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Report on
Geotechnical Assessment - Urban Capability

Proposed Subdivision (Zoning Extension)
Sunset Estate Stage 2
141 Googong Road, Googong

Prepared for
Binowee Developments Pty Ltd

Project 211145.00
December 2021

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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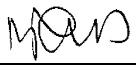
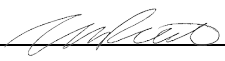
Author		23/12/2021
Reviewer		23/12/2021

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Report on Geotechnical Assessment - Urban Capability
Proposed Subdivision (Zoning Extension)
141 Googong Road, Googong

1. Introduction

This report presents the results of a geotechnical assessment - urban capability undertaken for a proposed subdivision (zoning extension) known as Sunset Estate Stage 2 at 141 Googong Road, Googong. The investigation was commissioned in an email dated 29/11/2021 by Hugh Cooke of Binowee Developments Pty Ltd and was undertaken in accordance with Douglas Partners' proposal 211145.00 dated 22/11/2021 .

It is understood that consideration is being given to applying for an extension to the current residential zoning of existing rural land for future residential subdivision. It is further understood that the current western/north western development boundary of the Stage 2 development is an irregular shaped boundary with no clear basis for its determination.

Assessment was carried out to provide preliminary information on geotechnical aspects of the site to assist in conceptual planning of the development and for submission to Queanbeyan Palerang Regional Council (QPRC) with the zoning extension application.

The assessment comprised a review of published information, test pit excavation at 5 locations and field mapping by a Principal Geotechnical Engineer followed by engineering analysis and reporting. Details of the work undertaken are given in the report, together with the identified development constraints and associated remedial measures/site controls and preliminary comments relating to site development, design and construction practice.

Site survey plans were provided by the client for the purpose of the assessment.

The details of the field work are presented in this report, together with comments and recommendations on the items listed above. This report must be read in conjunction with the notes “About this Report” which are included in Appendix A.

2. Proposed Development

It is understood that the proposed development is for residential purposes comprising in the order of 100 new allotments. The extent of bulk earthworks and design levels were unknown at the time of the assessment.

A preliminary lot layout for the Stage 2 development is provided below in Figure 1. Also on Figure 1 is current land zoning of R1 for the existing Stage 1 development (ie: south east corner) and the irregular boundary on the western side between R1 and E2 land use zones.

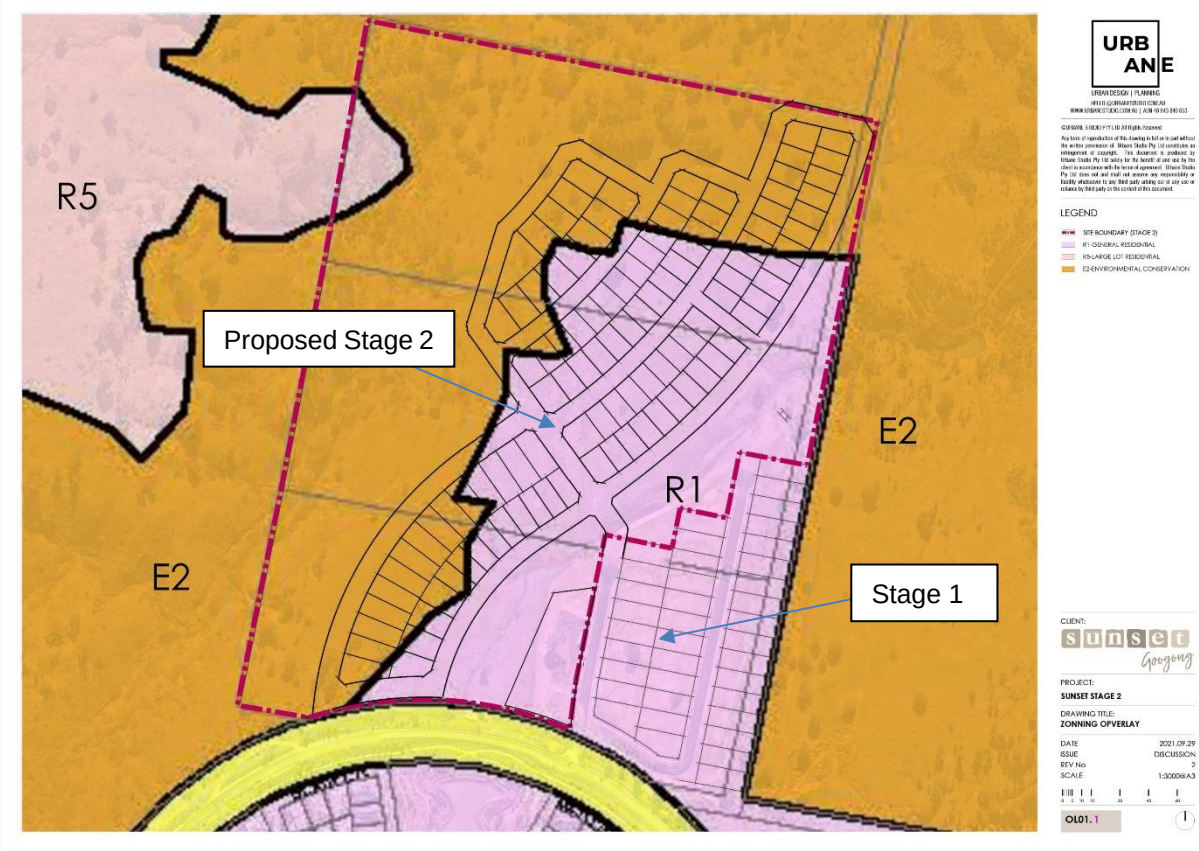

Figure 1: Preliminary Lot Layout and Current Land Use Zoning

3. Site Description

The proposed Stage 2 area comprises an irregular shaped area in the order of 15 hectares with the proposed zoning extension about 6.5 hectares. It is located along the top and flanks of a south west to north east trending ridgeline and is bordered to the west by a steeply sided gully/gorge, to the south by Googong Road, to the north and north east by vacant rural land and to the south east by a gully line (with a farm dam) then the existing Stage 1 development.

The site is mostly heavily vegetated with scattered mature trees through the middle part and thicker stands of trees at the northern and southern extents. A cattle yard was located roughly in the middle of the site.

Surface levels fall to the north west and south east away from the ridgeline at slopes of 1V in 60H (V=Vertical, H=Horizontal) along the top of the ridgeline to as steep as 1V in 3H falling into the gully/gorge on the west side of the site.

4. Assessment Methods

4.1 Information Review

A review of existing geological and soil landscape maps was undertaken as part of the assessment. The relevant maps reviewed were as follows:

- 1:100 000 Geological Series Sheet for Canberra (BMR, 1992),
- 1:100 000 Soil Landscape Sheet for Canberra (NSW DLWC, 2000),

4.2 Site Inspection

A site inspection was undertaken by a Principal Geotechnical Engineer on 9 December 2021, which included qualitative assessment of site stability considerations and mapping of site features. A series of photographs illustrating notable site features are presented in Appendix B.

4.3 Test Pits

The test pits (Pits 1 – 5) were excavated using a CAT305 CR (~5 tonne) mini-excavator fitted with a 300 mm wide toothed bucket to depths of 0.3 m to 1.7 m. The pits were logged onsite by a geotechnical engineer. Dynamic cone penetrometer testing (AS 1289 6.3.2:1997) was also undertaken adjacent to each pit to provide an indication of the in-situ strength profile of the upper site soils.

The approximate test location coordinates provided on each test pit log were determined on site using a hand-held GPS which is accurate to about 3 – 5 m. Surface levels have been broadly estimated from the supplied survey information and must not be relied on. The approximate test locations are shown on Drawing 1 in Appendix C.

5. Assessment Results

5.1 Geology

BMR (1992) indicated that the site is underlain by various units of the Colinton Volcanics Group of Silurian age. The north eastern half of the site is mapped as being underlain by dark green dacitic ignimbrite and minor volcaniclastic sediments (SVc) whilst the south western half is mapped as being underlain by either tuffaceous shale (SVc1) or limestone/dolomitic limestone (SVc2).

5.2 Soil Landscape

NSW DLWC (2000) indicates that majority of the site is underlain by the Burra soil group with the western edge of the site mapped as being underlain by the Campbell soil group.

The following is noted from NSW DLWC (2000) on each soil group:

- The Burra soil group is noted to be limited by strongly acid soils with low fertility and low available water holding capacity. Subsoils have low permeability. Moderate mass movement hazard, sheet erosion risk, run-on and localised shallow soils.
- The Campbell soil group is noted to be shallow, infertile and acidic. Subsoils have low permeability and are hard setting. Steep slopes; rock outcrop; sheet erosion risk; localised waterlogging (springs).

5.3 Site Inspection

The distribution of features noted during the field mapping are shown on Photos 1 – 12 in Appendix B. The principal observations are as follows:

The site generally comprises undulating to steeply undulating grazing land or undeveloped land which is moderately to heavily grassed,

A shallow gully in the northern part of the site comprises sedge/rush grass species which can be associated with waterlogging and/or groundwater springs,

Semi-mature to mature trees are scattered across the middle part of the site with a higher density at the northern and southern extents,

A farm dam is located in the gully line in between existing Stage 1 and proposed Stage 2 developments,

Surface cobbles and boulders were observed across the entire site along with rock outcropping in numerous locations,

A cattle yard area was located roughly in the middle of the site,

Minimal erosion was observed possibly due to largely intact grass/vegetation cover,

No obvious areas of fill having been placed on the site were observed,

With the exception of the farm dam and cattle yard area, the site is generally undisturbed,

The ridgeline and initial flanks are relatively flat to gently sloping becoming moderately then steeply sloping into the gorge/gullies on either side of the ridgeline,

No obvious signs of creep movements within near-surface soils were noted, nor any signs of deep-seated instability;

Some stability concerns would be associated with the steep gully line/gorge banks, though these are outside the Stage 2 development area.

5.4 Test Pits

Details of the subsurface conditions encountered in the test pits are summarised in the test pit logs included in Appendix D. The logs must be read in conjunction with the attached notes that define classification methods and terms used to describe the soils and rocks. A brief description of each test pit is provided below:

Pit 1: clayey silt topsoil to 0.1 m overlying medium strength siltstone/shale to the refusal depth of 0.3 m.

Pit 2: clayey silt topsoil to 0.15 m overlying firm silty gravelly clay to 0.45 m becoming very stiff (extremely weathered rock) then hard to the limit of investigation of 1.5 m.

Pit 3: silty clay topsoil to 0.1 m overlying medium to high strength dacite to the refusal depth of 0.6 m.

Pit 4: silty clay topsoil to 0.1 m, clayey silt to 0.2 m then stiff grading to very stiff to hard (extremely weathered rock) clay and silty clay to the limit of investigation at 1.65 m depth.

Pit 5: clayey silt topsoil to 0.05 m then very stiff to hard silty clay to 0.7 m depth overlying medium to high strength siltstone/shale to the refusal depth of 0.8 m.

No free groundwater was observed during the site investigation. However, it should be noted that the pits were backfilled immediately following excavation precluding longer term monitoring of groundwater levels. It should be noted that groundwater levels are affected by weather conditions and soil permeability and will vary with time. The conditions encountered during the current assessment may vary significantly following periods of either dry or wet weather.

6. Comments

6.1 General

The following comments are based on the results of site reconnaissance, limited test pit information, review of existing information and our involvement in similar projects.

It is understood further investigations will be undertaken at the appropriate time as the planning and design of the subdivision proceeds. Accordingly, this report and the comments given within must be considered as being preliminary in nature.

6.2 Development Considerations

6.2.1 Site Classification

Classification of residential blocks within the site should comply with the requirements of AS 2870:2011. Likely block classifications would range from Class A (sand/rock sites), Class S (slightly reactive) to Class M (moderately reactive) or Class H1/H2 (highly reactive), with the final classification dependent on soil reactivity, the presence of filling and rock depth. The topographic slope in various parts of the overall site range up to moderate to steep, however it is understood these areas would not be developed.

The areas of proposed development are limited to gently to moderately sloping land and accordingly, it is anticipated that some of the blocks (moderately sloping) will need to consider design and construction techniques that take account of the ground slope. It must be noted that areas with steep terrain are not considered suitable for development at this stage.

Despite for aesthetic or other planning reasons, there is no geotechnical basis for block sizes to be of certain sizing.

6.2.2 Stability Assessment

The site has been assessed with reference to the Australian Geomechanics Society Sub-Committee on Landslide Risk Management: "Landslide Risk Management Concepts and Guidelines" (AGS 2007). Based on the observations made during the inspection, an assessment of risk to property has been undertaken for each of three distinct zones as follows:

Zone 1: areas of gently sloping land ie: flatter than 1V:10H (vertical:horizontal) or 5 – 6° (referred to as “very low risk” as shown on Drawing 1);

Zone 2: areas of moderately sloping land ie: generally between 1V:10H and 1V:5H or 6 – 12° (referred to as “low risk” on Drawing 1);

Zone 3: areas of moderately to steeply and steeply sloping land ie: steeper than 1V:5H or 17° (referred to as “moderate/high risk”);

The results of the assessment for each of these areas are outlined in Tables 1 – 3.

Table 1 – Slope Stability Assessment – Zone 1 (Gently Sloping Areas)

Hazard	Likelihood	Consequence to Proposed Development	Risk to Proposed Development
Creep of surface soils	Barely credible	Minor	Very Low
Near surface slumping	Barely credible	Medium	Very Low
Active / deep seated slide	Barely credible	Major	Very Low

Table 2 – Slope Stability Assessment – Zone 2 (Moderately Sloping Areas)

Hazard	Likelihood	Consequence to Proposed Development	Risk to Proposed Development
Creep of surface soils	Unlikely	Minor	Low
Near surface slumping	Unlikely	Medium	Low
Active / deep seated slide	Rare	Major	Low

Table 3 – Slope Stability Assessment – Zone 3 (Moderately to Steeply and Steeply Sloping Areas)

Hazard	Likelihood	Consequence to Proposed Development	Risk to Proposed Development
Failure during construction	Possible – Likely	Medium	Moderate – High
Creep of surface soils	Possible – Likely	Minor	Moderate
Near surface slumping	Possible – Likely	Medium	Moderate – High
Active / deep seated slide	Rare- Unlikely	Major	Low – Moderate

In summary, it is considered that those portions of the site which are to be proposed to be developed (including the zoning extension area) is classified as very low or low risk of damage to property occurring as a result of slope instability. Large areas are considered of moderate or high risk (refer Drawing 1) of causing property damage due to the steep ground slopes and possible unsuitable design and construction practice.

Notwithstanding the various risk categories nominated, development of the site for residential purposes is considered feasible in areas of gently and moderately sloping land (very low and low instability risk) with erosion control measures and suitable dwelling design to be addressed. In areas of moderately sloping land, standard practices for hillside development must be incorporated into designs.

Areas of moderately to steeply and steeply sloping land (moderate and high risk) are not recommended for residential development at this stage. A detailed site stability assessment including subsurface investigations must be undertaken in these areas to establish an appropriate site model for analysis purposes to assess whether development is feasible in the high risk zones.

It is noted that revisions to the above risk classifications may be necessary following completion of bulk earthworks. It is recommended that if development is proposed within the moderate and high risk areas, further delineation and assessment be undertaken.

6.2.3 Soil Erosion

It is considered that the erosion hazard within the areas proposed for development would be within usually accepted limits and could be managed by good engineering and land management practices which will also be required to address flood hazard and localised waterlogging limitations of soils along gully lines and low lying flat areas. These hazards are considered to impose only a minor constraint to development.

6.2.4 Footings

All footing systems for standard residential dwellings should be designed and constructed in accordance with AS 2870:2011 for the appropriate classification. For hillside block construction (low risk or greater), reference should be made to the publication by AGS (2007), relevant extracts of which are included in Appendix E.

For preliminary sizing of footings, allowable base bearing pressures for the various strata likely to be encountered including controlled filling are given below:

- Stiff or loose to medium dense natural soils: 100 kPa
- Controlled Filling: 100 kPa
- Very stiff or medium dense natural soils: 150 kPa
- Extremely low and very low strength bedrock: 500 kPa
- Low strength bedrock: 1000 kPa

6.3 Site Preparation and Earthworks

6.3.1 Stripping

Site preparation for the construction of roadways and structures should include the removal of vegetation, topsoils, silty sandy soils, any existing filling and other deleterious materials from the proposed construction areas. Deep excavations (such as in gullies) could occur should localised deeper topsoils or unsuitable materials/filling be encountered, if inclement weather precedes construction or if the contractor adopts inappropriate stripping methods.

It is expected that the site is underlain at least in parts by silty sands/sandy silts (beneath the topsoils). This material is usually difficult to handle and compact and would require extremely careful moisture control. It is recommended that allowance be made for at least partial stripping of this material (say 0.3 m following topsoil stripping), with inspection undertaken by a suitably qualified geotechnical engineer to assess the depth of removal. Where possible (ie: in deep fill areas) this material could be designated to remain insitu, however if considered unsuitable would be required to be removed. Also, if stripping of the silty material is needed, it be limited to 0.4 m only as it is unlikely to improve with depth. The excavated material should be replaced with a granular bridging layer.

Depending on prior weather conditions it may also be necessary to use a geofabric separation layer in proposed road embankment areas of the development.

6.3.2 Excavation Conditions

Whilst limited subsurface investigation has been undertaken as part of this assessment, based on Douglas Partners involvement on nearby projects and from the site inspections it is expected that the subsurface profile will comprise a variable soil profile underlain by bedrock which in parts may be of very high to extremely high strength and massive.

The site soils and weathered bedrock up to low strength could be expected to be removed using conventional large earthmoving plant. The presence of outcropping rock or boulders at the surface may preclude effective use of scrapers in some areas.

Excavation of the bedrock will largely be dependent on the degree of fracturing/jointing and the strike and dip of bedding within the rock relative to the excavation. Depending on excavation depths, heavy ripping or heavy rock hammering may be required but would have low production rates; blasting would be recommended to further fracture the bedrock to expedite ripping activities.

The extent of groundwater inflow would be dependent on prior weather conditions. Given the extent of gully lines and relatively flat topography over some parts of the site, groundwater seepages should be anticipated, which would increase following rainfall.

6.3.3 Filling Placement

In areas that require filling, the stripped ground surfaces must be test rolled in the presence of a geotechnical engineer. Any areas exhibiting significant deflections under test rolling must be appropriately treated by over-excavation and replacement with material approved by the geotechnical engineer. All filling material must be placed in horizontal layers of maximum 250 mm loose thickness. The material must have a moisture content within the range of ±2% of modified optimum at the time of placement.

All permanent fill batters must be constructed no steeper than 1:3 (vertical:horizontal), appropriately protected against erosion with toe and spoon drains constructed as a means of controlling surface flows on the batters and vegetation of the batter.

6.3.4 Filling Compaction

All filling placed within construction platforms must be compacted to a minimum 90% modified maximum dry density, except for the upper 1.0 m within pavement areas, which must be compacted to a minimum of 95% modified maximum dry density.

To validate future site classifications, field inspections and in-situ testing of future earthworks must be undertaken on any controlled filling placed in residential blocks in order to satisfy the requirements of a Level 1 inspection and testing service as defined in AS 3798:2007.

6.4 Drainage

Parts of the site have average natural subsurface drainage. Infiltrated rainwater can become contained in the upper semi-pervious silty/sandy stratum and deeper sandy/gravelly layers. Seepage water may also enter fractures in the bedrock at locations where the bedrock outcrops or is at shallow depth. Seepage water in the subsurface profile may rise to the ground surface further downslope as springs.

The extent of surface and subsurface drainage at the site is difficult determine at this stage however, subsurface drains must be installed at both sides of all roads. Some sections of road subgrades may need to be provided with cross-drains or a drainage blanket to control upward seepages.

Treatment of groundwater springs on individual blocks must be assessed and treated individually at the time of construction.

6.5 Pavements

Whilst subgrade investigations and design of pavements have yet to be undertaken, based on the results of the site inspection and previous experience in the nearby area, Table 4 gives indicative design CBR values for the various likely subgrade conditions.

Table 4 – Design CBR Values

Subgrade Material	Design CBR (%)
Clay (high plasticity)	1.0 – 2.0
Clay (low to medium plasticity)	3.0
Sandy/Gravelly Soils	3.0 – 4.0
Recompacted (Igneous) Weathered Rock	5.0 – 7.0
Insitu (Igneous) Weathered Rock	7.0 – 10.0

There may be construction advantages in undertaking subgrade replacement in those areas where any high plasticity clay subgrades occur. Detailed investigations will be required following finalisation of subdivision layout to confirm and delineate, if possible the variation in subgrade conditions. Surface and subsurface drainage must be installed and maintained to protect the pavement and subgrade. The subsurface drains should extend a minimum of 0.5 m depth below the subgrade level.

6.6 Development Constraints

The assessment has identified a number of constraints on the development, which are:

- Potential for waterlogging in several areas including spring activity;
- Areas of moderate and high risk of damage to property with respect to slope instability;
- Outcropping and shallow very high strength bedrock.

Waterlogging: There is evidence of possible waterlogging conditions within the shallow gully in the northern part of the site. This area is characterised by grass species which from Douglas Partners experience indicates previous or current presence of elevated soil/groundwater levels.

Stability: Several areas (refer Drawing 1) have been assessed as having a potential moderate to high risk of damage to property from land instability.

High Strength Bedrock: The presence of very high strength bedrock as outcrops and at very shallow depths would prove difficult to excavate should design levels require cutting.

After the above constraints are addressed, the site would be considered suitable for the proposed development.

6.7 Remedial Measures/Site Controls

The main activities or methods to enable effective development of the site, from a geotechnical perspective, would be:

- planning/layout of development areas,
- drainage measures where required,
- timing of works,
- development restrictions from a slope instability perspective;
- minimising cut-fill on hillside blocks.

6.7.1 Planning/Layout of Development

The current preliminary development layout for Stage 2 utilises the more stable land (ie: no greater than low risk of instability) and avoids the areas of moderate or higher risk. From a geotechnical perspective, this aspect of the design is supported.

6.7.2 Drainage Measures

Engineered drainage both to divert overland flow and intercept subsurface flow combined with bulk earthworks to raise surface levels and or contour the surface level to improve drainage will be required if permanent structures are to be constructed in gully and/or low lying areas.

Besides the broad depression/shallow gully in the northern part of the site where the vegetation type suggests elevated soil moisture conditions, drainage measures are recommended as a minimum to be as per current best practice.

Should areas of groundwater or moisture impacted soils be encountered during construction phases, they should be treated at that time and assessed individually.

6.7.3 Timing of Works

Timing of the site works could also be a critical aspect that will require careful consideration. Bulk earthworks activities is suggested to be undertaken in the warmer months of the year and not the winter months when ground moisture is higher due to the negative evapotranspiration effect experienced in winter. If moist soils are encountered and require drying to enable reuse in controlled filling areas, the warmer months would allow more expedited processing negating the potential for several weeks of drying time expected during winter.

6.7.4 Development Restrictions

Development within areas of medium risk or greater of instability is technically feasible though would be required to be undertaken with geotechnical guidance. Site specific and development specific geotechnical investigation and advice would be required for individual structures.

At this stage without subsurface investigations, development within the medium risk or greater areas are not recommended. A comprehensive site stability assessment will be required if development in those areas are proposed.

6.7.5 Cut – Fill Minimisation on Hillside

It is standard hillside development practice to minimise the depths of cutting and filling. All proposed modification of the ground slope in hillside areas as part of subdivision must be subject to geotechnical review and comment.

6.8 Subsurface Investigations

Subsurface investigation and laboratory testing will be required as the conceptual design/planning progresses, and during the design and construction phases. Specific investigation would include a detailed geotechnical investigation to determine excavation conditions, road subgrade CBR values and confirm site classifications for each block. Whilst it is understood development of site areas of greater than low risk of instability are not being considered, should that change detailed assessment would be required to profile the subsurface conditions, undertake slope stability modelling and develop site specific development controls.

6.9 Summary

The site assessment undertaken as described above has indicated that the majority of the site (ie: areas of low or less risk of instability) is suitable from a geotechnical perspective for residential development. Comments have been given on the various geotechnical aspects of the proposed development and the identified development constraints and subsequent remedial and control measures.

Conceptual comments on design and construction aspects are also given in the report. Further testing and assessment will be required as the design of the subdivision proceeds and as such, this report must be considered as being preliminary in nature.

7. References

AGS. (2007). *Practice Note Guidelines for Landslide Risk Management.* Australian Geomechnics, Volume 42, No 1: Australian Geomechanics Society, Landslide Taskforce, Landslide Practice Note Working Group.

AS 2870. (2011). *Residential Slabs and Footings.* Standards Australia.

AS 3798. (2007). *Guidelines on Earthworks for Commercial and Residential Developments.* Standards Australia.

BMR. (1992). *Geology of Canberra 1:100 000 Geological Series Sheet 8727.* Bureau of Mineral Resources.

NSW DLWC (2000), *Soil Landscape of Canberra 1:100 000 Soil Landscape Series Sheet 8727*, NSW Dept of Land and Water Conservation.

8. Limitations

Douglas Partners (DP) has prepared this report for this project at 141 Googong Road, Googong in accordance with DP's proposal dated 22/11/2021 and acceptance received from Hugh Cooke dated 29/11/2021. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Binowee Developments Pty Ltd and Urban Studio Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the surface and sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the geotechnical components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or

conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

November 2020

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations 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.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report 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 or excavation. 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 and test pits 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 or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole 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; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements 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 advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP 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 conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

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

continued next page

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, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report 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. DP 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 and environmental 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.

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Appendix B

Site Photographs

Photo 1 – View of northern area with broad depression in the background.

Photo 2 – View of western edge of the development area. Pit 1 being excavated.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Subdivision (Zoning Extension)** **Sunset Estate Stage 2**[CR1] **141 Googong Road, Googong**	PROJECT: 211145.00 PLATE No: 1 REV: 0
	CLIENT: Binowee Developments P/L	DATE: 22/12/2021

Photo 3 – View of western edge of development

Photo 4 – View of steep gully/gorge at western edge of the site. Rock outcropping in foreground.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Subdivision (Zoning Extension)** **Sunset Estate Stage 2** **141 Googong Road, Googong**	PROJECT: 211145.00 PLATE No: 2 REV: 0
	CLIENT: Binowee Developments P/L	DATE: 22/12/2021

Photo 5 – View of western edge of development area.

Photo 6 – View of ridgeline crest with cattle yard in background.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Subdivision (Zoning Extension)** **Sunset Estate Stage 2** **141 Googong Road, Googong**	PROJECT: 211145.00 PLATE No: 3 REV: 0
	CLIENT: Binowee Developments P/L	DATE: 22/12/2021

Photo 7 – View of rock outcropping along western edge of development area.

Photo 8 – View of rock cropping along western edge of development.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Subdivision (Zoning Extension)** **Sunset Estate Stage 2** **141 Googong Road, Googong**	PROJECT: 211145.00 PLATE No: 4 REV: 0
	CLIENT: Binowee Developments P/L	DATE: 22/12/2021

Photo 9 – View of rock cropping near Pit 1.

Photo 10 – View of ridgeline and western extent of development area.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Subdivision (Zoning Extension)** **Sunset Estate Stage 2** **141 Googong Road, Googong**	PROJECT: 211145.00 PLATE No: 5 REV: 0
	CLIENT: Binowee Developments P/L	DATE: 22/12/2021

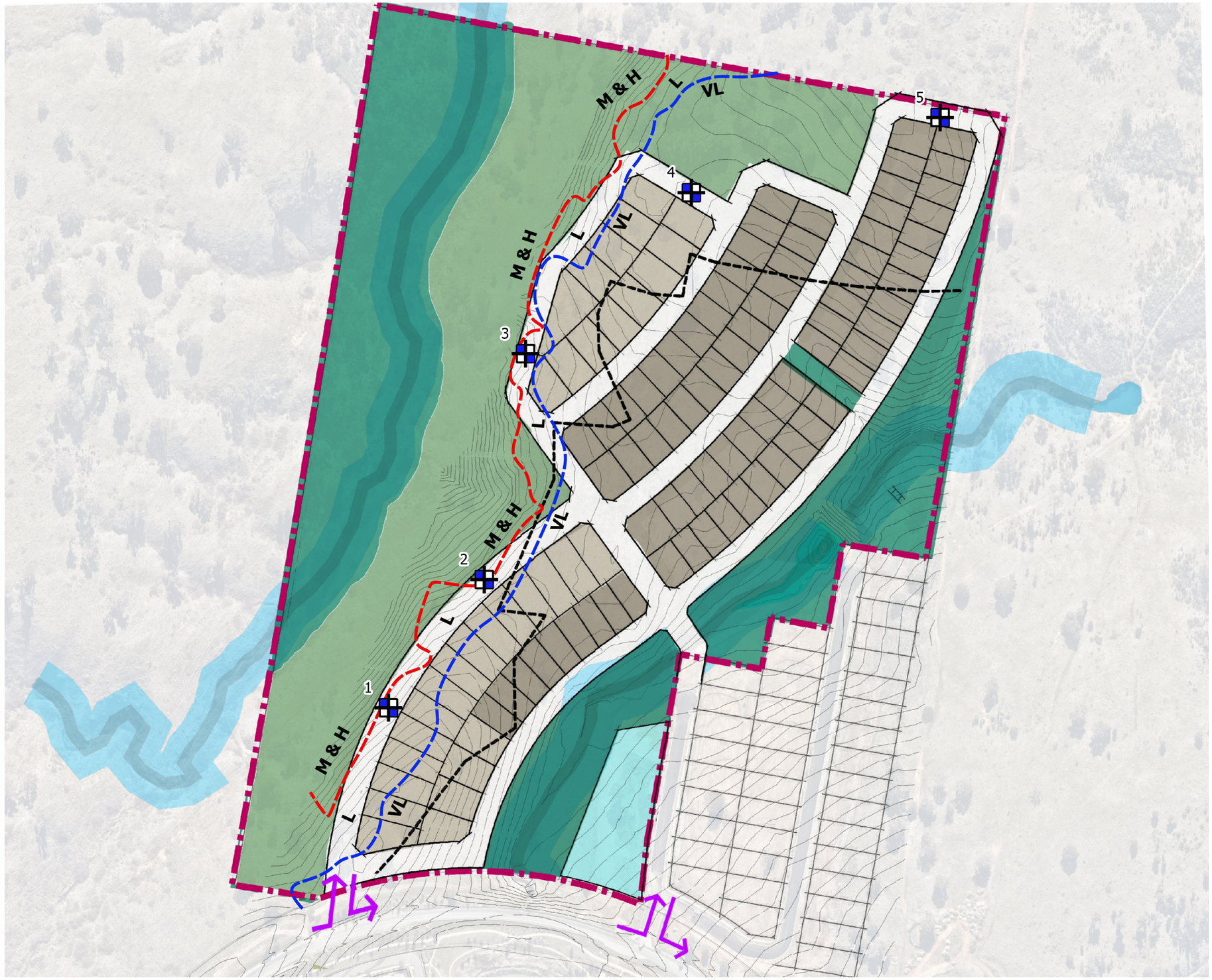
Photo 11 – View of ridgeline look towards the northern extent of the development area.

Photo 12 – View of from northern end of the site looking towards the southern end and Stage 1 of Sunset Estate to the rear left.

Douglas Partners Geotechnics / Environment / Groundwater	**Site Photographs** **Proposed Subdivision (Zoning Extension)** **Sunset Estate Stage 2** **141 Googong Road, Googong**	PROJECT: 211145.00 PLATE No: 6 REV: 0
	CLIENT: Binowee Developments P/L	DATE: 22/12/2021

Appendix C

Drawing 1



Site Location

Legend

- Approximate Test Pit Location
- Approximate Boundary of L & M/H Risk
- Approximate Boundary of VL & L Risk
- Existing Zoning Boundary
- Site Boundary

Notes

VL = Very Low
L = Low
M = Moderate
H = High

Drawing adapted from client supplied drawing titled "Concept Master Plan" dated "29.09.2021"
drawing no "CMP01.1"from URBANE STUDIO

0 125 250 375 500 m

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: PEET Pty Ltd		
OFFICE: Canberra	DRAWN BY: TBO	
SCALE: 1:4000 @ A3	DATE: 22 December 2021	

TITLE: **Test Location Plan**
Proposed Subdivision (Zoning Extension)
141 Googong Road, Googong, NSW

N

Project:	211145.00
DRAWING No:	1
REVISION:	0

DP.QGIS.A3LandScapeDrawingLayout.DftA

Appendix D

Explanatory Notes
Test Pit Logs (Pits 1 – 5)

Terminology, Symbols and Abbreviations

November 2020

Introduction to Terminology, Symbols and Abbreviations

Douglas Partners' reports, investigation logs, and other correspondence may use terminology which has quantitative or qualitative connotations. To remove ambiguity or uncertainty surrounding the use of such terms, the following sets of notes pages may be attached Douglas Partners' reports, depending on the work performed and conditions encountered:

- Soil Descriptions;
- Rock Descriptions; and
- Sampling, insitu testing, and drilling methodologies

In addition to these pages, the following notes generally apply to most documents.

Abbreviation Codes

Site conditions may also be presented in a number of different formats, such as investigation logs, field mapping, or as a written summary. In some of these formats textual or symbolic terminology may be presented using textual abbreviation codes or graphic symbols, and, where commonly used, these are listed alongside the terminology definition. For ease of identification in these note pages, textual codes are presented in these notes in the following style `XW`. Code usage conforms with the following guidelines:

- Textual codes are case insensitive, although herein they are generally presented in upper case; and
- Textual codes are contextual (i.e. the same or similar combinations of characters may be used in different contexts with different meanings (for example `PL` is used for plastic limit in the context of soil moisture condition, as well as in `PL(A)` for point load test result in the testing results column)).

Data Integrity Codes

Subsurface investigation data recorded by Douglas Partners is generally managed in a highly structured database environment, where records "span" between a top and bottom depth interval. Depth interval "gaps" between records are considered to introduce ambiguity, and, where appropriate, our practice guidelines may require contiguous data sets. Recording meaningful data is not always appropriate (for example assigning a "strength" to a concrete pavement) and the following codes may be used to maintain contiguity in such circumstances.

Term	Description	Abbreviation Code
Core loss	No core recovery	`KL`
Unknown	Information was not available to allow classification of the property. For example, when auguring in loose, saturated sand auger cuttings may not be returned.	`UK`
No data	Information required to allow classification of the property was not available. For example if drilling is commenced from the base of a hole predrilled by others	`ND`
Not Applicable	Derivation of the properties not appropriate or beyond the scope of the investigation. For example providing a description of the strength of a concrete pavement	`NA`

Graphic Symbols

Douglas Partners' logs contain a "graphic" column which provides a pictorial representation of the basic composition of the material. The symbols used are directly representing the material name stated in the adjacent "Description of Strata" column, and as such no specific graphic symbology legend has been provided in these notes.

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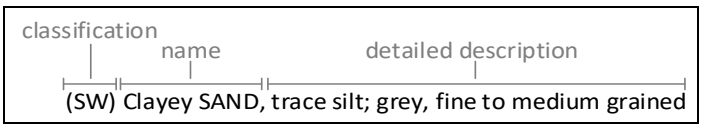
Introduction

All materials which are not considered to be "in-situ rock" are described in general accordance with the soil description model of AS 1726-2017 Part 6.1.3, and can be broken down into the following description structure:



The "classification" comprises a two character "group symbol" providing a general summary of dominant soil characteristics. The "name" summarises the particle sizes within the soil which most influence it's behaviour. The detailed description presents more information about the soil's composition, condition, structure, and origin.

Classification, naming and description of soils requires the relative proportion of particles of different sizes within the whole soil mixture to be considered.

Particle size designation and Behaviour Model

Solid particles within a soil are differentiated on the basis of size.

The engineering behaviour properties of a soil can subsequently be modelled to be either "fine grained" (also known as "cohesive" behaviour) or "coarse grained" ("non cohesive" behaviour), depending on the relative proportion of fine or coarse fractions in the soil mixture.

Particle Size Fraction	Particle Size (mm)	Behaviour Model	
		Behaviour	Approximate Dry Mass
Boulder	>200	Excluded from particle behaviour model as "oversize"	
Cobble	63 - 200		
Gravel[1]	2.36 - 63	Coarse	>65%
Sand[1]	0.075 - 2.36		
Silt	0.002 - 0.075	Fine	>35%
Clay	<0.002		

[1] – refer grain size subdivision descriptions below

The behaviour model boundaries defined above are not precise, and the material behaviour should be assumed from the name given to the material (which considers the particle fraction which dominates the behaviour, refer "component proportions" below), rather than strict observance of the proportions of particle sizes. For example, if a material is named a "Sandy CLAY", this is indicative that the material exhibits fine grained behaviour, even if the dry mass of coarse grained material may exceed 65%.

Component proportions

The relative proportion of the dry mass of each particle size fraction is assessed to be a "primary", "secondary", or "minor" component of the soil mixture, depending on its influence over the soils behaviour.

Component Proportion Designation	Definition[1]	Relative Proportion	
		In Fine Grained Soil	In Coarse Grained Soil
Primary	The component (particle size designation, refer above) which dominates the engineering behaviour of the soil	The clay/silt component with the greater proportion	The sand/gravel component with the greater proportion
Secondary	Any component which is not the primary, but is significant to the engineering properties of the soil	Any component with greater than 30% proportion	Any granular component with greater than 30%; or Any fine component with greater than 12%
Minor[2]	Present in the soil, but not significant to it's engineering properties	All other components	All other components

[1] As defined in AS1726-2017 6.1.4.4

[2] In the detailed material description, minor components are split into two further sub categories. Refer "identification of minor components" below

Composite Materials

In certain situations a lithology description may describe more than one material, for example, collectively describing a layer of interbedded sand and clay. In such a scenario, the two materials would be described independently, with the names preceded or followed by a statement describing the arrangement by which the materials co-exist. For example "INTERBEDDED Silty CLAY AND SAND".

Classification

The soil classification comprises a two character group symbol. The first symbol identifies the primary component. The second symbol identifies either the grading or presence of fines in a coarse grained soil, or the plasticity in a fine grained soil. Refer AS1726-2017 6.1.6 for further clarification.

Soil Name

For most soils the name is derived with the primary component included as the noun (in upper case), preceded by any secondary components stated in an adjective form. In this way the soil name also describes the general composition and indicates the dominant behaviour of the material.

Component[1]	Prominence in Soil Name
Primary	Noun (eg "CLAY")
Secondary	Adjective modifier (eg "Sandy")
Minor	No influence

[1] – for determination of component proportions, refer component proportions on previous page

For materials which cannot be disaggregated, or which are not comprised of rock or mineral fragments, the names "ORGANIC MATTER" or "ARTIFICIAL MATERIAL" may be used, in accordance with AS1726-2017 Table 14.

Commercial or colloquial names are not used for the soil name where a component derived name is possible (for example "Gravelly SAND" rather than "CRACKER DUST").

Materials of "fill" or "topsoil" origin are generally assigned a name derived from the primary/secondary component (where appropriate). In log descriptions this is preceded by uppercase "FILL" or "TOPSOIL". Origin uncertainty is indicated in the description by the characters `(?)`, with the degree of uncertainty described (using the terms "probably" or "possibly" in the origin column, or at the end of the description.

Identification of minor components

Minor components are identified in the soil description immediately following the soil name. The minor component fraction is usually preceded with a term indicating the relative proportion of the component.

Minor Component Proportion Term	Relative Proportion	
	In Fine Grained Soil	In Coarse Grained Soil
With	All fractions: 15-30%	Clay/silt: 5-12% sand/gravel: 15-30%
Trace	All fractions: 0-15%	Clay/silt: 0-5% sand/gravel: 0-15%

The terms "with" and "trace" generally apply only to gravel or fine particle fractions. Where cobbles/boulders are encountered in minor proportions (generally less than about 12%) the term "occasional" may be used. This term describes the sporadic distribution of the material within the confines of the investigation excavation only, and there may be considerable variation in proportion over a wider area which is difficult to factually characterize due to the relative size of the particles and the investigation methods.

Soil Composition

Plasticity

Descriptive Term	Laboratory liquid limit range	
	Silt	Clay
Non-plastic materials	Not applicable	Not applicable
Low plasticity	≤50	≤35
Medium plasticity	Not applicable	>35 and ≤50
High plasticity	>50	>50

Note, Plasticity descriptions generally describe the plasticity behaviour of the whole of the fine grained soil, not individual fine grained fractions.

Grain Size

Type		Particle size (mm)
Gravel	Coarse	19 - 63
	Medium	6.7 - 19
	Fine	2.36 – 6.7
Sand	Coarse	0.6 - 2.36
	Medium	0.21 - 0.6
	Fine	0.075 - 0.21

Grading

Grading Term	Particle size (mm)
Well	A good representation of all particle sizes
Poorly	An excess or deficiency of particular sizes within the specified range
Uniformly	Essentially of one size
Gap	A deficiency of a particular particle size with the range

Note, AS1726-2017 provides terminology for additional attributes not listed here.

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Soil Condition

Moisture

The moisture condition of soils is assessed relative to the plastic limit for fine grained soils, while for coarse grained soils it is assessed based on the appearance and feel of the material. The moisture condition of a material is considered to be independent of stratigraphy (although commonly these are related), and this data is presented in its own column on logs.

Applicability	Term	Tactile Assessment	Abbreviation code
Fine	Dry of plastic limit	Hard and friable or powdery	<PL
	Near plastic limit	Can be moulded	≈PL
	Wet of plastic limit	Water residue remains on hands when handling	>PL
	Near liquid limit	"oozes" when agitated	≈LL
	Wet of liquid limit	"oozes"	>LL
Coarse	Dry	Non-cohesive and free running	D
	Moist	Feels cool, darkened in colour, particles may stick together	M
	Wet	Feels cool, darkened in colour, particles may stick together, free water forms when handling	W

The abbreviation code NDF, meaning "not-assessable due to drilling fluid use" may also be used.

Note, observations relating to free ground water or drilling fluids are provided independent of soil moisture condition.

Consistency/Density/Compaction/Cementation/Extremely Weathered Rock

These concepts give an indication of how the material may respond to applied forces (when considered in conjunction with other attributes of the soil). This behaviour can vary independent of the composition of the material, and on logs these are described in an independent column and are generally mutually exclusive (i.e it is inappropriate to describe both consistency and compaction at the same time). The method by which the behaviour is described depends on the behaviour model and other characteristics of the soil as follows:

- In fine grained soils, the "consistency" describes the ease with which the soil can be remoulded, and is generally correlated against the materials undrained shear strength;
- In granular materials, the relative density describes how tightly packed the particles are, and is generally correlated against the density index;
- In anthropogenically modified materials the compaction of the material is described qualitatively;
- In cemented soils (both natural and anthropogenic), the cemented "strength" is described qualitatively, relative to the difficulty with which the material is disaggregated; and
- In soils of extremely weathered rock origin, the engineering behaviour may be governed by relic rock features, and expected behaviour needs to be assessed based the overall material description

Quantitative engineering performance of these materials may be determined by laboratory testing, or estimated by correlated field tests (for example penetration or shear vane testing). In some cases performance may be assessed by tactile or other subjective methods, in which case investigation logs will show the estimated value enclosed in round brackets, for example (VS).

Consistency (fine grained soils)

Consistency Term	Tactile Assessment	Undrained Shear Strength (kPa)	Abbreviation Code
Very soft	Extrudes between fingers when squeezed	<12	VS
Soft	Mouldable with light finger pressure	>12 - ≤25	S
Firm	Mouldable with strong finger pressure	>25 - ≤50	F
Stiff	Cannot be moulded by fingers	>50 - ≤100	ST
Very stiff	Indented by thumbnail	>100 - ≤200	VST
Hard	Indented by thumbnail with difficulty	>200	H
Friable	Easily crumbled or broken into small pieces by hand	-	FR

Relative Density (coarse grained soils)

Relative Density Term	Density Index	Abbreviation Code
Very loose	<15	VL
Loose	>15-≤35	L
Medium dense	>35-≤65	MD
Dense	>65-≤85	D
Very dense	>85	VD

Note, tactile assessment of relative density is difficult, and generally requires penetration testing, hence a tactile assessment guide is not provided.

Compaction (anthropogenically modified soil)

Compaction Term	Abbreviation Code
Well compacted	WC
Poorly compacted	PC
Moderately compacted	MC
Variably compacted	VC

Cementation (natural and anthropogenic)

Cementation Term	Abbreviation Code
Moderately cemented	MCE
Weakly cemented	WKCE
Cemented	CE
Strongly bound	SB
Weakly bound	WB
Unbound	UB

Extremely Weathered Rock

AS1726-2017 considers weathered rock material to be soil if the unconfined compressive strength is less than 0.6 MPa (i.e. very low strength rock). These materials may be identified as “extremely weathered rock” in reports and by the abbreviation code XWR on log sheets. This identification is not correlated to any specific qualitative or quantitative behaviour, and the engineering properties of this material must therefore be assessed according to engineering principles with reference to any relic rock structure, fabric, or texture described in the description.

Soil Origin

Term	Description	Abbreviation Code
Residual	Derived from in-situ weathering of the underlying rock	RES
Extremely weathered material	Formed from in-situ weathering of geological formations. Has strength of less than ‘very low’ as per as1726 but retains the structure or fabric of the parent rock.	XWM
Alluvial	Deposited by streams and rivers	ALV
Estuarine	Deposited in coastal estuaries	EST
Marine	Deposited in a marine environment	MAR
Lacustrine	Deposited in freshwater lakes	LCS
Aeolian	Carried and deposited by wind	AEO
Colluvial	Soil and rock debris transported down slopes by gravity	COL
Topsoil	Mantle of surface soil, often with high levels of organic material	TOP
Fill	Any material which has been moved by man	FILL
Littoral	Deposited on the lake or sea shore	LIT
Unidentifiable	Not able to be identified	UID

Cobbles and Boulders

The presence of particles considered to be “oversize” may be described using one of the following strategies:

- Oversize encountered in a minor proportion (when considered relative to the wider area) are noted in the soil description; or
- Where a significant proportion of oversize is encountered, the cobbles/boulders are described independent of the soil description, in a similar manner to composite soils (described above) but qualified with “MIXTURE OF”.

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Rock Strength

Rock strength is defined by the unconfined compressive strength and it refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects.

The Point Load Strength Index $I_{s(50)}$ is commonly used to provide an estimate of the rock strength and site specific correlations should be developed to allow UCS values to be determined. The point load strength test procedure is described by Australian Standard AS4133.4.1-2007. The terms used to describe rock strength are as follows:

Strength Term	Unconfined Compressive Strength (MPa)	Point Load Index[1] $I_{s(50)}$ MPa	Abbreviation Code
Very low	0.6 - 2	0.03 - 0.1	VL
Low	2 - 6	0.1 - 0.3	L
Medium	6 - 20	0.3 - 1.0	M
High	20 - 60	1 - 3	H
Very high	60 - 200	3 - 10	VH
Extremely high	>200	>10	EH

[1] Assumes a ratio of 20:1 for UCS to $I_{s(50)}$. It should be noted that the UCS to $I_{s(50)}$ ratio varies significantly for different rock types and specific ratios may be required for each site.

On investigation logs only, the following data contiguity codes may be in rock strength tables for layers or seams of material "within rock", but for which the equivalent UCS strength is less than 0.6 MPa.

Scenario	Abbreviation Code
The material encountered has an equivalent UCS strength of less than 0.6 MPa, and therefore is considered to be soil (as per Note 1 of Table 20 of AS 1726-2017). The properties of the material encountered over this interval are described in the "Description of Strata" and soil properties columns.	SOIL
The material encountered has an equivalent UCS strength of less than 0.6 MPa, and therefore is considered to be soil (as per Note 1 of Table 20 of AS 1726-2017). The prominence of the material is such that it can be considered to be a seam (as defined in Table 22 of AS1726-2017) and the properties of the material are described in the defect column.	SEAM

Degree of Weathering

The degree of weathering of rock is classified as follows:

Weathering Term	Description	Abbreviation Code
Residual Soil[1,2]	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.	RS
Extremely weathered[1,2]	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible	XW
Highly weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.	HW
Moderately weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.	MW
Slightly weathered	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.	SW
Fresh	No signs of decomposition or staining.	FR
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathered products in pores.	DW

[1] AS1726-2017 6.1.9 provides similar definitions for "residual soil" and "extremely weathered material" as soil origins. Generally, the soil origin terms would be used above the depth at which very low strength or stronger rock material is first encountered, while both soil origin and weathering should may be stated for soil encountered below the first contact with rock material, where appropriate.

[2] The parent rock type, of which the residual/extremely weathered material is a derivative, will be stated in the description (where discernible).

Degree of Alteration

The degree of alteration of the rock material (physical or chemical changes caused by hot gasses or liquids at depth) is classified as follows:

Term	Description	Abbreviation Code
Extremely altered	Material is altered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.	XA
Highly altered	The whole of the rock material is discoloured, usually by staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is changed by alteration. Some primary minerals are altered to clay minerals. Porosity may be increased by leaching, or may be decreased due to precipitation of secondary materials in pores.	HA
Moderately altered	The whole of the rock material is discoloured, usually by staining or bleaching to the extent that the colour of the original rock is not recognisable but shows little or no change of strength from fresh rock.	MA
Slightly altered	Rock is slightly discoloured but shows little or no change of strength from fresh rock	SA
Note: If HA and MA cannot be differentiated use DA (see below)		
Distinctly altered	Rock strength usually changed by alteration. The rock may be highly discoloured, usually by staining or bleaching. Porosity may be increased by leaching, or may be decreased due to precipitation of secondary minerals in pores.	DA

Degree of Fracturing

The following descriptive classification apply to the spacing of natural occurring fractures in the rock mass. It includes bedding plane partings, joints and other defects, but excludes drilling breaks. These terms are generally not required on investigation logs where fracture spacing is presented as a histogram, and where used are presented in an unabbreviated format.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} > 100 \text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or stronger. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

These terms may be used to describe the spacing of bedding partings in sedimentary rocks. Where used, these terms are generally presented in an unabbreviated format

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

Defect Descriptions

Defect Type

Term	Abbreviation Code
Bedding plane	B
Clay seam	CS
Cleavage	CV
Crushed zone	CZ
Decomposed seam	DS
Fault	F
Joint	J
Lamination	LAM
Parting	PT
Sheared zone	SZ
Vein	VN
Drilling/handling break	DB , HB
Fracture	FCT

Rock Defect Orientation

Term	Abbreviation Code
Horizontal	H
Vertical	V
Sub-horizontal	SH
Sub-vertical	SV

Rock Defect Coating

Term	Abbreviation Code
Clean	CLN
Coating	CO
Healed	HE
Infilled	INF
Stained	STN
Tight	TI
Veneer	VEN

Rock Defect Infill

Term	Abbreviation Code
Calcite	CA
Carbonaceous	CBS
Clay	CLY
Iron oxide	FE
Manganese	MN
Silty	SLT

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Rock Defect Shape/Planarity

Term	Abbreviation Code
Curved	CU
Irregular	IR
Planar	PL
Stepped	ST
Undulating	UN

Rock Defect Roughness

Term	Abbreviation Code
Polished	PO
Rough	RO
Slickensided	SL
Smooth	SM
Very rough	VR

Other Rock Defect Attributes

Term	Abbreviation Code
Fragmented	FG
Band	BND
Quartz	QTZ

Defect Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

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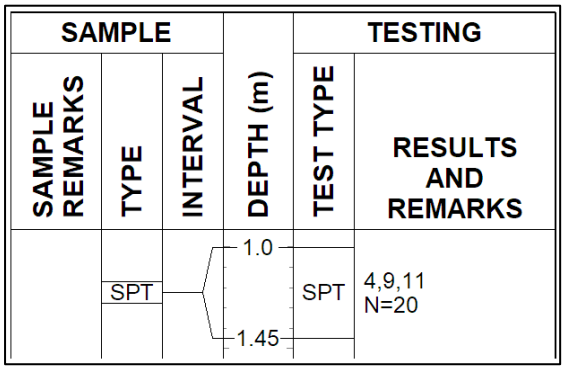
Sampling, Testing and Excavation Methodology

Terminology
Symbols
Abbreviations

November 2020

Sampling and Testing

A record of samples retained and field testing performed is usually shown on a Douglas Partners' log with samples appearing to the left of a depth scale, and selected field and laboratory testing (including results, where relevant) appearing to the right of the scale, as illustrated below:



Sampling

The type or intended purpose for which a sample was taken is indicated by the following abbreviation codes.

Sample Type	Code
Auger sample	A
Acid sulfate sample	ASS
Bulk sample	B
Core sample	C
Disturbed sample	D
Sample from SPT test	SPT
Environmental sample	E
Gas sample	G
Jar sample	J
Undisturbed tube sample	U[1]
Water sample	W
Piston sample	P
Core sample for unconfined compressive strength testing	UCS

[1] – numeric suffixes indicate tube diameter/width in mm

The above codes only indicate that a sample was retained, and not that testing was scheduled or performed.

Field and Laboratory Testing

A record that field and laboratory testing was performed is indicated by the following abbreviation codes.

Test Type	Code
Pocket penetrometer (kPa)	PP
Photo ionisation detector (ppm)	PID
Standard Penetration Test x/y =*x* blows for *y* mm penetration HB = hammer bouncing	SPT
Shear vane (kPa)	V
Unconfined compressive strength, (MPa)	UCS

Field and laboratory testing (continued)

Test Type	Code
Point load test, (MPa), axial (A), diametric (D), irregular (I)	PLT(_)
Dynamic cone penetrometer, followed by blow count penetration increment in mm (cone tip, generally in accordance with AS1289.6.3.2)	DCP/150
Perth sand penetrometer, followed by blow count penetration increment in mm (flat tip, generally in accordance with AS1289.6.3.3)	PSP/150

Groundwater Observations

▷	seepage/inflow
▽	standing or observed water level
NFGWO	no free groundwater observed
OBS	Observations obscured by drilling fluids

Drilling or Excavation Methods/Tools

The drilling/excavation methods used to perform the investigation may be shown either in a dedicated column down the left hand edge of the log, or stated in the log footer. In some circumstances abbreviation codes may be used.

Method	Abbreviation Code
Excavator/backhoe bucket	B[1]
Toothed bucket	TB[1]
Mud/blade bucket	MB[1]
Ripping tyne/ripper	RT
Rock breaker/hydraulic hammer	RB
Hand auger	HA[1]
NMLC series coring	NMLC
HMLC series coring	HMLC
NQ coring	NQ
HQ coring	HQ
PQ coring	PQ
Push tube	PT [1]
Rock roller	RR[1]
Solid flight auger. Suffixes: (TC) = tungsten carbide tip, (V) = v-shaped tip	SFA[1]
Sonic drilling	SON[1]
Vibrocore	VC[1]
Wash bore (unspecified bit type)	WB[1]
Existing exposure	X
Hand tools (unspecified)	HT
Predrilled	PD
Specialised bit (refer report)	SPEC[1]
Diatube	DT[1]
Hollow flight auger	HFA[1]
Vacuum excavation	VE

[1] – numeric suffixes indicate tool diameter/width in mm

TEST PIT LOG

CLIENT: Binowee Developments Pty Ltd
PROJECT: Proposed Subdivision (Zoning Extension)
LOCATION: 141 Googong Road, Googong

SURFACE LEVEL: 725 AHD
COORDINATE E:702797 **N:** 6078922
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 1
PROJECT No: 211145.00
DATE: 09/12/21
SHEET: 1 of 1

CONDITIONS ENCOUNTERED									SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.0	TOPSOIL/ (ML) Clayey SILT, with gravel; brown; silt fraction low plasticity; gravel fraction fine; with rootlets		TOP	NA	<PL						
		0.1	SILTSTONE/SHALE: fine grained, blue grey, medium strength, moderately weathered, highly fractured, near vertical laminations						D		0.1		
		0.3	Test pit discontinued at 0.30m depth Refusal										
	724	1									1		

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: CAT305E
OPERATOR: Bingley
LOGGED: LSDJ
METHOD: 300mm wide bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon

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TEST PIT LOG

CLIENT: Binowee Developments Pty Ltd
PROJECT: Proposed Subdivision (Zoning Extension)
LOCATION: 141 Googong Road, Googong

SURFACE LEVEL: 721 AHD
COORDINATE E:702876 **N:** 6079022
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 2
PROJECT No: 211145.00
DATE: 09/12/21
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING AND REMARKS: TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.0	TOPSOIL/ (ML) Clayey SILT; brown; low plasticity		TOP	NA	<PL						
		0.15	(CI) Silty Gravelly CLAY, trace sand; brown orange; clay fraction medium plasticity; gravel fraction fine to medium; sand fraction fine to coarse; (extremely weathered rock)			F	>PL						
			0.45m: extremely weathered rock										
	720	1			RES	VST	=PL				1	DCP/150	5 10 15
		1.5	Test pit discontinued at 1.50m depth Limit of investigation			H	<PL		D		1.4		

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: CAT305E
OPERATOR: Bingley
LOGGED: LSDJ

METHOD: 300mm wide bucket

REMARKS: At the base of a small rock shelf. Surface levels and coordinates are approximate only and must not be relied upon

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TEST PIT LOG

CLIENT: Binowee Developments Pty Ltd
PROJECT: Proposed Subdivision (Zoning Extension)
LOCATION: 141 Googong Road, Googong

SURFACE LEVEL: 719 AHD
COORDINATE E:702914 **N:** 6079202
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 3
PROJECT No: 211145.00
DATE: 09/12/21
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.0	TOPSOIL/ (CL-CI) Silty CLAY, trace gravel; brown; clay fraction low to medium plasticity; gravel fraction fine to medium; with rootlets		TOP								
		0.1	DACITE: fine to coarse grained, brown blue grey, medium to high strength, moderately to slightly weathered, fractured to slightly fractured										
		0.6	Test pit discontinued at 0.60m depth refusal										
	718	1									1		

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: CAT305E
OPERATOR: Bingley
LOGGED: LSDJ
METHOD: 300mm wide bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon

EXPORTED 22/12/21 13:23. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Binowee Developments Pty Ltd
PROJECT: Proposed Subdivision (Zoning Extension)
LOCATION: 141 Googong Road, Googong

SURFACE LEVEL: 729 AHD
COORDINATE E:703049 **N:** 6079328
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 4
PROJECT No: 211145.00
DATE: 09/12/21
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.0	TOPSOIL/ (CL) Silty CLAY, with sand, trace gravel; brown; clay fraction low plasticity; sand fraction fine to medium; gravel fraction fine to medium; with rootlets		TOP	NA	<PL to =PL					DCP/150	5 10 15
	0.1	(ML) Clayey SILT; grey; low plasticity			F TO ST	>PL						
	0.2	(CI-CH) CLAY; red brown; medium to high plasticity			F TO ST	>PL						
	0.85	(CI) Silty CLAY, trace sand; yellow brown mottled red brown; clay fraction medium plasticity; sand fraction fine to coarse			VST	=PL						
	728 1									1		
	1.1	(CL-CI) Silty CLAY; yellow brown mottled white grey; low to medium plasticity; extremely weathered rock		RES	(VST TO H)	<PL		D		1.3		
	1.65	Test pit discontinued at 1.65m depth Limit of investigation										

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: CAT305E
OPERATOR: Bingley
LOGGED: LSDJ
METHOD: 300mm wide bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon

EXPORTED 22/12/21 13:23. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Binowee Developments Pty Ltd
PROJECT: Proposed Subdivision (Zoning Extension)
LOCATION: 141 Googong Road, Googong

SURFACE LEVEL: 736 AHD
COORDINATE E:703250 **N:** 6079383
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 5
PROJECT No: 211145.00
DATE: 09/12/21
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.0	TOPSOIL/ (ML) Clayey SILT, trace sand, trace gravel; brown; silt fraction low plasticity; sand fraction fine to coarse; gravel fraction fine to coarse; with rootlets		TOP	NA	<PL					DCP/150	5 10 15
	0.05	(CI) Silty CLAY, with sand, with gravel; brown orange red brown; clay fraction medium plasticity; sand fraction fine to coarse; gravel fraction fine to medium			(VST TO H)	<PL to =PL		D	0.6			
	0.7	SILTSTONE/SHALE: fine grained, brown grey, medium to high strength, moderately to slightly weathered, fractured to slightly fractured										
	0.8	Test pit discontinued at 0.80m depth refusal										
	735 1									1		

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: CAT305E
OPERATOR: Bingley
LOGGED: LSDJ
METHOD: 300mm wide bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon

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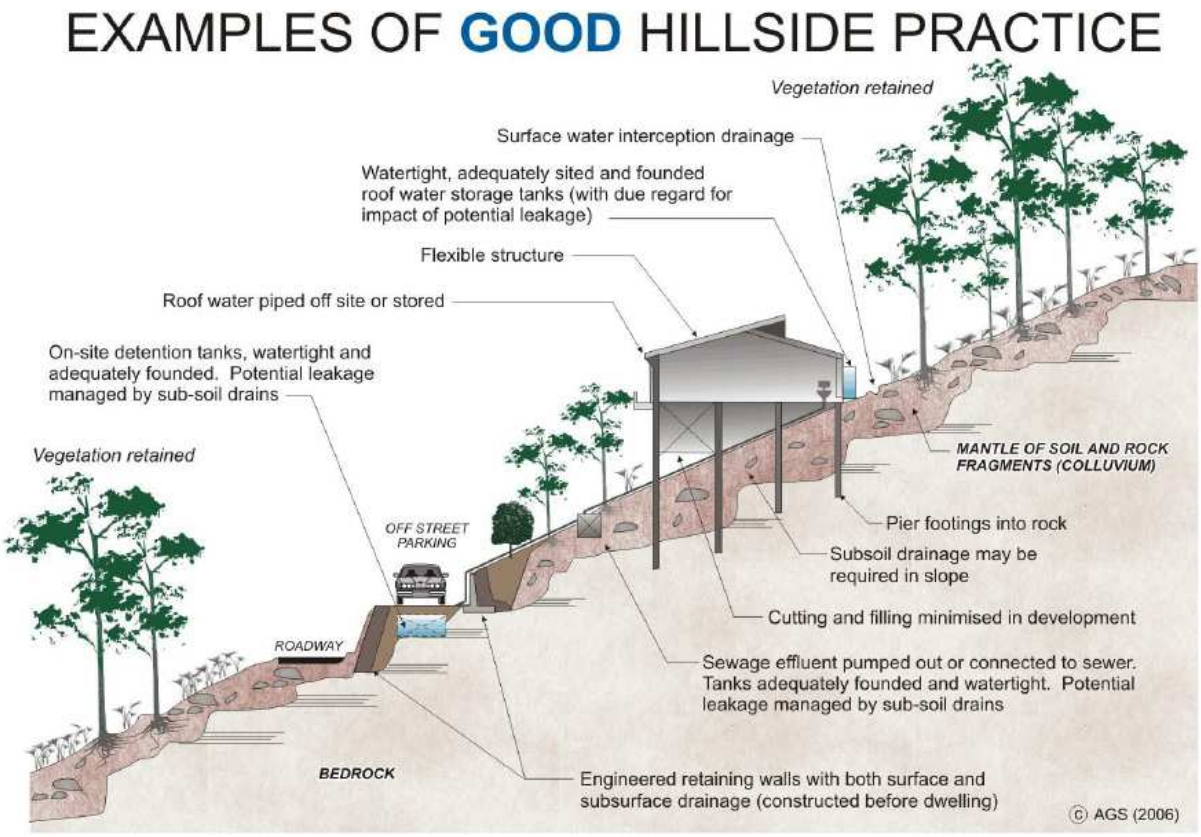
Appendix E

AGS Publication Extract

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
Cutting and filling minimised in development
ROADWAY
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)
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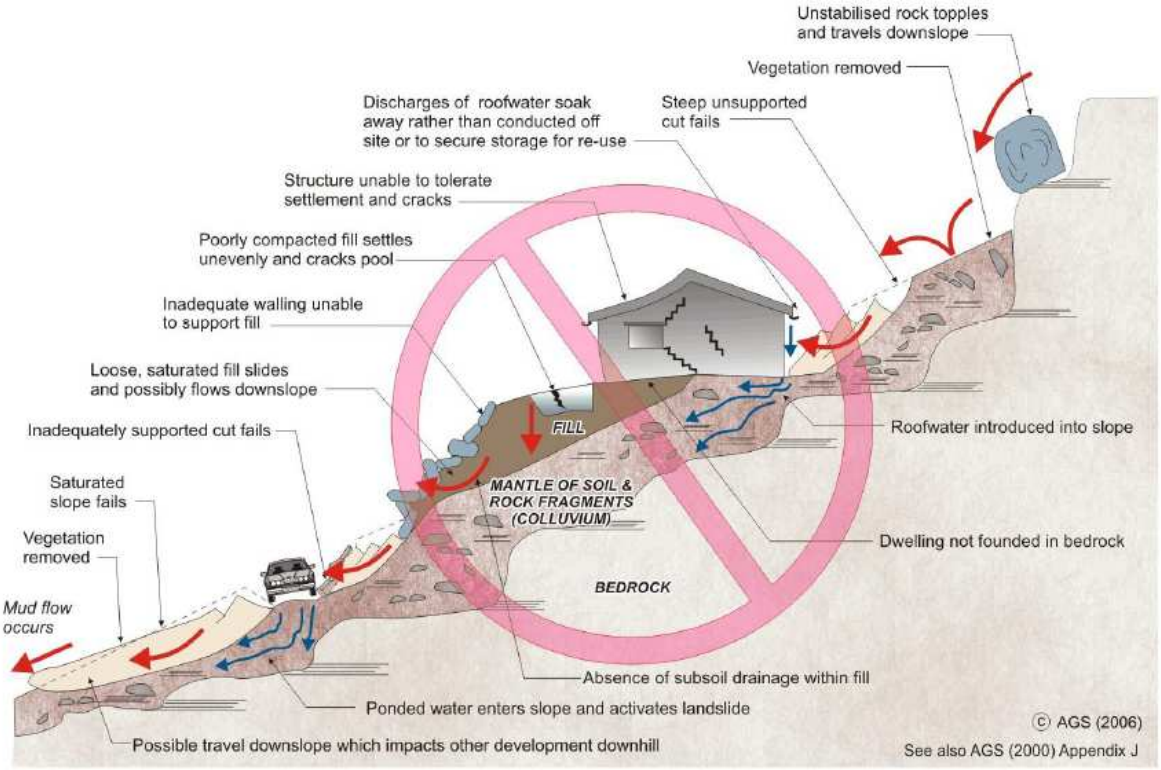
EXAMPLES OF POOR HILLSIDE PRACTICE
Unstabilised rock topples and travels downslope
Vegetation removed
Discharges of roofwater soak away rather than conducted off site or to secure storage for re-use
Steep unsupported cut fails
Structure unable to tolerate settlement and cracks
Poorly compacted fill settles unevenly and cracks pool
Inadequate walling unable to support fill
Loose, saturated fill slides and possibly flows downslope
Inadequately supported cut fails
FILL
Roofwater introduced into slope
Saturated slope fails
MANTLE OF SOIL & ROCK FRAGMENTS (COLLUVIUM)
Vegetation removed
Dwelling not founded in bedrock
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
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See also AGS (2000) Appendix J