechnical Report associated with the lodgment of a Building Certificate Application. The report must conform to the requirements of AGS 2007 for identification and treatment of risk to the “Acceptable Risk Management” criteria stated in this policy and the requirement to remove risk wherever reasonable and practical.

Geotechnical Engineer - means a specialist Geotechnical Engineer who is a registered professional engineer with chartered professional status being either CPEng or CPGeo or RPGeo with Landslide Risk Management as a Core Competency, and has an appropriate level of professional indemnity insurance.

Geotechnical Hazard - means a condition with the potential for causing the movement of rock, debris or earth, which may cause injury or death to persons or damage to, or destruction of property

Geotechnical Maps - means the maps identifying sites subject to Pittwater Council's Geotechnical Risk Management Policy for Pittwater Local Government Area. (See 3.2(b)).

Geotechnical Report - means a report prepared by and/or technically verified by a Geotechnical Engineer or Engineering Geologist as defined by this policy, which incorporates each of the elements, where applicable to the type of development, described in the "Preparation of the Geotechnical Reports" section of this policy.

Geotechnical Works - means the elements of site modification designed by the geotechnical engineer.

Life of the Structure – This provides the context within which the geotechnical risk assessment should be made. The required 100 year baseline broadly reflects the expectations of the community for the anticipated life of a residential structure and hence the timeframe to be considered when undertaking the geotechnical risk assessment and making recommendations as to the appropriateness of a development, its design and any remedial measures that should be put in place to control risk. It is recognized that in a 100-year period external factors that cannot reasonably be foreseen may affect the geotechnical risks associated with a site. Hence, the Policy does not seek the Geotechnical Engineers to warrant the development for a 100-year period, rather to provide a professional opinion that foreseeable geotechnical risks to which the development may be subjected in that timeframe have been reasonably considered.

Minor Development and/or Minor Alteration – Development/alterations with a value of less than $20,000 or as determined by Council from time to time every five years. That is, there can only be one minor development/alterations in any five-year period to a property for consideration under this category.

Occupation Certificate – means an interim or final Certificate under Section 109c of the EPA Act that if issued by Council or an accredited certifier, authorizes occupation and use of a building or part thereof.

Orders Process – Orders issued under Protection of the Environment Operations Act, 1997; Local Government Act, 1993; Environmental Planning & Assessment Act, 1979; Roads Act, 1993; and Noxious Weeds Act, 1993.

Policy - means this Geotechnical Policy.

Related Land - means land including roads and thoroughfares that could affect or could be affected by any development proposed on a site.

Remove Risk – It is recognized that, due to the many complex factors that can affect a site, the subjective nature of the science of geotechnical engineering, the risk for a site and/or development cannot be completely removed. It is, however, essential that risk be reduced to at least that which could be reasonably anticipated by the community in everyday life. Further, landowners should be made aware of the reasonable and practical measures available to them to reduce risk as far as possible. Hence where the Policy requires that "reasonable and practical measures have been identified to remove risk" it refers to the process of risk reduction. The Policy is not requiring the Geotechnical Engineer to warrant that risk has been completely removed, as this is not meaningfully achievable.

Requirements - include all acts, statutes, regulations, by-laws, ordinances, codes, delegated legislation, all approvals granted under any such instrument, the BCA, any applicable Australian Standard.

Risk - means a measure of the probability and severity of an adverse effect to health, property or the environment.

Site - means the whole of any parcel of land to which the carrying out of any development relates.

Site Classification - means a classification of the site in accordance with AS 2870.1 Australian Standard Residential Slabs and Footings.

Structure – Any building including, but not limited to residences, residential, industrial and commercial buildings, out buildings, pools and retaining walls.

Structural Design - means the selection and proportioning of load carrying elements incorporated in a structure, which require certification by a structural engineer.

Structural Document - means a document (which may be in the form of drawings) from a Structural Engineer or Civil Engineer which makes recommendations in respect of the Structural Design and Structural Works required for any structure to be erected on the site which, under this Policy, requires certification in accordance with Form 2.

Structural Works - means the elements of any structure designed by a structural engineer.

Tolerable Risk Management – The complete process of risk assessment and control of risk to the level defined as "tolerable" in this Policy.

Tolerable Risk – 10^{5} for the person(s) most at risk, per annum and "Moderate" for property, as defined in AGS 2007 (c & d). The Tolerable Risk criteria is only applicable to sites with structures that have been in existence in their present form for at least 10 years and have demonstrated a performance at a Tolerable Risk level, or better, during that period and there is not a foreseeable reason why this situation should change. Tolerable risk can only be considered as a criterion for the purpose of Building Certificates and under the Orders process.

Verifier - means a Geotechnical Engineer or Engineering Geologist or Coastal Engineer as defined by this policy who verifies a geotechnical report or aspects of a geotechnical report.

APPENDIX D

Limitations of this Report

(1 page)

APPENDIX D

LIMITATIONS OF THIS REPORT

Soil and rock formations are variable. The information presented as part of this report indicates the approximate subsurface conditions only at the specific test locations. Boundaries between zones on the logs or stratigraphic sections are often not distinct, but rather are transitional and have been interpreted.

The precision with which subsurface conditions are indicated depends largely on the frequency and method of sampling, and on the uniformity of subsurface conditions. The spacing of test sites also usually reflects budget and schedule constraints.

Groundwater conditions described in this report refer only to those observed at the place and under circumstances noted in the report. The conditions may vary seasonally or as a consequence of construction activities on the site or adjacent sites.

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

The comments given in this report are intended only for the guidance of the design engineer, or for other purposes specifically noted in the report. The number of boreholes or test excavations necessary to determine all relevant underground conditions which may affect construction costs, techniques and equipment choice, scheduling, and sequence of operations would normally be greater than has been carried out for design purposes. Contractors should therefore rely on their own additional investigations, as well as their own interpretations of the borehole data in this report, as to how subsurface conditions may affect their work.