GEOTECHNICAL INVESTIGATION REPORT

CLIENT

Queanbeyan-Palarang
Regional Council

ADDRESS

1241 Old Cooma Road,
Googong, NSW.

DATE

April 2017

ACT Geotechnical Engineers Pty Ltd
ACN 063 673 530

5/9 Beaconsfield Street, Fyshwick, ACT,2609
PO Box 9225, Deakin, ACT, 2600
Ph: (02) 6285 1547

13 April 2017
Our ref: MD/C8640

Queanbeyan-Palerang Regional Council
PO Box
Queanbeyan NSW 2620

Attention: Tim Geyer

Dear Sir

1241 OLD COOMA ROAD, GOOGONG, NSW

GEOTECHNICAL INVESTIGATION REPORT

We are pleased to present our geotechnical investigation report at 1241 Old Cooma Road, in Googong, NSW.

The report outlines the methods and results of exploration, describes site subsurface conditions and provides recommendations for excavation conditions, preparation of subgrades, stability of cut and fill batters and groundwater conditions.

Should you require any further information regarding this report, please do not hesitate to contact our office.

Yours faithfully
ACT Geotechnical Engineers Pty Ltd

Jeremy Murray
Director

QPRC

1241 OLD COOMA ROAD, GOOGONG, NSW

GEOTECHNICAL INVESTIGATION REPORT

APRIL 2017

QPRC

1241 OLD COOMA ROAD, GOOGONG, NSW

GEOTECHNICAL INVESTIGATION REPORT

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1241 OLD COOMA ROAD, GOOGONG, NSW

GEOTECHNICAL INVESTIGATION REPORT

1 INTRODUCTION

At the request of Queanbeyan-Palerang Regional Council (QPRC), ACT Geotechnical Engineers Pty Ltd carried out a geotechnical investigation at 1241 Old Cooma Road, in Googong, NSW. It has been indicated that the site will be used for an unspecified development.

The aim of the investigation was to:

(i) Identify subsurface conditions including the extent and nature of any fill materials, soil strata, bedrock type and depth, and groundwater presence.

(ii) Advise on excavation conditions and suitability of excavated material for use as structural fill.

(iii) other geotechnical advice.

2 SITE DESCRIPTION & GEOLOGY

The 36.4ha site is located on the eastern side of Old Cooma Road, at the Burra Drive intersection, in Googong, NSW. There is an existing cottage located at the centre of the site and the lot is used as pasture land. Church Creek drains NW through the site, with several smaller tributaries draining into it. The topography is mostly the flood-plain of the creek and its tributaries. The land starts to elevate along the NE Burra Road boundary of the site. Figure 1 shows the site locality and Figure 2 is a recent aerial photograph showing the present site layout.

The 1:100,000 Canberra Geology map (Reference 1) documents the site to be underlain by Silurian age Colinton Volcanics bedrock, which includes dark green dacitic ignimbrite and minor volcaniclastic sediments.

3 INVESTIGATION METHODS

To establish the subsurface conditions, a JCB 3CX backhoe with a ~300mm auger attachment was used to drill ten holes extending to the nominated investigation depth at 3.5m depth or earlier refusal in rock, on 6 April 2017. The subsurface profiles were logged in terms of the Unified Soil Classification System (USCS). The locations of the boreholes, designated 1A to 10A, are shown on Figure 2, and the detailed logs are included in Appendix A.

Definitions of geotechnical engineering terms used in the report on the borehole logs, including a copy of the USCS chart, are provided in Appendix B.

4 INVESTIGATION RESULTS

4.1 Subsurface Conditions

The subsurface conditions of the proposed development were investigated by ten auger holes designated 1A to 10A. The borehole logs in Appendix A can be referred to for more detail.

The investigation auger holes found the subsurface profile to comprise:

Geological Profile	Typical Depth Interval	Description
TOPSOIL	0m to 0.1m/0.2m	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots, dry to moist, loose.
SLOPEWASH	0.1m/0.2m to 0.4m/0.6m	SILTY SAND; fine to medium sand, low plasticity silt, pale grey-brown, dry to moist, medium dense. Only encountered in boreholes 1A, 2A, 5A, 8A and 9A.
ALLUVIAL/ RESIDUAL SOIL	0.1m/0.6 to 0.3m/>3.5m	SILTY SANDY CLAY, SILTY CLAYEY SAND, & SANDY CLAY; fine to coarse sand, low to medium and some medium to high plasticity clay, red-brown, orange-brown, brown, grey, dry to moist and moist, stiff to very stiff and dense.
BEDROCK	Below 0.2m/1m	DACITE; fine to coarse grained, orange brown, grey, highly weathered (HW) and weak rock grading to moderately weathered (MW) and medium strong rock. Only encountered in boreholes 4 A, 6A, 7A and 8A.

Bedrock was encountered in boreholes 4A, 6A, 7A and 8A, below 0.2m/1m, with refusal occurring at 1.5m, 0.3m, 0.6m and 1.3m depth in medium strong rock. The bedrock is predominantly on the elevated, northern portion of the site, towards the intersection of Old Cooma Road and Burra Road. Bedrock was not encountered within the remaining boreholes within the investigation depth of 3.5m, although bedrock could be encountered at greater depths.

4.2 Groundwater

Groundwater was not encountered and the soils were mostly dry to moist. However, temporary, perched seepages could be encountered following rainfall within the more pervious soils.

5 DISCUSSION & RECOMMENDATIONS

5.1 Building Footings

Footings and slabs for one and two-storey, residential-type structures must be in accordance with the principles of AS2870 (Reference 2). For structures founded at existing grade, footings, including thickened sections of slabs forming footings should be founded below any topsoil and slopewash, into the stiff to very stiff alluvial soils or weathered bedrock. A depth of ~0.2m/0.4m from existing levels may be required to reach a suitable founding stratum. Shallow footings could be founded in any newly placed controlled fill following removal of any topsoil and slopewash (see Section 5.5). Alternatively, footings could be founded on piers extending to weathered bedrock at 0.2m (1m depth (northern portion of site) or >3.5m depth (the remainder of the site).

If designing footings based on engineering principles, recommended allowable end-bearing pressures for various footing systems and likely foundation materials are provided in Table 1.

TABLE 1

Recommended Allowable End-Bearing Pressures for Footings

Foundation Material Type	Depth Below Existing Surface Level	Allowable End-Bearing Pressure			Allowable Shaft Adhesion on Bored Piers	
		Strips	Pads	Bored Piers	Downward Loading	Uplift
Newly Placed Controlled Fill	-	100kPa	125kPa	N.A	N.A	N.A
Stiff to Very Stiff Alluvial Soils	0.2m/0.4m	125kPa	150kPa	200kPa	20kPa	10kPa
HW & less weathered bedrock	0.2m/1m (northern portion) >3.5m (elsewhere)	1250kPa	1500kPa	2000kPa	200kPa	100kPa

All footings should be inspected and approved by an experienced geotechnical engineer to confirm the foundation material and design values, and to ensure the excavations are clean and stable.

Groundslabs can be constructed on the natural soils or newly placed controlled fill, following the removal of any topsoil. Following excavation to required level, slab areas on soil should be proof-rolled by a pad foot roller to check for any weak, wet or deforming soils that may require replacement. Suitable replacement fill should be compacted in not thicker than 150mm layers to not less than 98%StdMDD.

If required for design of ground slabs, a modulus of subgrade reaction of 30kPa/mm can be assumed for a natural soil or controlled fill foundation.

5.2 Excavation Conditions & Use of Excavated Material

Shallow excavations will be through topsoil, slopewash, alluvial soil, and bedrock. The soils are readily diggable by backhoe and medium sized excavator to at least 3.5m depth over most of the site. However, medium strong bedrock is exposed below 0.5m/1.5m depth on the northern portion of the site (in the vicinity of boreholes 4A, 6A, 7A and 8A), which will require heavy ripping and rock hammering to excavate.

The low/medium plasticity alluvial soils and weathered bedrock can be used in controlled fill construction of building platforms, although any rock particles should be broken down to <75mm size. Topsoil and silty slopewash should not be used in controlled fill construction, but could be used in non-structural applications such as landscaping.

If imported fill is required, a suitable select fill material would include a low or medium plasticity soil such as clayey sand or gravelly clayey sand, containing between 25% and 50% fines less than 0.075mm size (silt and clay), and no particles greater than 75mm size.

5.3 Stable Excavation Batters

Temporary site excavations to 1.5m depth can be formed near vertical, although loose topsoil should be cut back at 1(H):1(V). If required and space allows, deeper temporary cuts can be formed at 1(H):1(V) or benched at 1.5m intervals in soils. A geotechnical engineer should inspect all cut batters during construction to confirm stability. Exposed temporary batters should be protected from the weather by black plastic pinned to the face with link-wire mesh, or similar.

Permanent cut & fill batter slopes should be formed at no steeper than 2(H):1(V) in soil and EW bedrock and be protected against erosion by shotcreting, stone pitching or other suitable methods. Alternatively permanent excavations can be supported by structural retaining walls.

5.4 Low Retaining Walls

Retaining walls constructed in open excavation, with the gap between the excavation face and the wall backfilled later, can be designed for an earth pressure distribution given by:

$$\sigma_h = (K\gamma' h) + Kq$$

where,

- σ_h is the horizontal earth pressure acting on the back of the wall, in kPa
- K is the dimensionless coefficient of earth pressure; this can be assumed to be 0.4 when the top of the wall is unrestrained horizontally, and 0.6 when the top of the wall is restrained (i.e. by building slabs etc.)
- γ' is the effective unit weight of the backfill, and can be assumed to be 20kN/m^3 for a lightly compacted soil backfill
- h is the height of the backfill, in metres
- q is any uniform distributed vertical surcharge acting on the top of the backfill, in kPa

Apart from structural restraints such as floor slabs, resistance to overturning and sliding of retaining walls is provided by frictional and adhesive resistance on the base, and by passive resistance at the toe of the wall. For a natural soil or controlled fill foundation, an ultimate base friction factor (tanδ) of 0.4, base adhesion (c) of 50kPa, and allowable passive earth pressure coefficient Kp=2.5 can be used for calculation of sliding resistance.

Free-draining granular backfill or synthetic fabric drains should be installed behind all walls. These should connect to weep holes and/or a collector drain, and ultimately to the stormwater system. Granular backfill should be wrapped in a suitable filter fabric to minimise infiltration of silt/clay fines

5.5 Controlled Fill Construction

For construction of any new fill foundation platforms and road subgrades, it is recommended that:

- Areas be fully stripped of all topsoil. A stripping depth of ~0.2m/0.4m may be required. Stripped foundations should be proof-rolled by a vibratory pad-foot roller of not less than 9 tonne static mass to check for any weak or wet areas that would require replacement. No fill should be placed until a geotechnical engineer has confirmed the suitability of the foundation.

- Controlled fill comprising suitable site excavated or imported materials of not greater than 75mm maximum particle size, be compacted in not greater than 150mm layers to not less than 98%StdMDD at about OMC.

- Fill placement and control testing be overviewed and certified by a geotechnical engineer at Level 1 or 2 involvement of AS3798 – 1996 "Guidelines on Earthworks for Commercial & Residential Developments" (Reference 3).

5.6 Design CBR Values

On-grade carpark, and access ramp subgrades should be stripped of all topsoil and silty slopewash, and soil subgrades then proof-rolled by a pad-foot roller to check for any wet or otherwise weak spots which may require additional removal. Suitable replacement fill can be compacted in not thicker than 150mm layers, to not less than 98%StdMDD.

The silty topsoil and slopewash in the upper 0.2m/0.4m is susceptible to weakening when saturated. Therefore, the site will be difficult to traffic following rainfall, and hardstand or gravel haul roads may be required during construction.

Road and carpark pavements are expected to comprise natural soils or newly placed controlled fill or similar materials, and pavements can be designed for a subgrade CBR value of 3%. A geotechnical engineer should inspect prepared subgrades to confirm design values, and preferably view a proof-roll to identify any soft spots or other weaknesses.

5.7 Earthquake Site Factor

Table 2.3 of AS1170.4 "Minimum Design Loads on Structures - Part 4: Earthquake Loads" (Reference 4) lists the earthquake acceleration coefficients for major centres to be considered in structural design. The Googong area has an acceleration coefficient of 0.06.

Section 4.2 of AS1170.4 "Minimum Design Loads on Structures – Part 4: Earthquake Loads" lists the site sub-soil classes to be considered in structural design. The site is classified as a "Class C_e – Shallow Soil Site".

5.8 Site Drainage

Groundwater was not encountered during the investigation. The permanent groundwater table is expected to be well below expected excavations, although temporary perched seepages will be present following rain, but should be readily controllable through the use of pumps during construction.

Suitable surface drainage should be provided to ensure rainfall run-off or other surface water cannot pond against buildings or pavements. Drainage should be provided behind all retaining walls, and subsoil drains should be installed along the upslope sides of access roads and carparks.

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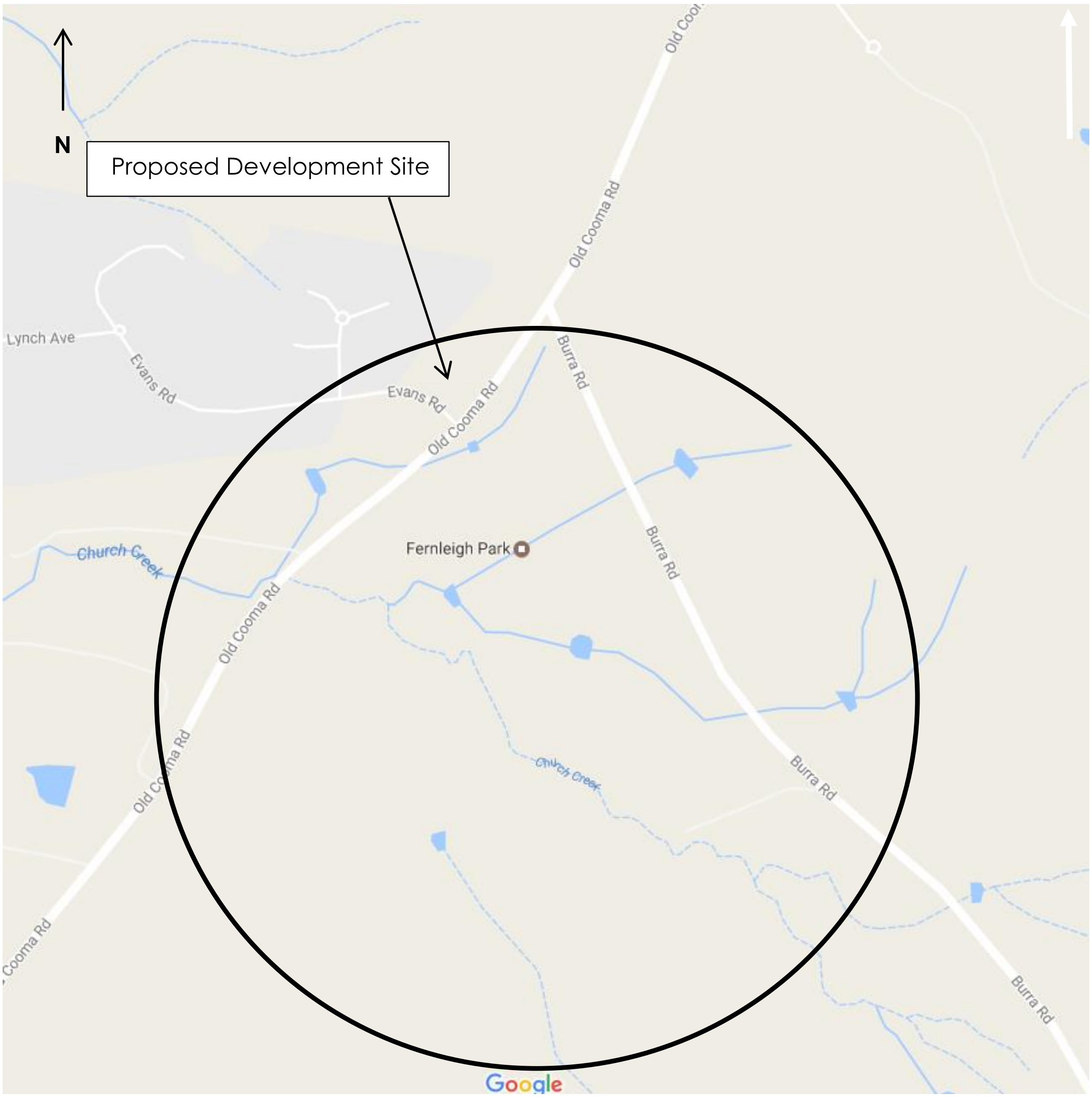
REFERENCES

1 Abell, R.S., 1992, South Bega (1:100 000 scale geology map), Bureau of Mineral Resources, Commonwealth of Australia.

2 Standards Australia, “AS2870 – Residential Slabs & Footings”, 2011.

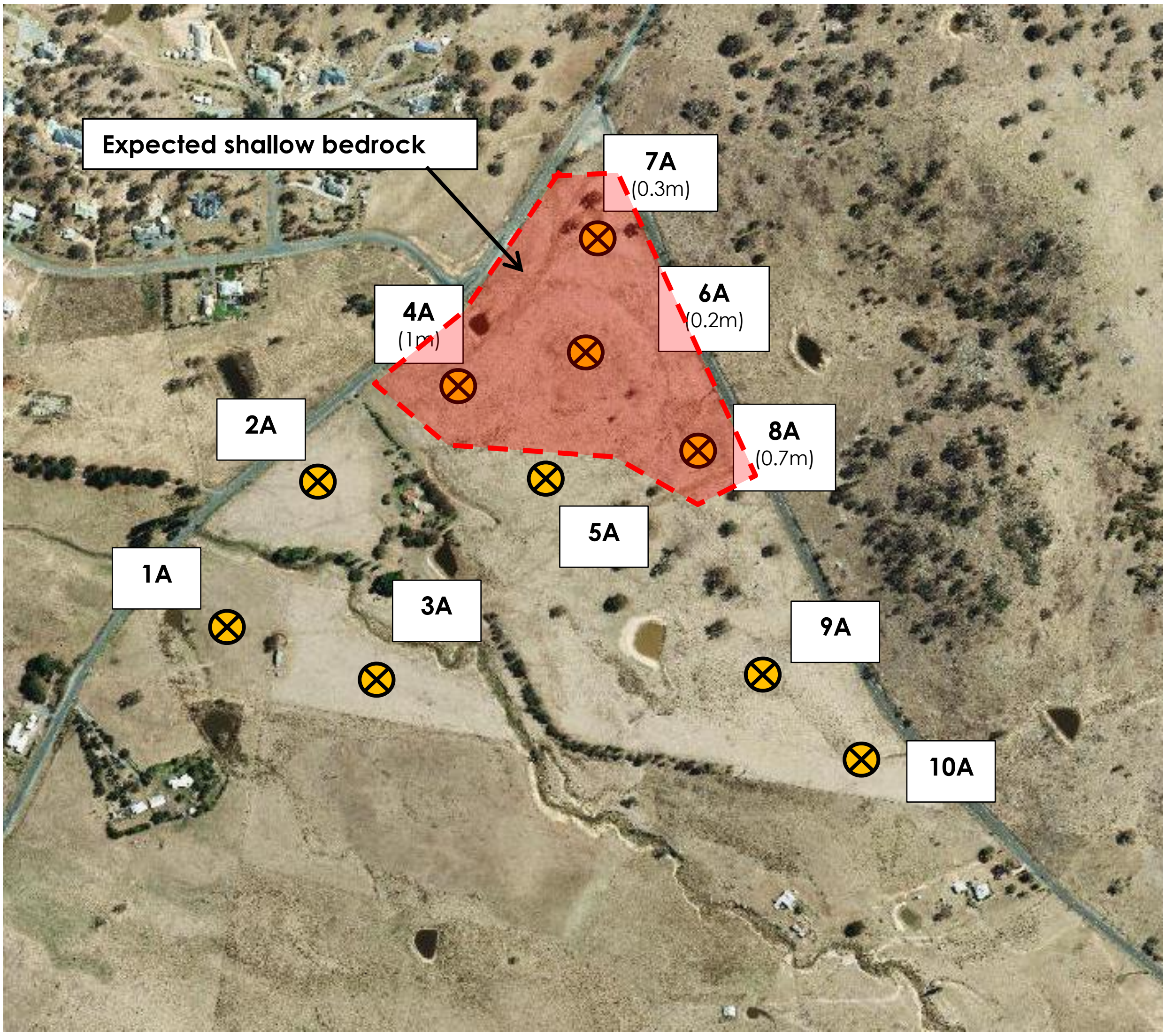
3 AS3798, “Guidelines on earthworks for commercial and residential developments”.

4 Standards Australia, “AS1170.4 – 2007 – Minimum Design Loads on Structures – Part 4 Earthquake Loads”.



QPRC
1241 OLD COOMA ROAD GOOGONG NSW
SITE LOCALITY

ACT Geotechnical Engineers Pty Ltd	**C8640**	**FIGURE 1**



LEGEND

Location of Borehole (depth to bedrock) -

N

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AERIAL PHOTOGRAPH & BOREHOLE LOCATIONS

ACT Geotechnical Engineers Pty Ltd	C8640	FIGURE 2

APPENDIX A
Borehole Log 1A to 10A

Excavation Log

Excavation No.	1A
Sheet	1 of 1
Job No.	C8640

CLIENT: QPRC

PROJECT Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Location : See report

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, dry to moist.	LOOSE		TOPSOIL
			0.6		SM	SILTY SAND; fine to medium sand, low plasticity silt, pale grey, dry to moist.	MEDIUM DENSE		SLOPEWASH
			1.0		CL	SILTY SANDY CLAY; medium plasticity clay, fine to coarse sand, brown, dry.	STIFF		ALLUVIUM
			2.0			some grey, dry to moist.			
			2.8		CL	SANDY CLAY; medium plasticity clay, fine to coarse sand, orange-brown, grey, some sub-angular gravels up to 20mm in size, dry to moist.	STIFF		
			3.0		SC	CLAYEY SAND; fine to coarse sand, low plasticity clay, grey, moist.	DENSE		
			3.5						
			4.0			EXCAVATION TERMINATED AT 3.5m			

Logged By : MD Date : 6-4-17 Checked By : Date :

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Excavation Log

Excavation No.	2A
Sheet	1 of 1
Job No.	C8640

CLIENT: QPRC

PROJECT: Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Location : See report

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, pale grey-brown, dry.	LOOSE		TOPSOIL
			0.4		SM	SILTY SAND; fine to medium sand, low plasticity silt, pale grey-brown, dry to moist.	MEDIUM DENSE		SLOPEWASH
			1.0 1.4		CL	SILTY SANDY CLAY/ SILTY CLAYEY SAND; medium plasticity fines, fine to coarse sand, orange-brown, dry to moist. some grey.	STIFF/ DENSE		ALLUVIUM
			2.0 2.1		CL	SILTY SANDY CLAY; medium plasticity fines, fine to coarse sand, orange-brown, borwn, grey, some sub-rounded gravels up to 20mm in size, moist.	STIFF TO VERY STIFF		
			3.0 3.5		SC	SILTY CLAYEY SAND; fine to coarse sand, low to medium plasticity fines, orange-brown, brown, grey, some sub-rounded gravels up to 20mm in size, moist.	DENSE		
			4.0			EXCAVATION TERMINATED AT 3.5m			

Logged By : MD Date : 6-4-17 Checked By : Date :

Excavation Log

Excavation No.	3A
Sheet	1 of 1
Job No.	C8640
Location : See report	
Surface Level : Not Known	

CLIENT: QPRC

PROJECT Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.1		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, dry to moist.	LOOSE		TOPSOIL
			0.7		CH	SANDY CLAY; high plasticity clay, fine to coarse sand, brown, dry.	STIFF TO VERY STIFF		ALLUVIUM
			1.0		CL-CH	SANDY CLAY; medium to high plasticity clay, fine to coarse sand, orange-brown, brown, grey, some ferruginous nodules up to 10mm in size, dry.	VERY STIFF		
			2.0			dry to moist.			
			2.5						
			3.0		CL	SANDY CLAY; medium plasticity clay, fine to coarse sand, brown, moist.	VERY STIFF		
			3.5						
			4.0			EXCAVATION TERMINATED AT 3.5m			

Logged By : MD Date : 6-4-17 Checked By : Date :

BOREHOLE/EXCAVATION LOG LOGS.GPJ ACT GEO.GDT 12-4-17

Excavation Log

Excavation No.	4A
Sheet	1 of 1
Job No.	C8640
Location : See report	
Surface Level : Not Known	

CLIENT: QPRC

PROJECT Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, dry.	LOOSE		TOPSOIL
					CL-CH	SANDY CLAY; medium to high plasticity clay, fine to coarse sand, orange-brown, some grey, dry.	STIFF		RESIDUAL
			1.0			grey, brown.			
			1.5			HW DACITE; fine to coasre grained, grey, orange-brown.	WEAK ROCK		BEDROCK
			2.0 3.0 4.0			EXCAVATION TERMINATED AT 1.5m REFUSAL IN MEDIUM STRONG ROCK			

Logged By : MD	Date : 6-4-17	Checked By :	Date :

BOREHOLE/EXCAVATION LOG LOGS.GPJ ACT GEO.GDT 12-4-17

Excavation Log

Excavation No.	5A
Sheet	1 of 1
Job No.	C8640

CLIENT: QPRC

PROJECT: Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Location : See report
Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.0–0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, dry.	LOOSE		TOPSOIL
			0.2–0.4		SM	SILTY SAND; fine to medium sand, low plasticity silt, grey-brown, dry.	MEDIUM DENSE		SLOPEWASH
			0.4–1.0		CL-CH	SANDY CLAY; medium to high plasticity clay, fine to coarse sand, orange-brown, dry to moist.	STIFF TO VERY STIFF		ALLUVIUM
			1.0–2.5		CH	SILTY SANDY CLAY; high plasticity clay, fine to coarse sand, orange-brown, grey, brown, some sub-rounded gravels up to 20mm in size, dry to moist.	VERY STIFF		
			2.5–3.5		CL-CH	SILTY SANDY CLAY; medium to high plasticity clay, fine to coarse sand, orange-brown, grey, brown, some sub-rounded gravels up to 20mm in size, dry to moist.	VERY STIFF		
			3.5			EXCAVATION TERMINATED AT 3.5m			

Logged By : MD Date : 6-4-17 Checked By : Date :

BOREHOLE/EXCAVATION LOG LOGS.GPJ ACT GEO.GDT 12-4-17

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Excavation Log

Excavation No.	6A
Sheet	1 of 1
Job No.	C8640

CLIENT: QPRC

PROJECT: Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Location : See report

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, dry.	LOOSE		TOPSOIL
			0.3			HW DACITE; fine to coarse grained, grey, dry.	WEAK ROCK		BEDROCK
						EXCAVATION TERMINATED AT 0.3m REFUSAL IN MEDIUM STRONG ROCK			

1.0

2.0

3.0

4.0

Logged By : MD Date : 6-4-17 Checked By : Date :

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Excavation Log

Excavation No.	7A
Sheet	1 of 1
Job No.	C8640

CLIENT: QPRC

PROJECT Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Location : See report

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, dry.	LOOSE		TOPSOIL
			0.3		CL	SILTY SANDY CLAY; medium plasticity clay, fine to coasre sand, pale brown, dry to moist.	STIFF		RESIDUAL
			0.6			HW DACITE; fine to coarse grained, grey.	WEAK ROCK		BEDROCK
						EXCAVATION TERMINATED AT 0.6m REFUSAL IN MEDIUM STRONG ROCK			
			1.0						
			2.0						
			3.0						
			4.0						

Logged By : MD Date : 6-4-17 Checked By : Date :

BOREHOLE/EXCAVATION LOG LOGS.GPJ ACT GEO.GDT 12-4-17

Excavation Log

Excavation No.	8A
Sheet	1 of 1
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CLIENT: QPRC

PROJECT Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Location : See report

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, dry	LOOSE		TOPSOIL
			0.4		SM	SILTY SAND; fine to coarse sand, low plasticity silt, pale grey-brown, dry.	MEDIUM DENSE		SLOPEWASH
			0.7		CL-CH	SANDY CLAY; medium to high plasticity clay, fine to coarse sand, brown,-grey, dry.	STIFF TO VERY STIFF		RESIDUAL
			1.0 1.3			HW DACITE; fine to coarse grained, brown-grey.	WEAK ROCK		BEDROCK
			2.0 3.0 4.0			EXCAVATION TERMINATED AT 1.3m REFUSAL IN MEDIUM STRONG ROCK			

Logged By : MD Date : 6-4-17 Checked By : Date :

BOREHOLE/EXCAVATION LOG LOGS.GPJ ACT GEO.GDT 12-4-17

Excavation Log

Excavation No.	9A
Sheet	1 of 1
Job No.	C8640

CLIENT: QPRC

PROJECT: Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Location : See report

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, dry	LOOSE		TOPSOIL
			0.4		SM	SILTY SAND; fine to coarse sand, low plasticity silt, pale grey-brown, dry.	MEDIUM DENSE		SLOPEWASH
			1.0		CL	SILTY SANDY CLAY/ SILTY CLAYEY SAND; fine to coarse sand, medium plasticity fines, orange-brown, dry.	STIFF/ DENSE		ALLUVIUM
			1.4		CL	SILTY SANDY CLAY; medium plasticity clay, fine to coasre sand, orange-brown, some grey, dry to moist.	STIFF TO VERY STIFF		
			2.0 2.3		CL	SANDY CLAY; medium plasticity clay, fine to coarse sand, dark brown, dry to moist.	VERY STIFF		
			3.0 3.5		SC	CLAYEY SAND; fine to coasre sand, low to medium plasticity clay, brown, moist to wet.	DENSE		
			4.0			EXCAVATION TERMINATED AT 3.5m			

Logged By : MD Date : 6-4-17 Checked By : Date :

ACT Geotechnical Engineers

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Excavation Log

Excavation No.	10A
Sheet	1 of 1
Job No.	C8640

CLIENT: QPRC

PROJECT: Geotechnical Investigation
1241 Old Cooma Road, Googong, NSW

Location : See report

Surface Level : Not Known

Equipment Type : JCB 3CX Backhoe
Excavation Dimensions : 300mm diameter

Samples	Water	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure (Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure)	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.0–0.2		SM	SILTY SAND; fine to coarse sand, low plasticity silt, brown, some grass roots at the surface, dry	LOOSE		TOPSOIL
			0.2–0.6		SC	CLAYEY SAND; fine to coarse sand, medium plasticity clay, orange-brown, dry.	DENSE		ALLUVIUM
			0.6–1.5		CL-CH	SANDY CLAY; medium to high plasticity clay, fine to coasre sand, red-brown, some ferruginous nodules up to 5mm in size, dry.	STIFF TO VERY STIFF		
			1.0			orange-brown, grey.	VERY STIFF		
			1.5–2.0		CL	SILTY SANDY CLAY; medium plasticity fines, fine to coarse sand, orange-brown, some grey, dry to moist.	VERY STIFF		
			2.0–3.5		CL	SANDY CLAY; medium plasticity clay, fine to coasre sand, brown, moist.	VERY STIFF		
			3.5			EXCAVATION TERMINATED AT 3.5m			
			4.0						

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APPENDIX B
Definitions of Geotechnical Engineering Terms

UNIFIED SOIL CLASSIFICATION SYSTEM (METRICATED)
DATA FOR DESCRIPTION IDENTIFICATION AND CLASSIFICATION OF SOILS

DESCRIPTION / FIELD IDENTIFICATION / LABORATORY CLASSIFICATION — COARSE GRAINED SOILS

MAJOR DIVISIONS		GROUP SYMBOL	GRAPHIC SYMBOL	TYPICAL NAME	GRADATIONS		NATURE OF FINES	DRY STRENGTH	GROUP SYMBOL	% [2] < 0.06mm	PLASTICITY OF FINE FRACTION	$C_u = \frac{D_{60}}{D_{10}}$	$C_c = \frac{(D_{30})^2}{D_{10}D_{60}}$
COARSE GRAINED SOILS — More than 50% by dry mass, less than 60mm is greater than 0.06mm	GRAVELS — More than 50% of coarse grains are greater than 2.0mm	GW		Well graded gravels and gravel-sand mixtures, little or no fines.	GOOD	Wide range in grain size	"Clean" materials (not enough fines to bind coarse grains)	None	GW	0-5	-	>4	between 1 and 3
		GP		Poorly graded gravels and gravel-sand mixtures, little or no fines.	POOR	Predominantly one size or range of sizes			GP	0-5	-	Fails to comply with above	
	GRAVELLY SOILS	GM		Silty gravels, gravel-sand-silt mixtures.	GOOD to FAIR	"Dirty" materials (excess of fines)	Fines are non-plastic (1)	None to medium	GM	12-50	Below 'A' line or $I_p<4$	-	-
		GC		Clayey gravels gravel-sand-clay mixtures.			Fines are plastic (1)	Medium to high	GC	12-50	Above 'A' line and $I_p>7$	-	-
	SANDS — More than 50% of coarse grains are less than 2.0mm	SW		Well graded sands and gravelly sands, little or no fines.	GOOD	Wide range in grain size	"Clean" materials (not enough fines to bind coarse grains)	None	SW	0-5	-	>6	between 1 and 3
		SP		Poorly graded sands and gravelly sands, little or no fines.	POOR	Predominately one size or range of sizes.			SP	0-5	-	Fails to comply with above	
	SANDY SOILS	SM		Silty sand, sand-silt mixtures.	GOOD to FAIR	"Dirty" materials (excess of fines)	Fines are non-plastic (1)	None to medium	SM	12-50	Below 'A' line or $I_p<4$	-	-
		SC		Clayey sands, sand-clay mixtures.			Fines are plastic (1)	Medium to high	SC	12-50	Above 'A' line and $I_p>7$	-	-

DESCRIPTIVE DATA (coarse grained soils): Give typical name, indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition and hardness of the coarse grains, local or geological name and other pertinent descriptive information; symbols in parenthesis.

For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.

EXAMPLE:
Silty Sand, gravelly, about 20% hard, angular gravel particles, 10mm maximum size; rounded and sub angular sand grains coarse to fine; about 15% non-plastic fines with low dry strength; well compacted and moist in place; light brown alluvial sand, (SM)

FIELD IDENTIFICATION: Determine approximate percentages of material over 60mm in size, maximum size, shape, surface texture, hardness of material, geological description. Identify on estimated percentage mass of the various fractions.

COARSE GRAINED SOILS — More than half of the material less than 60 mm is larger than 0.06mm

0.06mm is about the smallest particle visible to the naked eye

LABORATORY CLASSIFICATION: Use the gradation curve of material passing 60 mm for classification of fractions according to the criteria given under "Major Divisions".

NOTES

1. Identify fines by the method given for fine grained soils.
2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.06mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC

FINE GRAINED SOILS

SILT AND CLAY FRACTION — Fraction smaller than 0.20mm AS sieve size

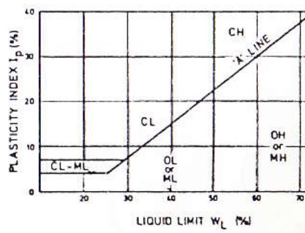
MAJOR DIVISIONS		GROUP SYMBOL	GRAPHIC SYMBOL	TYPICAL NAME	DRY STRENGTH	DILATANCY	TOUGHNESS	GROUP SYMBOL	More than 50% passing 0.06mm
FINE GRAINED SOILS — More than 50% by dry mass, less than 60mm is less than 0.06mm	Liquid Limit less than 50%	ML		Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.	None to low	Quick to slow	None	ML	Below 'A' line
		CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium	CL	Above 'A' line
		OL		Organic silts and organic silty clays of low plasticity.	Low to medium	Slow	Low	OL*	Below 'A' line
	Liquid Limit more than 50%	MH		Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.	Low to medium	Slow to none	Low to medium	MH	Below 'A' line
		CH		Inorganic clays of high plasticity, fat clays.	High to very high	None	High	CH	Above 'A' line
		OH		Organic clays of medium to high plasticity.	Medium to high	None to very slow	Low to medium	OH*	Below 'A' line
		Pt		Peat muck and other highly organic soils.	Readily identified by colour, odour, spongy feel and generally by fibrous texture			Pt*	*Effervesces with H_2O_2

DESCRIPTIVE DATA (fine grained soils): Give: typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains, colour in wet condition, odour if any; local or geological name and other pertinent descriptive information; symbols in parenthesis.

For undisturbed soil add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions.

EXAMPLE
Clayey Silt, brown; low plasticity, small percentage of fine sand; numerous vertical root-holes; firm and dry in place, fill, (ML)

FINE GRAINED SOILS — More than half of the material less than 60 mm is smaller than 0.06mm



PLASTICITY CHART
FOR CLASSIFICATION OF FINE GRAINED SOILS

FIELD IDENTIFICATION PROCEDURES FOR FINE GRAIN SOILS OR FRACTIONS

These proceedures are to be performed on the minus 0.6mm size particles. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests

Dilatancy (Reaction to Shaking)

After removing particles larger than 0.6mm size, prepare a pat of moist soil with a volume of about 10 cm³. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assists in identifying the character of the fines in the soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing Characteristics)

After removing particles larger than 0.6 mm size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic of clays in the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength but can be distinguished by feel when powdering the dry specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency Near Plastic Limit)

After removing particles larger than 0.6 mm size, a specimen of soil, about 10 cm³ in size, is moulded to the consistency of putty. If too dry, water must be add and, if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3mm diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Notes

1. *The above follows the original Unified Classification System (U.S.B.R. Earth Manual) and ASTM Designation D2487-69 except that it adopts the particle size limits given in AS 1289 and other standards, viz*

Gravel	*2 - 60 mm*
Sand	*0.06 - 2 mm*
Silt and Clay	*less than 0.06 mm*

   The system excludes the boulder and cobble fractions of the soil and classifies only the material less than 60 mm in size.

2. *As 60 mm, 2 mm and 0.06 mm sieve sizes are not normally used, the percentages passing these sizes can be obtained from a particle size distribution curve determined from a laboratory test. Alternatively, the percentages passing maybe estimated in the field.*
3. *Australian Standard Code of Practice for Site Investigation, Appendix D, and ASTM Designation D2488-69, Tables 1 to 4, contain standard terms and manual tests for describing and identifying soils.*

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ACN 063 673 530

DESCRIPTION AND CLASSIFICATION OF SOILS

The methods of description and classification of soils used in this report are based on Australian Standard 1726 - 1981, the SAA Site Investigation Code. In general, descriptions cover the following properties - soil type, colour, secondary grain size, structure, inclusions, strength or density and geological description.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy clay) on the following basis:

Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2.00mm
Gravel	2.00 to 60.00mm

Soils are also classified according to the Unified Soil Classifications System which is included in this Appendix.

Rock types are classified by their geological names.

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

Classification	Shear Strength kPa
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 insitu standard penetration tests as below:

Relative Density	"N" Value blows/300mm
Very loose	less than 5
Loose	5 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	greater than 50

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 provide information on colour, type, inclusions and depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are generally taken by one of two methods:

(i) driving or pushing a thinwalled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state.

(ii) Core drilling using a retractable inner tube (R.I.T.) core barrel.

Such samples yield information on structure and strength in addition to that obtained from disturbed samples 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.

PENETRATION TESTING

The relative density of non-cohesive soils is generally assessed by insitu penetration tests, the most common of which is the standard penetration test. The test procedure is described in Australian Standard 1289 "Testing Soils for Engineering Purposes" - Test No. F3.1.

The standard penetration test is carried out by driving a 50mm diameter split tube penetrometer of standard dimensions under the impact of a 63 kg hammer having a free fall of 750mm.

The "N" value is determined as the number of blows to achieve 300mm of penetration (generally after disregarding the first 150mm penetration through possibly disturbed material). The results of these tests can be related empirically to the engineering properties of the soil.

The test is also used to provide useful information in cohesive soils under certain conditions, a good quality disturbed sample being recovered with each test.

Other forms of insitu testing are used under certain conditions and where this occurs, details are given in the report.

DEFINITIONS OF ROCK, SOIL, AND DEGREES OF CHEMICAL WEATHERING

(A) GENERAL DEFINITIONS — ROCK AND SOIL

<u>ROCK</u> In engineering usage, rock is a natural aggregate of minerals connected by strong and permanent cohesive forces.

Note: Since "strong" and "permanent" are subject to different interpretations, the boundary between rock and soil is necessarily an arbitrary one.

<u>SOIL</u> In engineering usage, soil is a natural aggregate of mineral grains which can be separated by such gentle mechanical means as agitation in water, can be remoulded and can be classified according to the Unified Soil Classification System. Three principal classes of soil recognised are:

(a) Residual soils: soils which have been formed insitu by the chemical weathering of parent rock. Residual soil may retain evidence of the original rock texture or fabric or, when mature, the original rock texture may be destroyed.

(b) Transported soils: soils which have been moved from their places of origin and deposited elsewhere. The principal agents of erosion, transport and deposition are water, wind and gravity. Two important types of transported soil in engineering geology and materials investigations are:

(i) Colluvium - a soil, often including angular rock fragments and boulders, which has been transported downslope predominantly under the action of gravity assisted by water. The principal forming process is that of soil creep in which the soil moves after it has been weakened by saturation. It may be water borne for short distances

(ii) Alluvium - a soil which has been transported and deposited by running water. The larger particles (sand and gravel size) are water worn.

(c) Lateritic soils: soils which have formed insitu under the effects of tropical weathering and include all reddish residual and non residual soils which genetically form a chain of material ranging from decomposed rock through clays to sesquioxide rich crusts. The term does not necessarily imply any compositional, textural or morphological definition; all distinctions useful for engineering purposes are based on the differences in geotechnical characteristics.

(B) ROCK WEATHERING DEFINITIONS

<u>Extremely Weathered</u> (EW)
Rock substance affected by weathering to the extent that the rock exhibits soil properties, i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.

<u>Highly Weathered</u> (HW)
Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.

<u>Moderately Weathered</u> (MW)
Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.

<u>Slightly Weathered</u> (SW)
Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance, usually by limonite, has taken place. The colour and texture of the fresh rock is recognisable.

<u>Fresh</u> (Fr)
Rock substance unaffected by weathering.

The degrees of rock weathering may be gradational. Intermediate stages are described by dual symbols with the prominent degree of weathering first (e.g. EW-HW).

The various degrees of weathering do not necessarily define strength parameters as some rocks are weak, even when fresh, to the extent that they can be broken by hand across the fabric, and some rocks may increase in strength during the weathering process.

Fresh drill cores of some rock types, such as basalt and shale may disintegrate after exposure to the atmosphere due to slaking, desiccation, expansion or contraction, stress relief or a combination of any of these factors.

AN ENGINEERING CLASSIFICATION OF SEDIMENTARY ROCKS

This classification system provides a standardized terminology for the engineering description of the sandstone and shales in the Sydney area, but the terms and definitions may be used elsewhere when applicable. Where other rock types are encountered, such as in dykes, standard geological descriptions are used for rock types and the same descriptions as below are used for strength, fracturing and weathering.

Under this system rocks are classified by Rock Type, Strength, Stratification Spacing, Degree of Fracturing and Degree of Weathering. These terms do not cover the full range of engineering properties. Descriptions of rock may also need to refer to other properties (e.g. durability, abrasiveness, etc) where these are relevant.

ROCK TYPE DEFINITIONS

ROCK TYPE	DEFINITION
Conglomerate:	More than 50% of the rock consists of gravel sized (greater than 2mm) fragments.
Sandstone:	More than 50% of the rock consists of sand sized (.06 to 2mm) grains.
Siltstone:	More than 50% of the rock consists of silt-sized (less than .06mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of clay or sericitic material and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay sized particles and the rock is laminated.

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

STRATIFICATION SPACING

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

DEGREE OF FRACTURING

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

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

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Society of Rock Mechanics.

Term	Is(50) MPa	Field Guide	Approx. qu MPa*
Extremely Weak:	0.03	Easily remoulded by hand to a material with soil properties.	0.7
Very Weak:	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.	2.4
Weak:	0.3	A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	7
Medium Strong:	1	A piece of core 150mm long x 50mm dia. can be broken by hand with considerable difficulty. Readily scored with knife.	24
Strong:	3	A piece of core 150mm long x 50mm dia. core cannot be broken by unaided hands, can be slightly scratched or scored with knife.	70
Very Strong	10	A piece of core 150mm long x 50mm dia. may be broken readily with hand held hammer. Cannot be scratched with pen knife.	240
Extremely Strong:		A piece of core 150mm long x 50mm dia. is difficult to break with hand held hammer. Rings when struck with a hammer.	

The approximate unconfined compressive strength (qu) shown in the table is based on an assumed ratio to the point load index of 24:1. This ratio may vary widely.

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