**KEIGHRAN GEOTECHNICS**
Geotechnical • Pavements • Materials • Consulting Engineers

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Principal
G.D. Keighran BE MIE(Aust)

Date: 10th April 2025 Your Ref: Our Ref: 25008/GK/1 Rev 2

Mr P. Warnock
P.O. Box 7152
WARRINGAH MALL NSW 2100

Dear Sir,

**Re: Geotechnical Assessment**
**Residential Development**
**1 Coolalie Place**
**Allambie Heights**

## 1. Introduction

At your request, our Mr G. Keighran has inspected the above property on the 27th March 2025. The property is located on the south eastern corner of the intersection of Coolalie Place and Southern Cross Way at Allambie Heights. This property is currently developed with a primary and secondary dwelling across the triangular in shape property with frontages to Coolalie Place and Southern Cross Way and side and rear boundaries to the adjoining properties at No. 3 Coolalie Place and No. 11 Southern Cross Way.

The inspection was undertaken in order to assess:

- the stability of the subject property
- the suitability for a proposed re-development
- provide geotechnical recommendations for the construction of the proposed new dwelling and studio structures.

Our inspection is based on visual assessment and incorporates judgement based on experience with other sites within the Sydney Basin Region. The surface features, rocky outcrops and vegetation of the property and adjoining land were carefully inspected and interpreted to assess the geological profile and natural stability of the land in relation to the re development of the property as detailed in the Architectural Drawings prepared by SRH Architecture Pty Ltd

## 2. Site Conditions

The property is located on the south western corner of the intersection of Coolalie Place and Southern Cross Way at Allambie Heights. The subject property is trapezoidal in shape with the shared driveway entering from Coolalie Place to leading directly to the secondary dwelling on the eastern side with the older red brick dwelling on the western side of the driveway with a level grassed front yard.

The property is generally level with fall to the rear southern boundary where a substantial sandstone outcrop covers the width of the property behind the both dwellings. Just beyond the southern boundary the outcrop falls sharply into the adjoining properties about 3 to 4 metres below the boundary.


Sandstone Outcrops in Southern Cross Way


Level Front yard looking from Dwelling to Street


Red Brick Dwelling from Central Driveway


Rear of Red Brick Dwelling with


Rear corner of Secondary Dwelling sandstone outcrop


small landscape wall in south western corner


Red Brick Dwelling and sandstone outcrop


South East Corner from Southern Cross Way

The surface around the properties exposed substantial sandstone outcrops some of which are considered to be bedrock generally stepping horizontally with the fall in reduced level. The level grassed frontyard is considered comprise shallow residual soils overling the massive sandstone bedrock at typically less than 0.6 metres.

## 3. <u>Site Geology and Subsurface Conditions</u>

The subject property is shown on the 1:100,000 Geological Series Map as being underlain by Hawkesbury Group of Sandstones. Typically, Hawkesbury sandstone ridges slopes down to the creeks and rivers in a series of sandstone benches ranging in elevation from one to hundreds of metres in height.

Sandstone landforms usually form a series of stepped benches with bedrock outcrops exposed in the slope. When talus or colluvial soils (slopewash) are deposited over these slopes the areas between benches and sometimes the benches themselves become buried. The bedrock exposures on the properties around both dwellings and and in cutting along Southern Cross Way are at shallow depth (less than 0.6 metres). The exposures are considered to be massive with limited fracturing and jointing.

## 4. Site Stability

The subject property has been assessed with reference to the Australian Geomechanics Society subcommittee on “Landslide Risk Management Concepts and Guidelines” March 2000 (Reference 2) and has included consideration of observed surface slope, extensive exposure of the subsurface conditions and assessment of existing retaining and dwelling structures on adjoining and subject property.

The natural exposed sandy soils are very shallow with a substantial exposure of the sandstone bedrock across the property. There is no evidence of detached boulders or undercut jointing within the bedrock across the property.

In regard to the risk of instability of the subject property, it is considered that:-

a) The subject property has been assessed in accordance with AGS “Landslide Risk Management Concepts and Guidelines” March 2000 as follows:-

Landslide Risk Assessment – Risk to Property

| Hazard or Mode of Instability | Likelihood | Consequence to Existing or Proposed Development | Risk to Proposed Development | Remarks |
|---|---|---|---|---|
| Uncontrolled Fill Materials behind retaining wall in south east corner | Possible | Minor | Low | Fill materials can be recompacted during bulk earthworks for the new dwelling and studio construction |
| Soil Creep | Not Credible | Insignificant | Very Low | None Observed |
| Active or Deep seated Slide | Not Credible | Major | Very Low | None Observed |
| Rock Fall (Detached Boulders) above dwelling location | Not Credible | Major | Very Low | Detached boulders if encountered can be removed during dwelling construction |
| Rock Fall (Undercut Bedrock) | Unlikely | Minor | Low | Trimming of Undercut Bedrock and Support of dwelling and studio on sandstone bedrock |

b) the majority of the subject property is currently in a stable condition, however:-

- the compaction of the any fill materials in the rear south western corner may require recompaction subject to proof rolling during the bulk earthworks for studio building
- the existing sandstone bedrock outcrops present a low risk of instability to the proposed studio and dwelling construction although some excavation may be required for utility services trenches.

However, the above risks and be substantially reduced or eliminated during the bulk earthworks for dwelling construction by any removing detached sandstone to found on the bedrock and recompaction of uncontrolled fill materials encountered.

c) the property is suitable for construction of the proposed residential dwelling and studio structures provided that the various recommendations of this report are implemented and the assessed risks of landslide are reduced to acceptable levels as detailed in Section 5 – Development Recommendations;

## 5. Development Recommendations

The proposed redevelopment of the property is detailed in the architectural drawings Project 24055 by SRH Architecture Pty Ltd and comprise the demolition of the existing red brick dwelling and construction of a new dwelling in its place and construction of a studio structure in the north east corner.

Attention is drawn to the general guidelines to hillside construction and drainage provided in the Appendix B to this report. The relevant sections of these guidelines should be regarded as 'recommendations' in addition to the specific recommendations which follow:-

### 5.1 Dwelling Construction

**Earthworks**

- At the beginning of the earthworks, all detached boulders and tree stumps are to be removed from the dwelling and studio structure locations to exposed the natural surface or sandstone bedrock.

- The use excavating equipment close to structures on adjoining properties may have significant damaging effect. The extend of the effect is dependent on the frequency and amplitude of the excavation equipment, the stiffness of the underlying soil or bedrock and the distance from the structure.

  Based on our inspection, we consider that the distance to the nearest dwelling on the adjoining property is about 1 metres from the western boundary which has potential to cause damage to residential structures should medium to large ungoverned hydraulic hammers be used for close excavation as a result we recommend small hammers are used with sawcutting to excavate into the sandstone bedrock on the subject property.

  As a guide, vibration monitoring undertaken by Keighran Geotechnics at a range of sites around Sydney in Hawkesbury Sandstone has indicated the following relationships (Table 1) for peak particle velocities measure at a range of distances for various hammer weights and types.

**Table 1 - Measured relationships between hammer type and weights and distance from the hammer**

| Hammer Type | Distance | Peak Particle Velocity |
|---|---|---|
| Krupp 300 or equivalent | 1.0 m | 15 mm / sec |
| | 1.5 m | 10 mm / sec |
| | 2.0 m | 7 mm / sec |
| Krupp 600 or equivalent | 3.5 m | 10 mm / sec |
| | 6.0 m | 5 mm / sec |
| | 9.0 m | 2 mm / sec |
| Krupp 900 or equivalent | 6.0 m | 20 mm / sec |
| | 9.0 m | 11 mm / sec |
| | 20.0 m | 4 mm / sec |

Australian Standard AS 2187.2 1993 (Explosives Code) recommends the maximum peak particle of 10 mm / sec be adhered to a the site boundary unless a lesser value is imposed by a regulatory authority. It is therefore recommended that a Krupp 300 hammer or equivalent be use no closer than 1.5 metres from the nearest structure. Similarly a Krupp 600 or equivalent should not be used closer than 3.5 metres and a Krupp 900 hammer or equivalent should not be used on the subject property.

We advise that, although less than generally required to cause structure damage, residents will probably find vibration levels above 3 mm / sec as being strongly perceptible to disturbing. We recommend the operation of hydraulic hammers should include:

- Excavation of loose or rippable sandstone blocks by bucket or single ripper attachments prior to the commencement of rock hammering;
- Depending on the size of the hammer and distance from the adjoining structure, saw cutting of the sandstone bedrock along the extremity of proposed excavations may be undertaken to minimise vibrations travelling to adjoining structures.
- Progressive breakage from open excavated faces;
- Selective breakage along open joints where these are present;
- Use of rock hammers in short bursts to prevent generation of resonant frequencies;
- Orientation of the rock hammer pick away from property boundaries and into existing open excavation;

However, we would recommend that the method and size of proposed excavation equipment are advised and / or inspected prior to excavation being undertaken to assess their possible impact.

We recommend that a dilapidation photographs of the adjoining dwellings and structures which includes photos of the external and internal walls identifying any existing distress.

- The sandstone bedrock encountered in the excavation may be trimmed vertically for the short term (several months) until retained by the walls of the proposed dwelling are installed .

- We recommend that bulk excavation and stability of the excavated faces are inspection during excavation by a structural / geotechnical engineer to confirm the battered slopes and joints encountered in the sandstone are suitably stable.

**Retaining Walls**

- The design of these walls may be undertaken on the basis of the following soil/rock parameters are considered appropriate for assessing the design loads on the permanent retaining walls:

| | | |
|---|---|---|
| Residual sandy soils | Ka = 0.30 | Density = 19 kN/m$^3$ |
| Highly weathered sandstone rock | Ka = 0.15 | Density = 22 kN/m$^3$ |
| Moderately to Fresh Sandstone Bedrock | Ka = 0 | Density = 24 kN/m$^3$ |

- The foundations of the retaining wall should be founded on or socketted into weathered sandstone bedrock for which an allowable bearing capacity of 1200 kPa or better may be adopted.

- Natural rock retaining walls are to be suitably founded at least 1.0 metres from the edge of any excavation or natural fall greater than 1.0 metres in height. All rock within the wall to be orientated so the bedding planes and longest side are horizontal or sloping back into the wall at up to 20 degrees maximum. Any wall greater than 0.9 metres in height is to be designed by a structural / geotechnical engineer and is to be constructed to their design requirements.

- The retaining wall designs should also allow for any additional surcharge loads, e.g. due to sloping backfill, these loads should be calculated separately. Appropriate drainage systems and free draining backfill should be provided to prevent the build-up of hydrostatic pressures behind all retaining walls.

- All exposed slopes are to be landscaped or grassed as soon as possible to limit the potential for erosion and scouring. Any landscaping details should allow surface water to runoff the slope rather than ponding on the slope.

**Dwelling and Structure Foundations**

- footings for all residential structures are to found on weathered sandstone bedrock. Care should be taken not to found on detached boulders, if structures are located near the edge of vertical slopes. Footing dimensions and reinforcement details appropriate for Class A sites (AS 2870 – 2011) will be satisfactory, provided that the footings socket into sandstone bedrock.

- An allowable bearing capacity of 1200 kPa or better may be adopted for foundations founded on or in weathered sandstone bedrock using both high level pads / strips or deeper bored piers.

- footing excavations should be inspected by a suitably qualified structural or geotechnical engineer prior to placing concrete, to confirm that the base of the footing encounters parent bedrock.

**Drainage**

- all roof water and run-off water is to be directed in closed pipes to the street, interallotment stormwater system or, subject to Council approval, to a drainage easement.

## 6. General

It is to be noted that the recommendations, comments and opinions expressed in this Report are based on visual assessment and experience on similar sites within the Northern Beaches Council.

Should subsurface conditions be encountered which differ markedly from those inferred in the report, or should the scope of the development works planned vary significantly from the driveway and residential development anticipated, then further geotechnical advice should be obtained.

Yours faithfully,
**KEIGHRAN GEOTECHNICS**
per:

**G.D. KEIGHRAN B.E. MIE(Aust)**
**Director - Principal Engineer**

Attachments:-
Appendix A - Definition of Terms
Appendix B - Landslide Risk Assessment – (Appendix G - AGS 2000)
Appendix C - Some Guidelines for Hillside Construction (Appendix J – AGS 2000)
Appendix D - Drainage Details and Notes

# DEFINITION OF TERMS

## INTERNATIONAL UNION OF GEOLOGICAL SCIENCES WORKING GROUP ON LANDSLIDES, COMMITTEE ON RISK ASSESSMENT

**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.

**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.

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

**Probability** – The likelihood of a specific outcome, measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between 0 and 1, with 0 indicating an impossible outcome, and 1 indicating that an outcome is certain.

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

**Likelihood** – used as a qualitative description of probability or frequency.

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

**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.

**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.

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

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

**Individual Risk** – 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.

**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.

**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.

**Tolerable Risk** – A risk that society is willing to live with so as to secure certain net benefits in the confidence that it is being properly controlled, kept under review and further reduced as and when possible.

In some situations risk may be tolerated because the individuals at risk cannot afford to reduce risk even though they recognise it is not properly controlled.

**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.

**Note:** Reference should also be made to Figure 1 which shows the inter-relationship of many of these terms and the relevant portion of Landslide Risk Management.

(from Australian Geomechanics Journal 1975)

This classification system provides a standardised terminology for the engineering description of the sandstone and shales in the Sydney Area, but the terms and definitions may be used elsewhere when applicable. Under this system rocks are classified by rock type, degree of weathering, strength, stratification spacing, and degree of fracturing are consistent with the terms described in AS 1726 - 2017. These terms do not cover the full range of engineering properties. Descriptions of rock may also need to refer to other properties (e.g. durability, abrasiveness, etc.) where these are relevant.

ROCK TYPE DEFINITIONS

| Rock Type | Definition |
|---|---|
| Conglomerate | More than 50% of the rock consists of gravel sized (greater than 2mm) fragments. |
| Sandstone | More than 50% of the rock consists of sand sized (.06 to 2mm) grains. |
| Siltstone | More than 50% of the rock consists of silt-sized (less than .06mm) granular particles and the rock is not laminated. |
| Claystone | More than 50% of the rock consists of clay or scricitic material and the rock is not laminated. |
| Shale | More than 50% of the rock consists of silt or clay sized particles and the rock is laminated. |

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, e.g. clayey sandstone, sandy shale.

DEGREE OF WEATHERING

| Term | Symbol | Definition |
|---|---|---|
| Extremely | EW | Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. Weathered it can be remoulded and can be classified according to the Unified Classification System but the texture of the original is still evident. |
| Highly | HW | Rock substance affected by weathering to the extent that limonite staining or bleaching affects Weathered the whole of weathered substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable. |
| Moderately | MW | Rock substance affected by weathering to the extent that staining extends throughout the whole. Weathered of the rock weathered substance and the original colour of the fresh rock is no longer recognisable. |
| Slightly | SW | Rock substance affected by weathering to the extent that partial staining or discolouration of the Weathered rock substance usually by limonite has taken place. The colour and texture of the fresh recognisable. |
| Fresh | Fr | Rock substance unaffected by weathering. |

DEGREE OF FRACTURING

The classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks.

| Type | Description |
|---|---|
| Fragmented | The core is comprised primarily of fragments of length less than 20mm, and mostly of width less than the core diameter. |
| Highly fractured | Core lengths are generally less than 20mm - 40mm with occasional fragments. |
| Fractured | Core lengths are mainly 30mm - 100mm with occasional shorter and longer sections. |
| Slightly fractured | Core lengths are generally 300mm - 1000mm with occasional longer sections and occasional sections 100mm - 300mm. |
| Unbroken | The core does not contain any fracture. |

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics (1972).

| Term | IS(50) MPa |
|---|---|
| Described as Soil | |
| | 0.03 |
| Very Low Strength | |
| | 0.1 |
| Low Strength | |
| | 0.3 |
| Medium Strength | |
| | 1.0 |
| High Strength | |
| | 3.0 |
| Very High Strength | |
| | 10.0 |
| Extremely High Strength | |

| Stratification Spacing Term | Separation of Stratification Planes |
|---|---|
| Thinly laminated | <6mm |
| Laminated | 6mm to 20mm |
| Very thinly bedded | 20mm to 60mm |
| Thinly bedded | 60mm to 0.2m |
| Medium bedded | 0.2m to 0.6m |
| Thickly bedded | 0.6m to 2m |
| Very thickly bedded | 2m |

# APPENDIX J

## SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

| | *GOOD ENGINEERING PRACTICE* | *POOR ENGINEERING PRACTICE* |
|---|---|---|
| **ADVICE** | | |
| GEOTECHNICAL ASSESSMENT | Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works. | Prepare detailed plan and start site works before geotechnical advice. |
| **PLANNING** | | |
| SITE PLANNING | Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind. | Plan development without regard for the Risk. |
| **DESIGN AND CONSTRUCTION** | | |
| HOUSE DESIGN | Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding.<br>Consider use of split levels.<br>Use decks for recreational areas where appropriate. | Floor plans which require extensive cutting and filling.<br>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.<br>Council specifications for grades may need to be modified.<br>Driveways and parking areas may need to be fully supported on piers. | Excavate and fill for site access before geotechnical advice. |
| EARTHWORKS | Retain natural contours wherever possible. | Indiscriminant bulk earthworks. |
| Cuts | Minimise depth.<br>Support with engineered retaining walls or batter to appropriate slope.<br>Provide drainage measures and erosion control. | Large scale cuts and benching.<br>Unsupported cuts.<br>Ignore drainage requirements |
| Fills | Minimise height.<br>Strip vegetation and topsoil and key into natural slopes prior to filling.<br>Use clean fill materials and compact to engineering standards.<br>Batter to appropriate slope or support with engineered retaining wall.<br>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.<br>Block natural drainage lines.<br>Fill over existing vegetation and topsoil.<br>Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill. |
| Rock Outcrops & Boulders | Remove or stabilise boulders which may have unacceptable risk.<br>Support rock faces where necessary. | Disturb or undercut detached blocks or boulders. |
| RETAINING WALLS | Engineer design to resist applied soil and water forces.<br>Found on rock where practicable.<br>Provide subsurface drainage within wall backfill and surface drainage on slope above.<br>Construct wall as soon as possible after cut/fill operation. | Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork.<br>Lack of subsurface drains and weepholes. |
| FOOTINGS | Found within rock where practicable.<br>Use rows of piers or strip footings oriented up and down slope.<br>Design for lateral creep pressures if necessary.<br>Backfill footing excavations to exclude ingress of surface water. | Found on topsoil, loose fill, detached boulders or undercut cliffs. |
| SWIMMING POOLS | Engineer designed.<br>Support on piers to rock where practicable.<br>Provide with under-drainage and gravity drain outlet where practicable.<br>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.<br>Discharge to street drainage or natural water courses.<br>Provide general falls to prevent blockage by siltation and incorporate silt traps.<br>Line to minimise infiltration and make flexible where possible.<br>Special structures to dissipate energy at changes of slope and/or direction. | Discharge at top of fills and cuts.<br>Allow water to pond on bench areas. |
| Subsurface | Provide filter around subsurface drain.<br>Provide drain behind retaining walls.<br>Use flexible pipelines with access for maintenance.<br>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.<br>Storage tanks should be water-tight and adequately founded. | Discharge sullage directly onto and into slopes.<br>Use absorption trenches without consideration of landslide risk. |
| EROSION CONTROL & LANDSCAPING | Control erosion as this may lead to instability.<br>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.<br>Where structural distress is evident see advice.<br>If seepage observed, determine causes or seek advice on consequences. | |

LANDSLIDE RISK MANAGEMENT AGS SUB-COMMITTEE

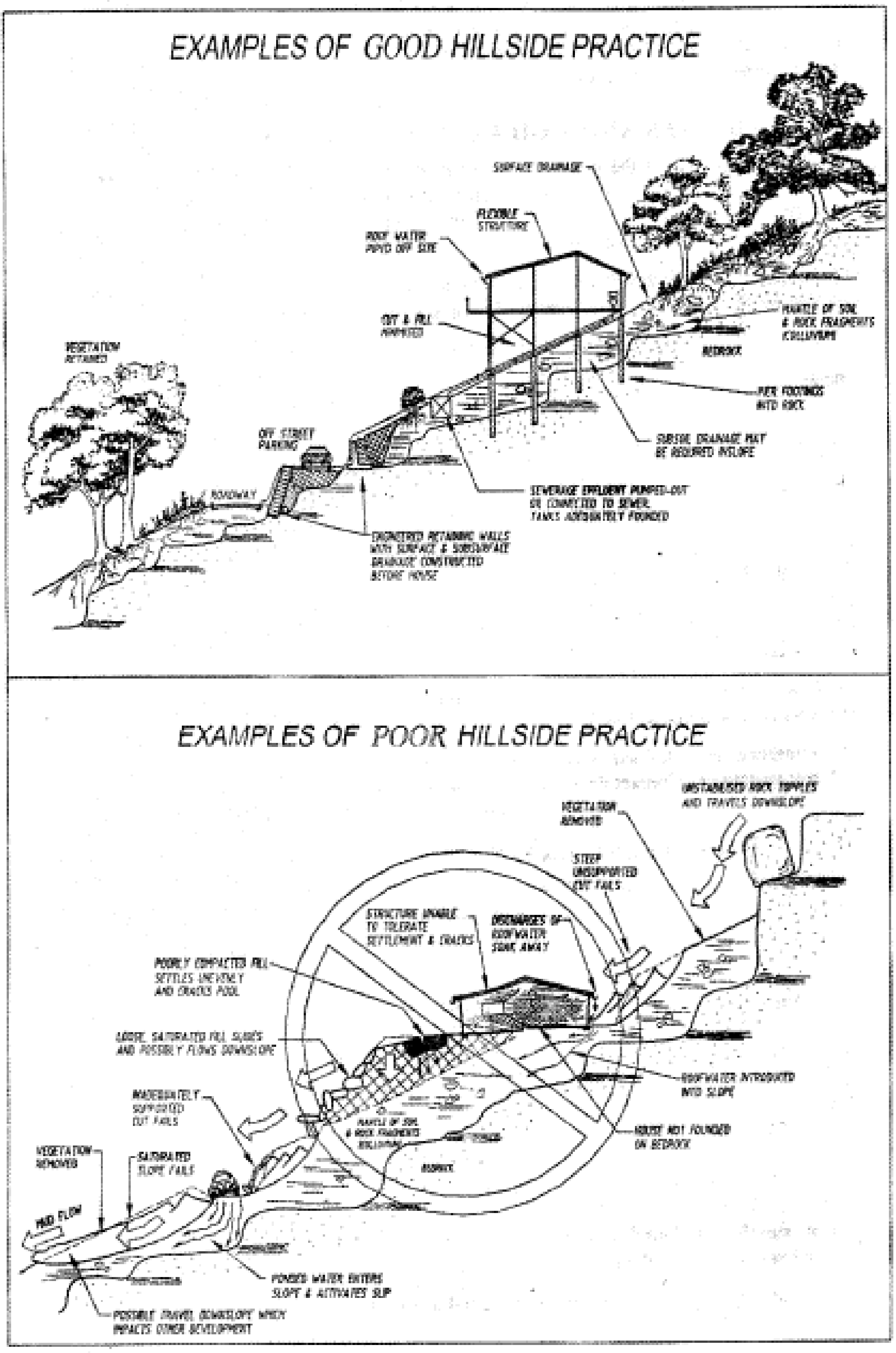


**Figure J1: Illustrations of Good and Poor Hillside Practice**

# APPENDIX G

## LANDSLIDE RISK ASSESSMENT – EXAMPLE OF QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

***Qualitative Measures of Likelihood***

| Level | Descriptor | Description | Indicative Annual Probability |
|---|---|---|---|
| A | ALMOST CERTAIN | The event is expected to occur | $>\approx 10^{-1}$ |
| B | LIKELY | The event will probably occur under adverse conditions | $\approx 10^{-2}$ |
| C | POSSIBLE | The event could occur under adverse conditions | $\approx 10^{-3}$ |
| D | UNLIKELY | The event might occur under very adverse circumstances | $\approx 10^{-4}$ |
| E | RARE | The event is conceivable but only under exceptional circumstances. | $\approx 10^{-5}$ |
| F | NOT CREDIBLE | The event is inconceivable or fanciful | $<10^{-6}$ |

**Note:** "≈" means that the indicative value may vary by say ±• order of magnitude, or more.

***Qualitative Measures of Consequences to Property***

| Level | Descriptor | Description |
|---|---|---|
| 1 | CATASTROPHIC | Structure completely destroyed or large scale damage requiring major engineering works for stabilisation. |
| 2 | MAJOR | Extensive damage to most of structure, or extending beyond site boundaries requiring significant stabilisation works. |
| 3 | MEDIUM | Moderate damage to some of structure, or significant part of site requiring large stabilisation works. |
| 4 | MINOR | Limited damage to part of structure, or part of site requiring some reinstatement/stabilisation works. |
| 5 | INSIGNIFICANT | Little damage. |

**Note:** The "Description" may be edited to suit a particular case.

***Qualitative Risk Analysis Matrix – Level of Risk to Property***

| LIKELIHOOD | CONSEQUENCES to PROPERTY | | | | |
|---|---|---|---|---|---|
| | 1: CATASTROPHIC | 2: MAJOR | 3: MEDIUM | 4: MINOR | 5: INSIGNIFICANT |
| A – ALMOST CERTAIN | VH | VH | H | H | M |
| B – LIKELY | VH | H | H | M | L-M |
| C – POSSIBLE | H | H | M | L-M | VL-L |
| D – UNLIKELY | M-H | M | L-M | VL-L | VL |
| E – RARE | M-L | L-M | VL-L | VL | VL |
| F – NOT CREDIBLE | VL | VL | VL | VL | VL |

***Risk Level Implications***

| Risk Level | | Example Implications(1) |
|---|---|---|
| VH | VERY HIGH RISK | Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to acceptable levels; may be too expensive and not practical |
| H | HIGH RISK | Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels |
| M | MODERATE RISK | Tolerable provided treatment plan is implemented to maintain or reduce risks. May be accepted. May require investigation and planning of treatment options. |
| L | LOW RISK | Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk. |
| VL | VERY LOW RISK | Acceptable. Manage by normal slope maintenance procedures. |

**Note:**
(1) The implications for a particular situation are to be determined by all parties to the risk assessment; these are only given as a general guide.
(2) Judicious use of dual descriptors for Likelihood, Consequence and Risk to reflect the uncertainty of the estimate may be appropriate in some cases.

Each building block has its own particular topographic and subsurface features. Drainage design (surface and subsurface) can only be assessed after detailed inspection of the block and often only after several inspections during heavy rain periods. However, the following general principals should prove helpful in reviewing drainage requirements on most blocks. They are provided as guidelines only and specific drainage designs should be reviewed by an engineer.

## SUBSURFACE DRAINS

### Drain Pipes Available for Use in Subsurface Drains

A slotted PVC pipe or slotted corrugated/flexible pipe is preferred. The purpose is to let water in but to exclude soil solids. Such drains increase the rate of flow of water from the drained area.

### Filter/Fill Material in Trench

The basic purpose is to let water seep through it without allowing migration of fines into the pipe (causing clogging). Because most natural soils are very fine grained (often clayey) it is often necessary to use a two stage filter system, with coarse fill around pipe (which won't pass into pipe through holes or slots) surrounded by a finer fill between the coarse fill and the natural soil. Water will pass through the soil zones/layers but soil migration into the filter is minimised, avoiding clogging.

A more recent innovation is to enclose the granular fill within a subsurface drainage trench in a geofabric which prevents the migration of fines into the granular fill used. Alternatively geocomposites have been developed which perform the function of the filter drain.

A common misconception of many builders is that a very coarse mixture of bricks, rocks,etc will act as a good drainage material in a subsurface drain. Although initially very pervious, such coarse filling is unsatisfactory over the long term because of "silting up" or blockage due to the migration of clay and fines into the large voids in the material.

### Seal Surface

Subsurface drains are designed to pick up and remove subsurface seepage. They should be isolated from surface water drainage systems. The quantity of subsurface drainage in most instances will be quite small. Provide a surface layer of clayey soil, concrete slab, patio stones or equivalent above subsurface drains to prevent ingress of surface water. Do not divert surface interceptor drains, roof drains, etc. to subsurface system. This will simply recharge the groundwater in the area of the subsurface drains.

### Slope of Pipe

0.5% grade minimum, that is, 500mm drop for a 100m run of 250mm drop for a 50m run. If the subsurface drain does not have a pipe but consists simply of a trench backfilled with a filter material ("French Drain") then the fall should be increased to about 3%.

### Clean Outs

Where the subsurface drains are critical, say around a basement being used as living space, then clean outs should be provided to allow long term maintenance. These should be provided at connections or corners in the system.

## SURFACE DRAINS

The basic purpose of surface drains is to collect, control and dispose of surface water flow and thus prevent washouts, saturation of soil mass, etc. Mostly, they will be installed on the uphill side of block to prevent flow towards and into the soil mass in the house area.

After interception and collection above the house, the water should be carried to the lower side of the block in sealed pipes. (These may be buried but should not be slotted, perforated, to avoid re-charge of the subsoil).

The base of open surface drains should be sealed to prevent seepage into the soil. The use of concrete, half round pipes or similar will allow easy cleaning of these drains.

The collected water will be diverted to sealed pipes. The opening to the sealed pipes should be provided with a coarse screen to prevent blockage by large objects. Periodic cleaning of screen will be required.

### Discharge at Lower Side of Block

Where a street, storm drain, natural water course, etc. are not located on the downhill side of the block, the concentrated discharge of collected water could in itself create problems for neighbours downhill. Where no inter-allotment drainage is provided liaisson with the downhill neighbour will be required.