

**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

28 August 2023  
Our ref: EM/C14593

GHD  
Via email: [david.bell@ghd.com](mailto:david.bell@ghd.com)

**Attention: David Bell**

**PROPOSED EXTENTION – NATIONAL LIBRARY OF AUSTRALIA REPOSITORY  
44 TRALEE STREET, HUME**

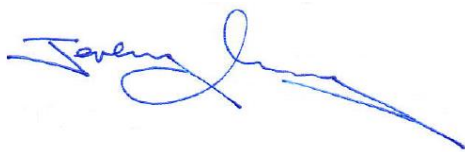
**GEOTECHNICAL INVESTIGATION REPORT**

We are pleased to present our geotechnical investigation report for a proposed extension to the National Library of Australia (NLA) Repository, in Hume, ACT.

The report outlines the methods and results of exploration, describes site subsurface conditions and provides recommendations for building footing design, excavation conditions, preparation of subgrades, stability of cut and fill batters, retaining wall design, earthquake classification, provides indicative design CBR values, and site drainage advice.

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**

Senior Geotechnical Engineer | Director  
FIEAust CPEng Eng Exec NER RPEQ APEC Engineer IntPE(Aust)  
Registered Professional Engineer of Queensland (RPEQ) #19719  
NSW Professional Engineer Registration #PRE0001487

**GHD**

**PROPOSED EXTENTION – NATIONAL LIBRARY OF AUSTRALIA REPOSITORY  
44 TRALEE STREET, HUME**

**GEOTECHNICAL INVESTIGATION REPORT**

**AUGUST 2023**

PROPOSED EXTENTION – NATIONAL LIBRARY OF AUSTRALIA REPOSITORY  
44 TRALEE STREET, HUME

GEOTECHNICAL INVESTIGATION REPORT

TABLE OF CONTENTS

<b>1</b>	<b>INTRODUCTION .....</b>	<b>3</b>
<b>2</b>	<b>SITE DESCRIPTION &amp; GEOLOGY .....</b>	<b>3</b>
<b>3</b>	<b>INVESTIGATION METHODS .....</b>	<b>3</b>
<b>4</b>	<b>INVESTIGATION RESULTS .....</b>	<b>4</b>
4.1	Subsurface Conditions .....	4
4.2	Groundwater .....	5
<b>5</b>	<b>DISCUSSION &amp; RECOMMENDATIONS .....</b>	<b>5</b>
5.1	Site Classification.....	5
5.2	Building Footings.....	6
5.3	Excavation Conditions and Use of Excavated Material .....	6
5.4	Stable Excavation Batters .....	7
5.5	Low Retaining Walls .....	7
5.6	Controlled Fill Construction .....	8
5.7	Design CBR Values .....	8
5.8	Earthquake Site Factor .....	8
5.9	Site Drainage .....	9

REFERENCES

<b>FIGURE 1</b>	-	Site Locality
<b>FIGURE 2</b>	-	Aerial Photograph and Borehole Locations
<b>FIGURE 3</b>	-	Subsurface Section A-A'
<b>APPENDIX A</b>	-	Borehole Logs BH1 to BH4
<b>APPENDIX B</b>	-	Definitions of Geotechnical Engineering Terms

**PROPOSED EXTENSION – NATIONAL LIBRARY OF AUSTRALIA REPOSITORY  
44 TRALEE STREET, HUME**

**GEOTECHNICAL INVESTIGATION REPORT**

**1 INTRODUCTION**

At the request of the client, ACT Geotechnical Engineers Pty Ltd carried out a geotechnical investigation for the proposed extension to the National Library of Australia (NLA) Repository, in Hume, ACT.

The project involves the construction of a ~30m×30m extension to the NE end of the existing building. It is assumed that the extension will comprise a warehouse-type structure on a ground slab. 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) Provide site classification to AS2870 "Residential Slabs & Footings".
- (iv) Advise on suitable footings systems, founding depths, allowable bearing pressures and design parameters for ground slabs.
- (v) Provide guidelines for construction of controlled fill platforms.
- (vi) Advise on stable batter slopes and retaining wall design parameters.
- (vii) Provide subgrade CBR value(s).
- (viii) Drainage and other geotechnical advice.

**2 SITE DESCRIPTION & GEOLOGY**

The site is legally described as Block 21, Section 1, in Hume, ACT, and is located at 44 Tralee Street. The area is approximately 900m<sup>2</sup>, and is bounded by Monaro Highway to the northwest, Tralee Street to the southeast, existing National Library Repository building to the southwest and a general industry block to the northeast. The site is presently grasses with some trees, and relatively flat. Figure 1 shows the site locality, while Figure 2 is a recent aerial photo showing the present site layout.

The 1:10,000 Canberra Geology map (Sheet 8727; Reference 1) documents the site underlain by Silurian age Deakin Volcanics bedrock, which includes Rhyodacitic Ignimbrite and minor volcanics, covered by Quaternary age alluvial deposits associated with Woden Creek, a tributary of Jerrabomberra Creek.

**3 INVESTIGATION METHODS**

The field investigation was carried out on 17 August 2023, comprising four (4) boreholes, designated BH1 to BH4, drilled to 5m depth. The boreholes were drilled by a 250mm auger. Following drilling, the subsurface condition was visually logged by an experienced geotechnical engineer (results summarized in Section 4.3) and the holes immediately backfilled upon completion.

The borehole locations are shown on Figure 2 and the borehole logs are presented in Appendix A. The subsurface profiles were logged in accordance with the Unified Soil Classification System (USCS). Definitions of geotechnical engineering terms used on the logs and in this report, 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 four (4) boreholes. In summary, the results of the investigation indicate that the subsurface profile across the site comprises topsoil, over uncontrolled fill, underlain by alluvial soils to >5m depth.

Table 1 outlines the subsurface conditions found during our investigation and Table 2 summarises the subsurface profile encountered in each borehole. The logs should be referred to for more detail, and are attached to this report as Appendix A.

**Table 1 –Subsurface Conditions**

Geological Profile	Typical Depth Interval	Description
TOPSOIL	Unit 1	Silty SAND; fine to coarse, dark brown, low plasticity silt, trace of root fibres, moist, loose.
FILL	Unit 2a	Silty gravelly SAND; fine to coarse, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, dry, loose.
	Unit 2b	Sandy gravelly CLAY; low to medium plasticity, brown, red-brown, fine to coarse sand, sub-rounded to sub-angular, fine to coarse gravel, moist less than plastic limit, firm.
ALLUVIAL SOIL	Unit 3a	Silty SAND; fine to coarse, pale grey, pale brown, some mottled red, low plasticity silt, trace of sub-rounded to sub-angular, fine to coarse gravel, cemented, moist, dense (partially cemented).
	Unit 3b	Silty gravelly SAND; fine to medium, red-brown, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, moist, medium dense.
	Unit 3c	Gravelly SAND; fine to coarse, pale grey, rounded to sub-rounded, fine to medium gravel, trace of low plasticity silt, moist, very dense (cemented).
	Unit 3d	Clayey Silty SAND; fine to coarse, pale grey, low plasticity silt, with rounded to sub-rounded, fine to coarse gravel, moist, dense.
	Unit 3e	Gravelly SAND; fine to coarse, grey, pale grey, rounded to sub-rounded, fine to medium gravel, with of low plasticity silt, moist, dense to very dense.

**Table 2 – Depth Interval of geological profiles encountered in each borehole.**

Geological Profile	Units	Depth of layer bottom below ground level (m)			
		BH1	BH2	BH3	BH4
TOPSOIL	Unit 1	0m - 0.1m	0m - 0.1m	0m - 0.1	0m - 0.1m
FILL	Unit 2a	0.1m - 0.6m	0.1m - 1.0m	0.1m - 0.8m	0.1m - 0.8m
	Unit 2b	0.6m - 1.0m	1.0m - 1.7m	0.8m - 2.0m	0.8m - 1.6m
ALLUVIUM	Unit 3a	1.0m - 2.3m	1.7m - 2.4m	2.0m - 2.5m	1.6m - 2.2m
	Unit 3b	2.3m - 3.0m	2.4m - 2.8m	2.5m - 3.0m	2.2m - 3.8m
	Unit 3c	3.0m - 4.0m	2.8m - 4.0m	3.0m - 4.0m	3.8m - 4.3m
	Unit 3d	4.0m - 4.5m	4.0m - >5.0m	4.0m - 4.8m	4.3m - 4.8m
	Unit 4e	4.5m - >5.0m	-	4.8m - >5.0m	4.8m - >5.0m

Figure 3 shows a schematic subsurface section of the soil and main geotechnical units along the BH2 to BH4. Unsuitable topsoil and uncontrolled fill extend to 1.0m/2.0m depth, underlain by medium dense to very dense, sandy alluvial soils to greater than 5m depth.

## 4.2 Groundwater

The soil was generally dry and permanent groundwater is not expected within ~5m of existing surface level. However, perched, temporary seepages have previously been encountered within the sandy alluvial soils at nearby sites. Such seepages are expected to occur at shallow depth following rain, within pervious alluvial soil aquifers.

ACT Geotechnical Engineers has provided geotechnical engineering advice during the earthworks stage of many developments in the Hume area. During these earthworks, perched seepages were encountered, although most seepage occurred at discrete locations as aquifers and had to be controlled by collecting in a sump and pumping into a detention pond or stormwater system.

It is our assessment that rainwater enters the subsurface in the hills to the east of the site. The water migrates downslope within beds of relatively pervious sandy alluvial soil, with the water generally held up on beds of practically impervious sandy clay stratum, and gradually migrates downslope through the sandy aquifers until it eventually discharges to creeks or gullies downstream. As the source of the water is from a much higher RL, some seepages could be under artesian pressure. The seepages generally dissipate within a few weeks after rain. During drier periods these same soils become dry and hard, causing cementation within the sandy soils, and can be difficult to excavate.

## 5 DISCUSSION & RECOMMENDATIONS

### 5.1 Site Classification

Due to the presence of uncontrolled fill materials exceeding 2.0m depth, the site is designated as a Class "P" (problem) site in accordance with AS2870. If the fill is removed, or if footings are founded in the alluvial soil below the fill, a Class "M" (moderately reactive) category can be used in design of new footings. The characteristic ground surface movement "ys", as defined by AS2870 for the range of normal soil moisture conditions is estimated to be between 20mm to 40mm for the encountered subsurface profile described in Section 2.

Should earthworks (cut or fill) be undertaken on the site, or other activities which may cause abnormal moisture conditions to impact the soils within or near the building envelope beyond those addressed herein, the site classification shall be reassessed. The site classifications for individual lots within the subdivision must be established following the completion of the subdivision earthworks.

## 5.2 Building Footings

As the site has been classified as Class P, footing design shall be undertaken in accordance with engineering principles, based upon the requirements on AS2870 and the characteristic ground surface movement estimate of 20mm to 40mm.

For structures founded at grade, footings including thickened sections of slabs must be founded below any topsoil, uncontrolled fill, loose/wet material, into the medium dense /alluvial soils. The depth to suitable alluvial soil foundation material is indicated in Table 2. Shallow footings could be founded in any newly placed controlled fill following the removal of any topsoil material (see Section 5.6).

If designing footings based on engineering principles, recommended allowable end-bearing pressures for various footing systems and likely foundation materials are provided in Table 3.

**TABLE 3 - 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	N.A	100kPa	125kPa	N.A	N.A	N.A
Alluvial soil (Medium dense)	~2m	125kPa	150kPa	200kPa	20kPa	10kPa
Alluvial soil (Dense or better)	~4m	200kPa	300kPa	400kPa	40kPa	20kPa

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.

Ground slabs can be constructed on the natural soils or newly placed controlled fill, following the removal of any topsoil, and uncontrolled fill material. 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 95%ModMDD.

## 5.3 Excavation Conditions and Use of Excavated Material

Excavations through fill, and into alluvial soils to 5m depth are readily diggable by backhoe and medium sized. However, some sections of the sandy alluvial soils could be cemented, which will require excavator or dozer (D8 or D9) ripping, and possibly rock hammering.

The low/medium plasticity existing fill and alluvial soils can be used in controlled fill construction of building platforms, although soils with excessive silt content should be avoided or blended with more clayey material. Topsoil should not be used in controlled fill construction.

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.

#### 5.4 Stable Excavation Batters

Temporary site excavations to 1.5m depth can be formed near vertical, although topsoil and loose fill 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, and 0.5(H):1(V) in dense cemented 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 be protected against erosion by shotcreting, stone pitching or other suitable methods. Alternatively permanent excavations can be supported by structural retaining walls.

#### 5.5 Low Retaining Walls

Retaining walls constructed in an 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,

$\sigma_h$  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.)

$\gamma'$  is the effective unit weight of the backfill, and can be assumed to be 20kN/m<sup>3</sup> 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 ( $\tan\delta$ ) of 0.4, and allowable passive earth pressure coefficient  $K_p=2.5$  can be used for calculation of sliding resistance.

**Table 4 - Shear Strength Parameters**

Soil/Rock Property	Bulk Density $\gamma_b$ (kN/m <sup>3</sup> )	C (kPa)	$\phi'$ (degrees)	Elastic Modulus (MPa)	Poisson's Ratio	Active $K_a$	At Rest $K_o$	Passive $K_p$	Modulus of Subgrade Reaction (MN/m <sup>3</sup> )
FILL	19	0	20	10	0.25	0.49	0.66	2.1	10
Alluvial soil (Medium dense)	21	0	30	30	0.3	0.33	0.50	3.0	50
Alluvial soil (Dense or better)	21	0	35	50	0.3	0.37	0.43	3.7	100

$\gamma$  - Bulk unit weight,  $C_u$  - undrained shear strength,  $\phi$  - soil friction angle, c - Cohesion



The above values can be used in software programs to design retaining walls, however, it is recommended that the values for lateral earth pressures in section 5.5 be used as a minimum.

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.

## 5.6 Controlled Fill Construction

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

- Areas are fully stripped of all topsoil and uncontrolled fill material. A typical stripping depth of between 1m and 2m is expected (See Table 2). 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 95%ModMDD at about OMC.
- Fill placement and control testing be overviewed and certified by a geotechnical engineer at Level 1 involvement of AS3798 – 2007 “Guidelines on Earthworks for Commercial & Residential Developments” (Reference 3).

## 5.7 Design CBR Values

It is expected that new access roads and carpark pavements will be constructed at about existing level, and that subgrades will comprise in-situ alluvial soil or newly placed controlled fill. Following stripping of unsuitable existing fill, exposed subgrade should be 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 95%ModMDD. A geotechnical engineer should be present during the proof-rolling to ensure all wet and weak spots are removed and to confirm the recommended design CBR values.

Recommended subgrade design CBR are given in Table 5.

**Table 5 – Recommended Design CBR Values**

Subgrade material	Recommended Design CBR Value	
	Cut Proof-Rolled Subgrade	Properly Compacted Fill Subgrade
Sandy gravelly CLAY (old fill)	2%	2%-5%
Alluvial silty SAND/ Clayey silty SAND	8%	8%

## 5.8 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 centers to be considered in structural design. The Canberra has an acceleration coefficient of 0.08.

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<sub>e</sub> – Shallow Soil Site”.

## **5.9 Site Drainage**

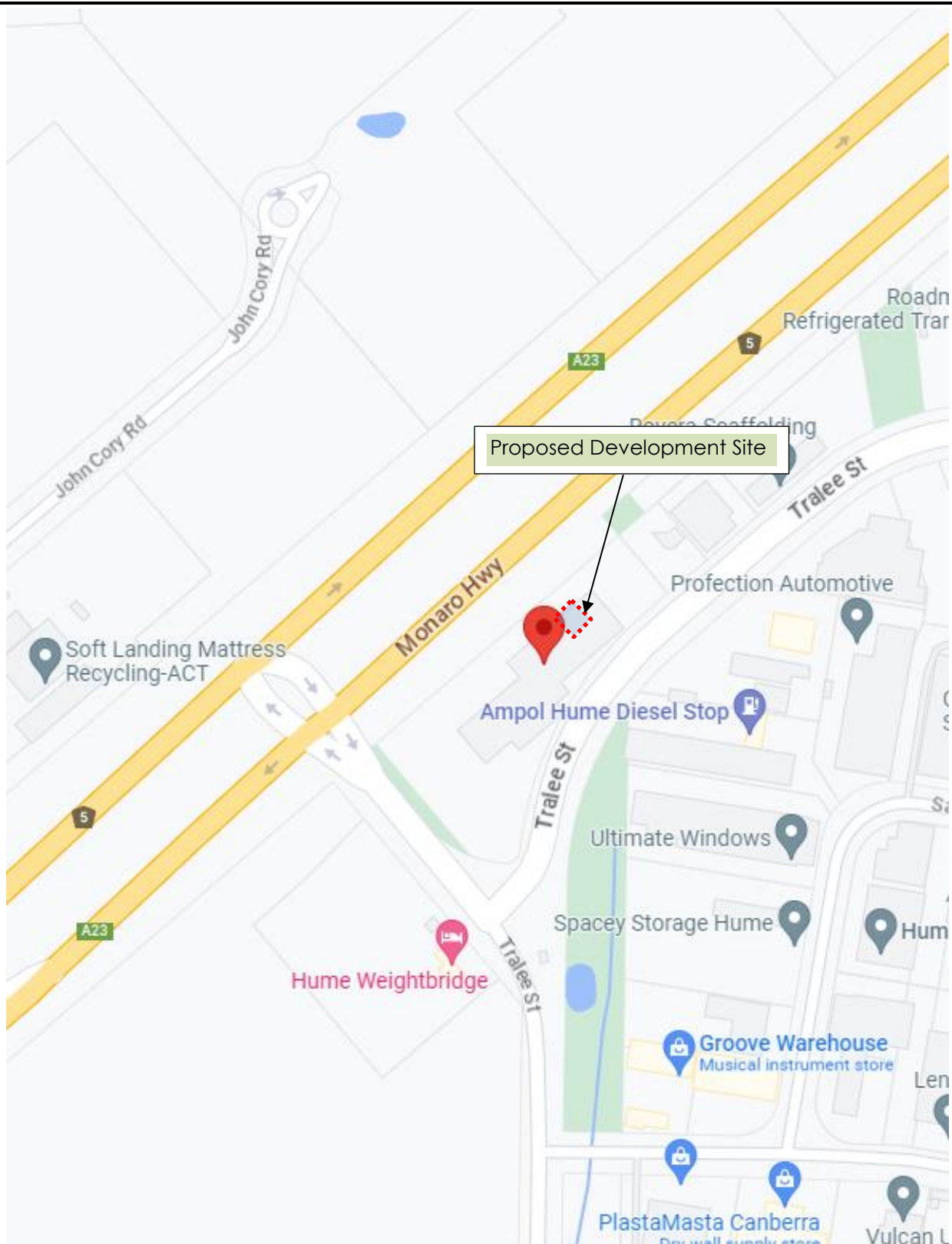
Groundwater was not encountered during the investigation. The permanent groundwater table is expected to be well below expected excavations, although temporary perched seepages will be present following rain, but should be readily controllable through the use of pumps during construction.

The moisture regime associated with a pavement has a major influence on the performance of the pavement since the stiffness/strength of the pavement materials is dependent on the moisture content of the materials. Accordingly, to protect pavement materials from wetting up and softening, particular care would be required to provide a waterproof seal for the pavement materials, along with adequate surface and sub-surface drainage of the pavement and adjacent areas.

Suitable surface drainage should be provided to ensure rainfall run-off or other surface water cannot pond on pavements. Subsoil drains should be installed along the upslope sides of all new roads where boxed construction is used.

## REFERENCES

- 1 Australia. Bureau of Mineral Resources, Geology and Geophysics. (1992). Canberra 1:100 000 geological map (sheet 8727).
- 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".



**GHD**  
**PROPOSED EXTENTION – NATIONAL LIBRARY REPOSITORY**  
**44 TRALEE STREET, HUME**  
**SITE LOCATIONS**

ACT Geotechnical Engineers Pty Ltd

C14593

FIGURE 1



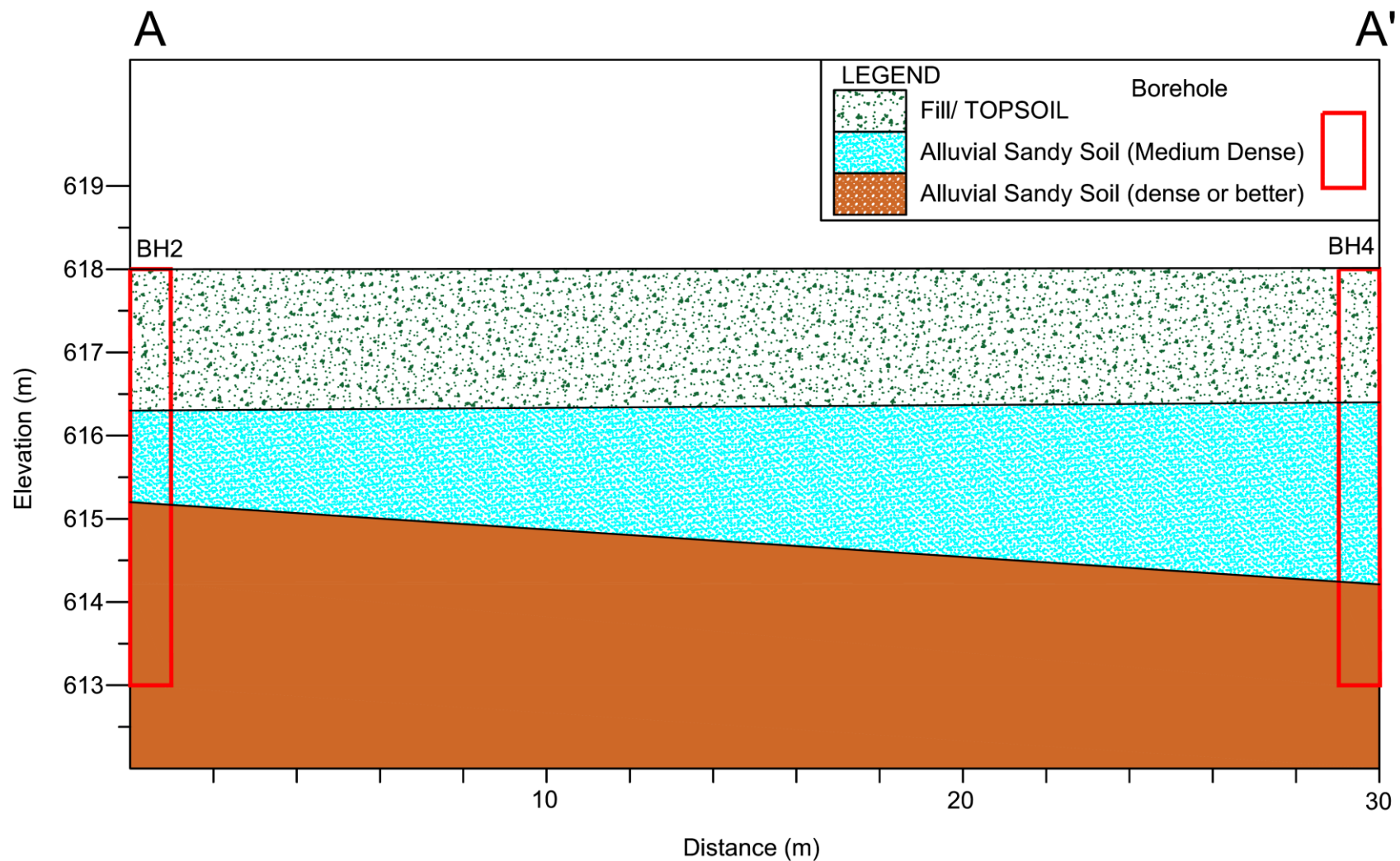


GHD  
PROPOSED EXTENTION – NATIONAL LIBRARY REPOSITORY  
44 TRALEE STREET, HUME  
BOREHOLE LOCATIONS & SECTION LINE

ACT Geotechnical Engineers Pty Ltd

C14593

FIGURE 2



GHD  
 PROPOSED EXTENTION – NATIONAL LIBRARY REPOSITORY  
 44 TRALEE STREET, HUME  
 SUBSURFACE SECTION A-A'

## **APPENDIX A**

### **Borehole Logs**

# Borehole Log

Borehole No.	<b>BH1</b>
Sheet	1 of 2
Job No.	<b>C14593</b>
Location	: See Report
Collar Level	: Not Known
Angle From Vertical	: 0°
Bearing	: N.A.

CLIENT:	GHD
PROJECT	PROPOSED EXTENTION, NATIONAL LIBRARY REPOSITORY 44 Tralee Street, Hume ACT
Equipment Type :	
Hole Diameter :	250mm

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure <small>Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure</small>	Consistency or Relative Density	Field Test Results	Geological Profile
		0.1		SM	Silty SAND; fine to coarse, dark brown, low plasticity silt, trace of root fibres, moist.	LOOSE		TOPSOIL
				SM	Silty gravelly SAND; fine to coarse, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, dry.	LOOSE		FILL
		0.6		CL	Sandy gravelly CLAY; low to medium plasticity, brown, red-brown, fine to coarse sand, sub-rounded to sub-angular, fine to coarse gravel, moist less than plastic limit.	FIRM		
		1.0		SP-SM	Silty gravelly SAND; fine to medium, red-brown, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, moist.	MEDIUM DENSE		ALLUVIUM
		1.5		SM	Silty SAND; fine to coarse, pale grey, pale brown, some mottled red, low plasticity silt, trace of sub-rounded to sub-angular, fine to coarse gravel, cemented, moist.	DENSE		
		2.0						
		2.3		SP-SM	Gravelly silty SAND; fine to medium, pale grey, pale brown, sub-rounded to rounded, fine to coarse gravel, low plasticity silt, moist.	DENSE		
		3.0		SW	Gravelly SAND; fine to coarse, pale grey, rounded to sub-rounded, fine to medium gravel, cemented, trace of low plasticity silt, moist.	VERY DENSE		
		4.0		SC-SM	Clayey silty SAND; fine to coarse, pale grey, low plasticity silt, with rounded to sub-rounded, fine to coarse gravel, moist.	DENSE		
		4.5		SW	Gravelly SAND; fine to coarse, grey, pale grey, rounded to sub-rounded, fine to medium gravel, with of low plasticity silt, moist.	DENSE to VERY DENSE		
		5.0						

AUGERING

BOREHOLE TERMINATED AT 5m

Logged By : EM

Date : 17/8/23

Checked By : JM

Date :

BOREHOLE/EXCAVATION LOG C14593 - NATIONAL LIBRARY REPOSITORY.GPJ ACT GEO.GDT 25/8/23



# Borehole Log

Borehole No.	<b>BH2</b>
Sheet	1 of 2
Job No.	<b>C14593</b>
Location :	See Report
Collar Level :	Not Known
Angle From Vertical :	0°
Bearing :	N.A.

CLIENT:	GHD
PROJECT	PROPOSED EXTENTION, NATIONAL LIBRARY REPOSITORY 44 Tralee Street, Hume ACT
Equipment Type :	
Hole Diameter :	250mm

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure <small>Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure</small>	Consistency or Relative Density	Field Test Results	Geological Profile
		0.1		SM	Silty SAND; fine to coarse, dark brown, low plasticity silt, trace of root fibres, moist.	LOOSE		TOPSOIL
				SM	Silty gravelly SAND; fine to coarse, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, dry.	LOOSE		FILL
		1.0		CL	Sandy gravelly CLAY; low to medium plasticity, brown, red-brown, fine to coarse sand, sub-rounded to sub-angular, fine to coarse gravel, moist less than plastic limit.	FIRM		
		1.7		SM	Silty SAND; fine to coarse, pale grey, pale brown, some mottled red, low plasticity silt, trace of sub-rounded to sub-angular, fine to coarse gravel, cemented, moist.	DENSE		ALLUVIUM
		2.0						
		2.4		SP-SM	Silty gravelly SAND; fine to medium, red-brown, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, moist.	MEDIUM DENSE		
		2.8		SW	Gravelly SAND; fine to coarse, pale grey, rounded to sub-rounded, fine to medium gravel, cemented, trace of low plasticity silt, moist.	VERY DENSE		
		3.0						
		4.0		SC-SM	Clayey silty SAND; fine to coarse, pale grey, low plasticity silt, with rounded to sub-rounded, fine to coarse gravel, moist.	DENSE		
		5.0						

AUGERING

BOREHOLE TERMINATED AT 5m  
Desired Depth

Logged By : EM

Date : 17/8/23

Checked By : JM

Date :

BOREHOLE/EXCAVATION LOG C14593 - NATIONAL LIBRARY REPOSITORY.GPJ ACT GEO.GDT 25/8/23

# Borehole Log

Borehole No.	<b>BH3</b>
Sheet	1 of 2
Job No.	<b>C14593</b>
Location :	See Report
Collar Level :	Not Known
Angle From Vertical :	0°
Bearing :	N.A.

CLIENT:	GHD
PROJECT	<b>PROPOSED EXTENTION, NATIONAL LIBRARY REPOSITORY 44 Tralee Street, Hume ACT</b>
Equipment Type :	
Hole Diameter :	250mm

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure <small>Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure</small>	Consistency or Relative Density	Field Test Results	Geological Profile
		0.1		SM	Silty SAND; fine to coarse, dark brown, low plasticity silt, trace of root fibres, moist.	LOOSE		TOPSOIL
				SM	Silty gravelly SAND; fine to coarse, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, dry.	LOOSE		FILL
		0.8		CL	Sandy gravelly CLAY; low to medium plasticity, brown, red-brown, fine to coarse sand, sub-rounded to sub-angular, fine to coarse gravel, moist less than plastic limit.	FIRM		
		1.0						
		2.0		SM	Silty SAND; fine to coarse, pale grey, pale brown, some mottled red, low plasticity silt, trace of sub-rounded to sub-angular, fine to coarse gravel, cemented, moist.	DENSE		ALLUVIUM
		2.5		SP-SM	Silty gravelly SAND; fine to medium, red-brown, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, moist.	MEDIUM DENSE		
		3.0		SW	Gravelly SAND; fine to coarse, pale grey, rounded to sub-rounded, fine to medium gravel, cemented, trace of low plasticity silt, moist.	VERY DENSE		
		4.0		SC-SM	Clayey silty SAND; fine to coarse, pale grey, low plasticity silt, with rounded to sub-rounded, fine to coarse gravel, moist.	DENSE		
		4.8		SW	Gravelly SAND; fine to coarse, grey, pale grey, rounded to sub-rounded, fine to medium gravel, with of low plasticity silt, moist.	DENSE to VERY DENSE		
		5.0						

AUGERING

BOREHOLE TERMINATED AT 5m

Logged By : EM

Date : 17/8/23

Checked By : JM

Date :

BOREHOLE/EXCAVATION LOG C14593 - NATIONAL LIBRARY REPOSITORY.GPJ ACT GEO.GDT 25/8/23

# Borehole Log

Borehole No.	<b>BH4</b>
Sheet	1 of 2
Job No.	<b>C14593</b>
Location	See Report
Collar Level	Not Known
Angle From Vertical	0°
Bearing	N.A.

CLIENT:	GHD
PROJECT	PROPOSED EXTENTION, NATIONAL LIBRARY REPOSITORY 44 Tralee Street, Hume ACT
Equipment Type :	
Hole Diameter :	250mm

Samples	Casing	Depth Metres	Graphic Log	U.S.C.S.	Material Description, Structure <small>Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure</small>	Consistency or Relative Density	Field Test Results	Geological Profile
		0.1		SM	Silty SAND; fine to coarse, dark brown, low plasticity silt, trace of root fibres, moist.	LOOSE		TOPSOIL
				SM	Silty gravelly SAND; fine to coarse, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, dry.	LOOSE		FILL
		0.8		CL	Sandy gravelly CLAY; low to medium plasticity, brown, red-brown, fine to coarse sand, sub-rounded to sub-angular, fine to coarse gravel, moist less than plastic limit.	FIRM		
		1.0						
		1.6		SM	Silty SAND; fine to coarse, pale grey, pale brown, some mottled red, low plasticity silt, trace of sub-rounded to sub-angular, fine to coarse gravel, cemented, moist.	DENSE		ALLUVIUM
		2.0						
		2.2		SP-SM	Silty gravelly SAND; fine to medium, red-brown, brown, sub-angular to sub-rounded, fine to coarse gravel, low plasticity silt, moist.	MEDIUM DENSE		
		3.0						
		3.8		SW	Gravelly SAND; fine to coarse, pale grey, rounded to sub-rounded, fine to medium gravel, cemented, trace of low plasticity silt, moist.	VERY DENSE		
		4.0						
		4.3		SC-SM	Clayey silty SAND; fine to coarse, pale grey, low plasticity silt, with rounded to sub-rounded, fine to coarse gravel, moist.	DENSE		
		4.8		SW	Gravelly SAND; fine to coarse, grey, pale grey, rounded to sub-rounded, fine to medium gravel, with of low plasticity silt, moist.	DENSE to VERY DENSE		
		5.0						

AUGERING

BOREHOLE TERMINATED AT 5m

Logged By : EM

Date : 17/8/23

Checked By : JM

Date :

BOREHOLE/EXCAVATION LOG C14593 - NATIONAL LIBRARY REPOSITORY.GPJ ACT GEO.GDT 25/8/23

## **APPENDIX B**

### **Definitions and Limitations**

## DESCRIPTION AND CLASSIFICATION OF SOILS

The methods of description and classification of soils used in this report are based on the Australian Standard 1726 – 1993, Geotechnical site investigations. 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	0.002mm to 0.06mm
Sand	0.06mm to 2.00mm
Gravel	2.00mm to 60.00mm
Cobbles	60mm (63mm) to 200mm
Boulders	>200mm

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:

Consistency	Shear Strength $s_u$ (kPa) (Representative Undrained Shear)	
Very soft	< 12	<2 (~SPT "N")
Soft	12 - 25	2-4
Firm	25 - 50	4-8
Stiff	50 – 100	8-15
Very Stiff	100 – 200	15-30
Hard	> 200	>30

Non-cohesive soils are classified on the basis of relative density, generally from the results of in-situ standard penetration tests as below:

Term	Relative Density (%)	SPT Blows/300mm 'N'
Very loose	< 15	<4
Loose	15-35	4-10
Medium dense	35-65	10-30
Dense	65-85	30-50
Very Dense	>85	>50

## SAMPLING

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of 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:

1. Driving or pushing a thin walled sample tube into the soil and withdrawing with a sample of soil in a relatively undisturbed state.
2. Core drilling using a retractable inner tube (R.I.T.) core barrel.

Such samples yield information on structure and strength in additions 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 in-situ 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" 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 in situ 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

### GENERAL DEFINITIONS – ROCK AND SOIL

**ROCK** 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.

**SOIL** 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 recognized are:

Residual soils: soils which have been formed in-situ 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.

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:

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 principle 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.

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

Lateritic soils: soils which have formed in situ under the effects of tropical weathering include all reddish residual and non residual soils which genetically form a chain of material ranging from decomposed rock through clay to sesqui-oxide 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.

### ROCK WEATHERING DEFINITIONS

Extremely Weathered (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.
Highly Weathered (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 the 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.
Moderately Weathered (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.
Slightly Weathered (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.
Fresh (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 standardised terminology for the engineering description of the sandstone and shales in the Sydney area, but the terms and definitions may be used elsewhere when applicable. 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 (0.06 to 2mm) grains.
Siltstone:	More than 50% of the rock consists of silt-sized (less than 0.06mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of silt or clay sized particles 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.

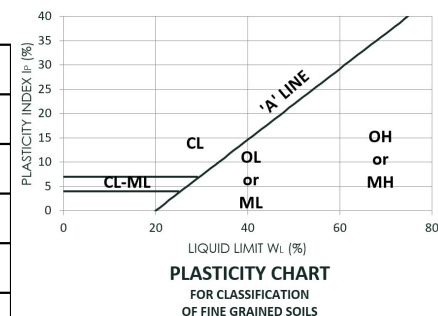
Term	Point Load Index Is(50) MPa	Field Guide	Approx qu MPa*
Extremely Weak:	0.03	Easily remoulded by hand to a material with soil properties.	0.7
Very Weak:	0.1	May be crumbled in the hand. Sandstone is “sugary” and friable.	2.4
Weak:	0.3	A piece of core 150mm long x 50mm dia. May be broken by hand and 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: (SW)	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 (SW)	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 (Fr)	>10	A piece of core 150mm long x 50mm dia. is difficult to break with hand held hammer. Rings when struck with a hammer.	>240

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.

## Unified Soil Classification System (Metricated)

### Data for Description Identification and Classification of Soils

MAJOR DIVISIONS				DESCRIPTION				FIELD IDENTIFICATION						LABORATORY CLASSIFICATION											
				Group Symbol	Graphic Symbol	TYPICAL NAME	DESCRIPTIVE DATA	GRAVELS AND SANDS			Group Symbol	% [2] < 0.06mm	PLASTICITY OF FINE FRACTION			NOTES									
COARSE GRAINED SOILS	More than 50% by dry mass, less than 60mm is greater than 0.06mm.	GRAVELS		GW	Well graded gravels and gravel-sand mixtures, little or no fines	Determine approximate percentages of material over 60mm 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 60mm is larger than 0.06mm	0.06mm is about the smallest particle visible to the naked eye	GOOD	Wide range in grain size	"Clean" materials (not enough fines to band coarse grains)	None	GW	Use the gradation curve of material passing 60mm for classification of fractions according to criteria given under Major Division:	More than 50% passing 0.06mm	0-5	-	>4	Between 1 and 3	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 eg SP-SM GW-GC				
		GP		Poorly graded gravels and gravel-sand mixtures, little or no fines	POOR					Predominantly one size or range of sizes	None to medium						GP	0-5	-	Fails to comply with above					
		GM		Silty gravels, gravel-sand-silt mixtures	GOOD TO FAIR					"Dirty" materials (Excess of fines)		Fines are non-plastic [I]  Fines are plastic [I]	GM	12-50			Below 'A' line and Ip > 7	-	-						
		GC		Clayey gravels gravel-sand-clay mixtures							GC		12-50	Above 'A' line and Ip > 7			-	-							
	SANDS	More than 50% of coarse grains are greater 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 band coarse grains)	None	SW	0-5			-	>6	between 1 and 3						
			SP	Poorly graded sands and gravelly sands, little or no fines	POOR					Predominantly one size or range of sizes			SP	0-5			-	Fails to comply with above							
			SM	Silty sand, sand-silt mixtures	GOOD TO FAIR					"Dirty" materials (Excess of fines)	Fines are non-plastic [I]  Fines are plastic [I]	None to medium	SM	12-50			Below 'A' line or Ip < 4	-	-						
			SC	Clayey sands, sand-clay mixtures									SC	12-50			Above 'A' line and Ip > 7	-	-						
													SILT AND CLAY FRACTION												
													Fraction smaller than 0.20mm AS sieve size												
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.	Determine approximate percentages of material over 60mm size, maximum size, shape, surface texture, hardness of material, geological description, identify on estimated percentage mass of the various fractions.	FINE GRAINED SOILS	More than half of the material less than 50mm is less than 0.06mm	0.06mm is about the smallest particle visible to the naked eye	DRY STRENGTH	DILATANCY	TOUGHNESS		ML	More than 50% passing 0.06mm	Plasticity Index Ip (%)		LIQUID LIMIT WL (%)	PLASTICITY CHART FOR CLASSIFICATION OF FINE GRAINED SOILS						
				None to low	Quick to slow					None															
				Medium to high	None to very slow					Medium															
				Low to medium	Slow					Low															
	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												
			CH	Inorganic clays of high plasticity, fat clays.	High to very high					None	High		CH												
			OH	Organic clays of medium to high plasticity.	Medium to high					None to very slow	Low to medium		OH												
			Pt	Peat muck and other highly organic soils.	Readily identified by colour, odour, spongy feel and generally by fibrous texture						Pt*	*Effervescence with H2O2													



## **Limitations in the Use and Interpretation of this Geotechnical Report**

Our Professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the Owner in the design of the subject development and should be made available to potential contractors and/or the Contractor for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive borehole and test pit logs, cross- sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the exploratory bore holes, test pits, and/or probes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the exploratory bore holes and test pits, or assumed to exist in the excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. If there is a substantial lapse of time between conducting this investigation and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and the recommendations considering the changed conditions and time lapse.

The summary bore hole and test pit logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the test holes progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The bore hole and test pit logs and related information depict subsurface conditions only at the specific locations and at the particular time designated on the logs. Soil conditions at the other locations may differ from conditions occurring at these bore hole and test pit locations. Also, the passage of time may result in a change in the soil conditions at these test locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the boring logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples, bore holes or test pits. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. It is recommended that the Owner consider providing a contingency fund to accommodate such potential extra costs.

This firm cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report: nor can our company be responsible for any construction activity on sites other than the specific site referred to in this report.