FIGURE 4.5 COASTAL SLOPE INSTABILITY HAZARD STUDY

LEGEND

- Estimated Cliff Line
- 50yr 50% Recession Risk Line
- 50yr 5% Recession Risk Line
- Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre
- Additional lots subject to potential hazard
- DAs to require detailed geotech assessment
FIGURE 4.7  CLIFF RECESSION HAZARD LINES
HYAMS POINT

LEGEND

- Estimated Cliff Line
- 50yr 50% Recession Risk Line
- 50yr 5% Recession Risk Line
- Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre

COASTAL SLOPE INSTABILITY
HAZARD STUDY
FIGURE 4.8  CLIFF RECESSION HAZARD LINES
PLANTATION POINT
FIGURE 4.8  CLIFF RECESSION HAZARD LINES
PLANTATION POINT

LEGEND

- Estimated Cliff Line
- 50yr 50% Recession Risk Line
- 50yr 5% Recession Risk Line
- Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre

COASTAL SLOPE INSTABILITY
HAZARD STUDY
LEGEND

- Estimated Cliff Line
- 50yr 50% Recession Risk Line*
- 50yr 5% Recession Risk Line*
- Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre

* Recession Risk lines calculated based on rock platform width at Plantation Point
FIGURE 4.9  CLIFF RECESSION HAZARD LINES
PENGUIN HEAD AND CULBURRA BEACH

LEGEND

- Estimated Cliff Line
- 50yr 50% Recession Risk Line
- 50yr 5% Recession Risk Line
- Elevation Contour (m AHD)
- Wastewater lines
- Water supply lines
- Cadastre
APPENDIX A

Definition of Terms
APPENDIX A

GUIDELINE FOR LANDSLIDE SUSCEPTIBILITY, HAZARD AND RISK ZONING

APPENDIX A - DEFINITION OF TERMS

Acceptable Risk – A risk which, for the purposes of life or work, society is 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.

Danger – The natural phenomenon that could lead to damage, described in terms of its geometry, mechanical and other characteristics. The danger can be an existing one (such as a creeping slope) or a potential one (such as a rock fall). The characterisation of a danger does not include any forecasting.

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 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 probability 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 inventory – An inventory of the location, classification, volume, activity and date of occurrence of landsliding.

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

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

Landslide Susceptibility – A quantitative or qualitative assessment of the classification, volume (or area) and spatial distribution of landslides which exist or potentially may occur in an area. 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, judgement, 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, judgement 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.
APPENDIX A

GUIDELINE FOR LANDSLIDE SUSCEPTIBILITY, HAZARD AND RISK ZONING

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 individuals, 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 judgements enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental and economic consequences, in order to identify a range of alternatives for managing the risks.

Risk 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 affected area 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.

Zoning: The division of land into homogeneous areas or domains and their ranking according to degrees of actual or potential landslide susceptibility, hazard or risk.
# Appendix B

## Practice Note Guidelines for Landslide Risk Management 2007

### Appendix C: Landslide Risk Assessment

## Qualitative Measures of Likelihood

<table>
<thead>
<tr>
<th>Indicative Value</th>
<th>Implied Indicative Landslide Recurrence Interval</th>
<th>Description</th>
<th>Descriptor</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-5}$</td>
<td>5 x $10^{-2}$ years</td>
<td>The event is expected to occur over the design life.</td>
<td>ALMOST CERTAIN</td>
<td>A</td>
</tr>
<tr>
<td>$10^{-4}$</td>
<td>5 x $10^{-3}$ years</td>
<td>The event will probably occur under adverse conditions over the design life.</td>
<td>LIKELY</td>
<td>B</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>5 x $10^{-4}$ years</td>
<td>The event could occur under adverse conditions over the design life.</td>
<td>POSSIBLE</td>
<td>C</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>5 x $10^{-5}$ years</td>
<td>The event might occur under very adverse circumstances over the design life.</td>
<td>UNLIKELY</td>
<td>D</td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>5 x $10^{-6}$ years</td>
<td>The event is conceivable but only under exceptional circumstances over the design life.</td>
<td>RARE</td>
<td>E</td>
</tr>
<tr>
<td>$10^0$</td>
<td>5 x $10^{-7}$ years</td>
<td>The event is inconceivable or fanciful over the design life.</td>
<td>BARELY CREDIBLE</td>
<td>F</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Indicative Value</th>
<th>Nodal Boundary</th>
<th>Description</th>
<th>Descriptor</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$200%$</td>
<td>100%</td>
<td>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</td>
<td>CATASTROPHIC</td>
<td>1</td>
</tr>
<tr>
<td>$60%$</td>
<td>40%</td>
<td>Extensive damage to most of structure, and/or extending beyond site boundary's requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage</td>
<td>MAJOR</td>
<td>2</td>
</tr>
<tr>
<td>$50%$</td>
<td>20%</td>
<td>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</td>
<td>MEDIUM</td>
<td>3</td>
</tr>
<tr>
<td>$3%$</td>
<td>1%</td>
<td>Limited damage to part of structure and/or part of site requiring some small stabilisation works.</td>
<td>MINOR</td>
<td>4</td>
</tr>
<tr>
<td>$0.5%$</td>
<td>0.1%</td>
<td>Little damage. (Note for high probability event (Almost Certain), this category may be subdivided as a nodal boundary of 0.1%.)</td>
<td>INsignificant</td>
<td>5</td>
</tr>
</tbody>
</table>

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 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.

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APPENDIX B

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

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

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

<table>
<thead>
<tr>
<th>LIKELIHOOD</th>
<th>CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1: CATASTROPHIC 20%</td>
</tr>
<tr>
<td>A - ALMOST CERTAIN</td>
<td>$10^5$</td>
</tr>
<tr>
<td>B - LIKELY</td>
<td>$10^3$</td>
</tr>
<tr>
<td>C - POSSIBLE</td>
<td>$10^{-1}$</td>
</tr>
<tr>
<td>D - UNLIKELY</td>
<td>$10^{-5}$</td>
</tr>
<tr>
<td>E - RARE</td>
<td>$10^{-7}$</td>
</tr>
<tr>
<td>F - BARELY CREDIBLE</td>
<td>$10^{-9}$</td>
</tr>
</tbody>
</table>

Notes:
(5) For Cell AS, 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

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>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.</td>
</tr>
<tr>
<td>MEDIUM</td>
<td>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.</td>
</tr>
<tr>
<td>LOW</td>
<td>May be tolerable 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.</td>
</tr>
<tr>
<td>VERY LOW</td>
<td>Usually acceptable to regulator. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.</td>
</tr>
</tbody>
</table>

Note: 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 C

Guidelines for Hillside Construction
APPENDIX C

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

<table>
<thead>
<tr>
<th>ADVICE</th>
<th>GOOD ENGINEERING PRACTICE</th>
<th>POOR ENGINEERING PRACTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOLOGICAL ASSESSMENT</td>
<td>Obtain advice from a qualified, experienced geotechnical practitioner at an early stage of planning and before site works.</td>
<td>Require detailed plans and tender site works before geotechnical advice.</td>
</tr>
<tr>
<td>PLANNING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SITE PLANNING</td>
<td>Having obtained geotechnical advice, plan the development with the risk factors from the identified hazards and consequences in mind.</td>
<td>Plan development with disregard for the risk.</td>
</tr>
<tr>
<td>DESIGN AND CONSTRUCTION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOUSE DESIGN</td>
<td>Use durable structure which incorporates properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.</td>
<td>Floor plans which require extensive cutting and filling. Movement intolerant structures.</td>
</tr>
<tr>
<td>SITE CLEARING</td>
<td>Retain natural vegetation wherever practicable. Clear vegetation and debris suitable for local recycling.</td>
<td>Subsequently clear the site.</td>
</tr>
<tr>
<td>ACCESS &amp; DRIVeways</td>
<td>Site regulations below for cuts, fills, retaining walls and drainage. Council specifications. Graded areas may need to be modified.</td>
<td>Drainage requirements.</td>
</tr>
<tr>
<td>EARTHWORKS</td>
<td>Run natural contours wherever possible.</td>
<td>Subterranean bulk earthworks.</td>
</tr>
<tr>
<td>CUTS</td>
<td>Minimise depth. Support with engineered retaining walls or better to appropriate slope. Provide drainage measures and erosion control.</td>
<td>Large scale cuts and backfilling. Unsuitable cut.</td>
</tr>
<tr>
<td>FILLS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAISED OUTDOORS &amp; BUILDINGS</td>
<td>Remove or stabilise buildings which may have unacceptable risk. Support rock face where necessary.</td>
<td>Disturb or undermine detached buildings or buildings.</td>
</tr>
<tr>
<td>RETAINING WALLS</td>
<td>Engineer design to resist applied soil and water forces. Excavate site where practicable. Provide subsurface drainage within walls backfill and surface drainage on slope above. Construct wall as soon as possible after cut fill operation.</td>
<td>Construct a structurally inadequate wall, such as Substitute flagging, brick or unreinforced block.</td>
</tr>
<tr>
<td>FOOTINGS</td>
<td>Found within rock where practicable. Use rows of piers or strip footings spaced up and down slope. Design for lateral creep pressure where necessary. Backfill footing accretions to withstand ingress of surface water.</td>
<td>Found on topsoil, loose fill, detached boulder or undercliff.</td>
</tr>
<tr>
<td>SWIMMING POOLS</td>
<td>Engineer designed. Support on piles to rock where practicable. Provide with water drainage and gravity drain outer where practicable. Design for high and pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.</td>
<td></td>
</tr>
<tr>
<td>DRAINAGE</td>
<td>Provide at top of cut and fill slopes. Discharge to street drainage or natural watercourses. Provide general falls to prevent backwash by infiltration and incorporate silt traps. Line to minimise infiltration and make feasible where possible. Special structures to discharge excess of slope and direction.</td>
<td>Discharge at top of fills and cuts. Allow water to pond on bench areas.</td>
</tr>
<tr>
<td>SUBSURFACE</td>
<td>Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipework with access for maintenance.</td>
<td>Discharge roof runoff into absorption trenches.</td>
</tr>
<tr>
<td>SWING &amp; BARRIER</td>
<td>Utility requires pump-out or mains sewer systems. Discharge may be possible in some areas if risk is acceptable.</td>
<td>Discharge sewage directly onto site. Use absorption trenches without consideration of landside risk.</td>
</tr>
<tr>
<td>EROSION CONTROL &amp; LANDSCAPING</td>
<td>Control section as this may lead to instability. Revegetate cleared areas.</td>
<td>Failure to observe earthworks and drainage recommendations when landscaping.</td>
</tr>
<tr>
<td>DRAWINGS AND SITE VISITS DURING CONSTRUCTION</td>
<td>Building Application drawings should be viewed by a geotechnical consultant. Site visits by consultant may be appropriate during construction.</td>
<td></td>
</tr>
<tr>
<td>INSPECTION AND MAINTENANCE BY OWNER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OWNERS &amp; RESPONSIBILITY</td>
<td>Main drainage systems, repair broken joints in drains and leaks in supply pipes. Where structural distress is evident seek advice. If damage observed, determine cause or seek advice on consequences.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

EXAMPLES OF GOOD HILLSIDE PRACTICE

EXAMPLES OF POOR HILLSIDE PRACTICE
APPENDIX D

Notes Relating to Geotechnical Report
NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

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

Geotechnical Reports

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

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

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

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

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

If these occur, SMEC would be pleased to resolve the matter through further investigation, analysis or advice.

Unforseen Conditions

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

Subsurface Information

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

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

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

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

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

Supply of Geotechnical Information for Tendering Purposes

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