

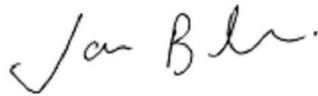
Where changes to site conditions are identified during the maintenance and inspection program, reference should be made to relevant professionals (e.g. structural engineer, geotechnical engineer or Council). It is assumed that Pittwater Council will control development on neighbouring properties, carry out regular inspections and maintenance of the road verge, stormwater systems and large trees on public land adjacent to the site so as to ensure that stability conditions do not deteriorate with potential increase in risk level to the site. Also individual Government Departments will maintain public utilities in the form of power lines, water and sewer mains to ensure they don't leak and increase either the local groundwater level or landslide potential. A maintenance program for construction within hill slopes is also provided in Appendix: 5.

## **5. CONCLUSION:**

The site investigation identified fill soils at the front of the site up to 1.20m depth underlain by soft clays and sand. Further towards the rear residual sandy clay and clayey sand below fill and topsoil which extended to approximately 1.20m depth. Bedrock depth at the rear is interpreted from penetrometer testing to be present from 1.80m to 2.40m depth. At the front of the site extremely low strength bedrock was intersected between 2.50m to 3.0m depth. The bedrock was deeply weathered with extremely low strength bedrock extending to 7.60m depth at the front south-east corner. Very low to low strength rock was intersected from between 4.50m to 7.60m depth.

The proposed works involve an excavation that will be up to 2.50m depth which reduces significantly towards the front of the site due to the natural ground surface slope. A groundwater table is not expected to be intersected in the excavation however water seepage was noted at the front of the site over the bedrock surface and the excavation may experience water seepage. It is expected that the excavation will intersect fill and residual soils underlain by extremely low to very low strength bedrock. Hard rock is not expected however ironstone banding may be encountered. It is recommended that small scale excavation hammers be used for any bedrock excavation at the site. Where harder rock is exposed or larger equipment proposed then the excavation should be halted until assessed by the geotechnical engineer. It is recommended that the geotechnical engineer be advised of the proposed excavation methodology, equipment and support to ensure appropriate methods are used to protect the site and neighbouring properties.

The existing site has been assessed as per the Pittwater Council Geotechnical Risk Management Policy 2009. The risk levels related to the existing site and proposed development are considered to be within the "Tolerable" and "Acceptable" risk levels. Provided engineer designed excavation support measures are implemented and appropriate methods followed then the excavation hazard can be reduced to "Acceptable" levels. It is therefore considered that the site and proposed works can maintain the "Acceptable" risk criteria for the design life of the development, taken as 100 years , provided proper engineering design and construction methods are implemented, including but not limited to the recommendations of this report.



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## 6. REFERENCES:

1. Australian Geomechanics Society 2007, "Landslide Risk Assessment and Management" Australian Geomechanics Journal Vol. 42, No 1, March 2007.
2. Geotechnical Risk Management Policy for Pittwater, 20<sup>th</sup> July 2009.
3. Geological Society Engineering Group Working Party 1972, "The preparation of maps and plans in terms of engineering geology" Quarterly Journal Engineering Geology, Volume 5, Pages 295 - 382.
4. E. Hoek & J.W. Bray 1981, "Rock Slope Engineering" By The Institution of Mining and Metallurgy, London.
5. C. W. Fetter 1995, "Applied Hydrology" by Prentice Hall.
6. V. Gardiner & R. Dackombe 1983, "Geomorphological Field Manual" by George Allen & Unwin.

# Appendix 1

# NOTES RELATING TO THIS REPORT

## Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

## Description and classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigation Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. Sandy clay) on the following bases:

| <b>Soil Classification</b> | <b>Particle Size</b> |
|----------------------------|----------------------|
| Clay                       | less than 0.002 mm   |
| Silt                       | 0.002 to 0.06 mm     |
| Sand                       | 0.06 to 2.00 mm      |
| Gravel                     | 2.00 to 60.00mm      |

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows:

| <b>Classification</b> | <b>Undrained<br/>Shear Strength kPa</b> |
|-----------------------|-----------------------------------------|
| Very soft             | less than 12                            |
| Soft                  | 12 - 25                                 |
| Firm                  | 25 - 50                                 |
| Stiff                 | 50 - 100                                |
| Very stiff            | 100 - 200                               |
| Hard                  | Greater than 200                        |

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

| <b>Relative Density</b> | <b>SPT<br/>"N" Value<br/>(blows/300mm)</b> | <b>CPT<br/>Cone Value<br/>(Qc - MPa)</b> |
|-------------------------|--------------------------------------------|------------------------------------------|
| Very loose              | less than 5                                | less than 2                              |
| Loose                   | 5 - 10                                     | 2 - 5                                    |
| Medium dense            | 10 - 30                                    | 5 - 15                                   |
| Dense                   | 30 - 50                                    | 15 - 25                                  |
| Very dense              | greater than 50                            | greater than 25                          |

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

## Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling to allow information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

## Drilling Methods

The following is a brief summary of drilling methods currently adopted by the company and some comments on their use and application.

**Test Pits** – these are excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descent into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

**Large Diameter Auger (eg. Pengo)** – the hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

**Continuous Sample Drilling** – the hole is advanced by pushing a 100mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

**Continuous Spiral Flight Augers** – the hole is advanced using 90 – 115mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPT's or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

**Non-core Rotary Drilling** - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

**Rotary Mud Drilling** – similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. From SPT).

**Continuous Core Drilling** – a continuous core sample is obtained using a diamond-tipped core barrel, usually 50mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

## Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedures is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150mm of say 4, 6 and 7  
as 4, 6, 7  
N = 13
- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm  
as 15, 30/40mm.

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50mm diameter thin wall sample tubes in clay. In such circumstances, the test results are shown on the borelogs in brackets.

## Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch Cone – abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australia Standard 1289, Test 6.4.1.

In tests, a 35mm diameter rod with a cone-tipped end is pushed continually into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) their information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: -

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0 – 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0 – 50 MPa) is less sensitive and is shown as a full line. The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios 1% - 2% are commonly encountered in sands and very soft clays rising to 4% - 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range: -

$$Q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) N \text{ blows (blows per 300mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range: -

$$Q_c = (12 \text{ to } 18) C_u$$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculations of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

## Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer – a 16mm diameter flattened rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test 6.3.2). The test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS 1289, Test 6.3.2). The test was developed initially for pavement sub-grade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

## Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 “Methods of Testing Soil for Engineering Purposes”. Details of the test procedure used are given on the individual report forms.

## Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than ‘straight line’ variations between the boreholes.

## Ground Water

Where ground water levels are measured in boreholes there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made. More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be interference from a perched water table.

## Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. A three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. To a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions – the potential for this will depend partly on bore spacing and sampling frequency,
- changes in policy or interpretation of policy by statutory authorities,
- the actions of contractors responding to commercial pressures,

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

### **Site Anomalies**

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

### **Reproduction of Information for Contractual Purposes**

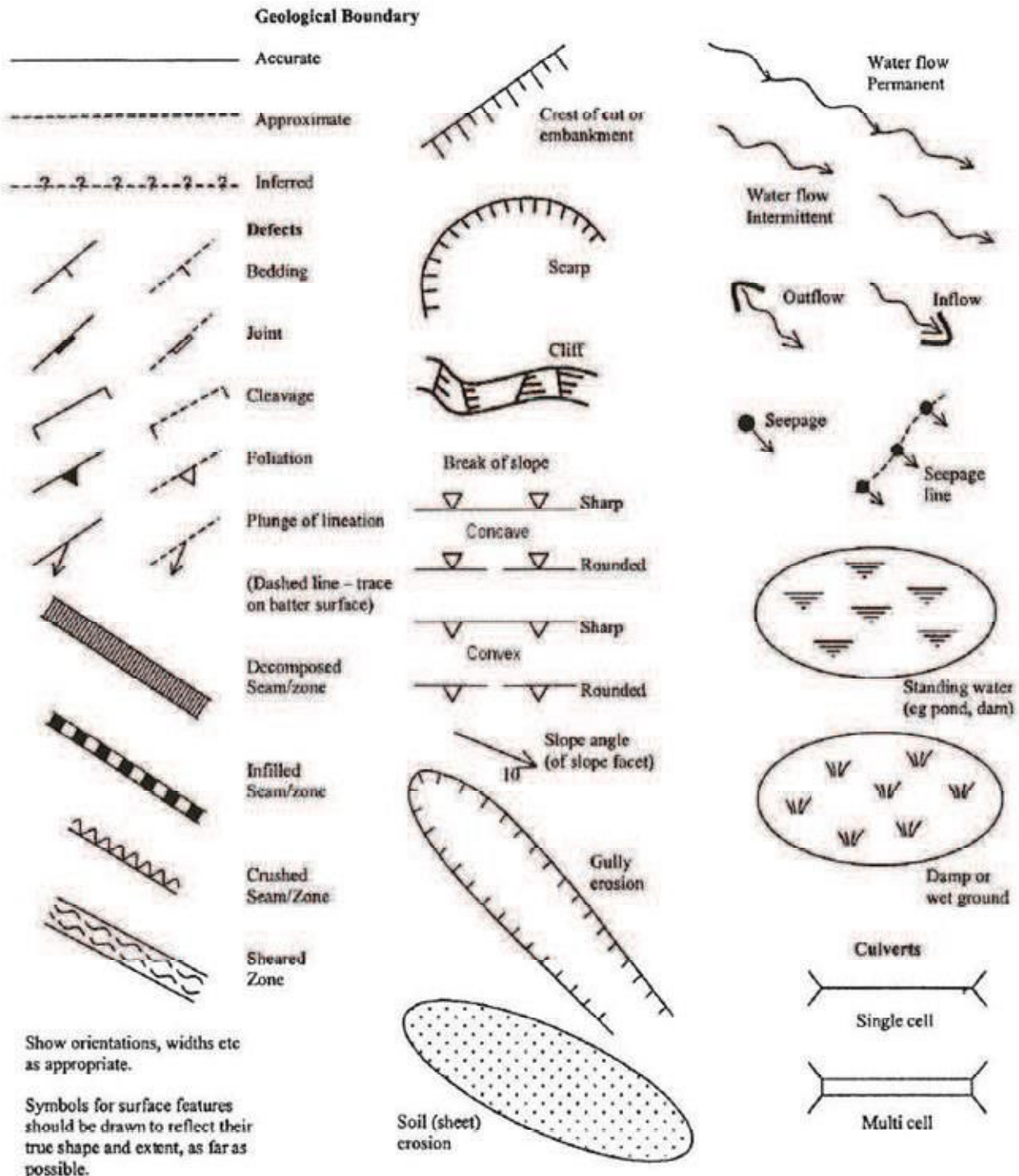
Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

### **Site Inspection**

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

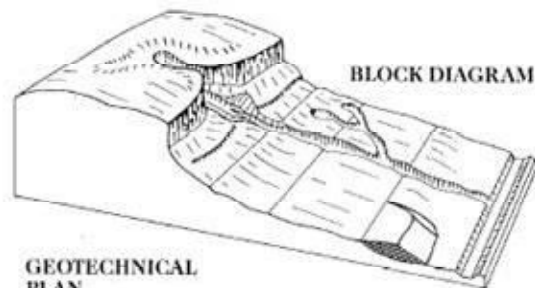
# PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

## APPENDIX E - GEOLOGICAL AND GEOMORPHOLOGICAL MAPPING SYMBOLS AND TERMINOLOGY



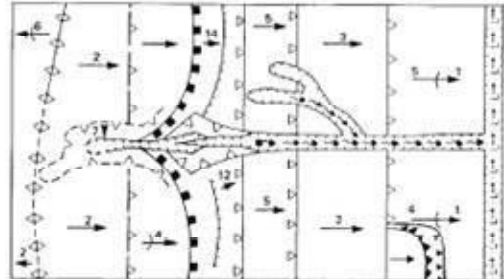
Examples of Mapping Symbols (after Guide to Slope Risk Analysis Version 3.1 November 2001, Roads and Traffic Authority of New South Wales).

## PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007



BLOCK DIAGRAM

GEOTECHNICAL  
PLAN



| SYMBOL | GROUND PROFILE |                                                                                |
|--------|----------------|--------------------------------------------------------------------------------|
|        |                | Convex                                                                         |
|        |                | Concave                                                                        |
|        |                | Convex                                                                         |
|        |                | Concave                                                                        |
|        |                | Breaks of slope                                                                |
|        |                | Changes of slope                                                               |
|        |                | Sharp                                                                          |
|        |                | Rounded                                                                        |
|        |                | Cliff or escarpment or sharp break<br>40° or more (estimated height in metres) |
|        |                | 15° Uniform slope                                                              |
|        |                | 10° Concave slope                                                              |
|        |                | 8° Convex slope                                                                |
|        |                | Top                                                                            |
|        |                | Bottom                                                                         |
|        |                | Hummocky or irregular ground                                                   |
|        |                | Open drain, unlined                                                            |
|        |                | Open drain, lined                                                              |
|        |                | Fence line                                                                     |
|        |                | Property boundary                                                              |
|        |                | Dry stone wall                                                                 |
|        |                | Major joint in rock face (opening in millimetres)                              |
|        |                | Tension crack (opening in millimetres)                                         |

### Example of Mapping Symbols

(after V Gardiner & R V Dackombe (1983). Geomorphological Field Manual. George Allen & Unwin).