



Proposed Hoarding

CLIENT

Projex Building

ADDRESS

1 Swanson Court,
Belconnen, ACT

DATE

November 2024



15 November 2024

Our ref: EM/C15935

Mufie Hussain

Via email: mufie@projexbuilding.com.au

Attention: Mufie Hussain

Proposed Hoarding – 1 Swanson Court, Belconnen, ACT

Geotechnical Investigation Report

We are pleased to present our geotechnical investigation report for the proposed hoarding at 1 Swanson Court, Belconnen, ACT.

The report outlines the methods and results of exploration, describes site subsurface conditions and provides recommendations for footing design, excavation conditions, excavation support, preparation of subgrades, earthquake classification, site drainage advice and geotechnical inspection requirements.

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

Yours faithfully

Fortify Geotech

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About us

We work with our clients to provide practical advice and solutions tailored to each project. Our professional services are reliable, responsive and efficient.

Our highly capable Geotechnical Engineers and Geologists have a comprehensive understanding of the industry. We provide the best engineering solution for complicated geotechnical engineering issues. This has earned us a solid reputation with our Construction Industry, Municipal and Government clients.

INDUSTRIES WE WORK IN

- Residential
- Commercial
- Transport Infrastructure
- Industrial Developments of all sizes.

SERVICES

- Geotechnical Site Investigations and Reporting;
- Engineering Geology;
- Mining/Rock Geotechnics;
- Foundation Engineering;
- Dam Engineering; Embankment Design and Specification;
- Geotechnical Design Recommendations;
- Pavement Engineering and Design;
- Pavement Condition Surveys;
- Slope Stability and Risk Assessments;
- Geotechnical and Hydrological Instrumentation and Monitoring;
- Footing and Excavation Supervision and Certifications;
- Excavated soil/rock assessments and VENM assessments;
- Supervision and Certification of Earthworks and Controlled Fill, including Level 1 supervision;
- Geotechnical Construction Specifications;
- Deep Excavation Support; and
- Slope/Retaining Structure Analysis and Design

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Geotechnical Investigation Report

Proposed Hoarding – 1 Swanson Court, Belconnen, ACT

QUALITY INFORMATION

Revision history

Reference/ Revision	Description	Date	Author	Reviewer
EM/C15935 Rev0	For issue – Geotechnical Investigation	15/11/2024	EM	JM

Projex Building

Proposed Hoarding – 1 Swanson Court, Belconnen, ACT *Geotechnical Investigation Report*

1 INTRODUCTION

At the request of the client, Fortify Geotech Pty Ltd carried out a geotechnical investigation for a proposed hoarding at 1 Swanson Court, Belconnen, ACT.

The project will involve the construction of a hoarding around the perimeter of the site. The previous investigations have indicated the site is underlain by uncontrolled fill material. 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) Provide site classification to AS2870 “Residential Slabs & Footings”.
- iii) Advise on suitable footings systems, founding depths, allowable bearing pressures.
- iv) Advice on preparation of subgrades for building slabs, vehicle pavements and carpark.
- v) Provide subgrade CBR value(s) for pavement design.
- vi) Provide design parameters & shear strength parameters for each soil layer.
- vii) Provide earthquake classification of this site.
- viii) Drainage and other geotechnical advice.

2 SITE DESCRIPTION & GEOLOGY

2.1 SITE LOCATION AND SITE DESCRIPTION

The investigation site is legally registered as Block 45, Section 54, (1 Swanson Court), in Belconnen, ACT. The length of the proposed hoarding is approximately 224m. The site is presently under development and there is an old excavation in the middle and western portion of the site. Figure 1 shows the site locality, while Figure 2 is a recent aerial photo showing the present site layout.

2.2 TOPOGRAPHY AND DRAINAGE

The existing ground surface is relatively flat with an old excavation up to 2.5m depth in the middle and western side of the site. The ground surface level is around RL584. Drainage in surrounding streets is expected to be through pits and pipe network via street guttering.

2.3 REGIONAL GEOLOGY

The 1:10,000 Central Canberra Geology Map documents the site to be underlain by Silurian age Deakin Volcanics, which includes Rhyodacitic Ignimbrite and minor volcanoclastic and argillaceous sedimentary rocks. The geology map, which is an extract from Minview that shows the location of the site.



Plate 2-1: Geology Map Extract from Minview Showing Location of the Site

3 INVESTIGATION METHODS

To establish the subsurface conditions, a 250mm diameter Auger and a 50mm push tube were used to drill four (4) boreholes, designated BH1 to BH4, on 11 November 2024. Boreholes BH1 to BH3 were drilled to 1.25m to 1.5m target depth from existing ground level (RL584) and BH4 was drilled at the bottom of the excavation (~RL581.2) to 1.25m depth. The subsurface profiles were logged in general accordance with AS1726-2017. The locations of the boreholes 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 four (4) boreholes. In summary, the results of the investigation indicate that the subsurface profile across the site comprises uncontrolled fill material.

The logs in Appendix A can be referred to for more detail. The investigation by 4 boreholes found the subsurface profile to comprise as shown in Table 4-1.

Table 4-1: Subsurface Profile Summary

Geological Profile	Unit	Description
FILL	Unit 1a: Sandy GRAVEL	Sandy GRAVEL; fine to coarse, sub-rounded to sub-angular gravel, dark brown, brown, fine to coarse sand, with low plasticity clay, moist, medium dense to dense.
	Unit 1b: Gravelly SAND	Gravelly SAND; fine to coarse sand, dark brown, brown, fine to coarse, sub-rounded to sub-angular gravel, with low plasticity clay, moist, medium dense to dense.
	Unit 1c: Gravelly clayey SAND	Gravelly clayey SAND/ Gravelly sandy CLAY; fine to coarse sand, low plasticity clay, brown, fine to coarse, angular to sub angular gravel, dry, medium dense.
	Unit 1d: Sandy gravelly CLAY	Sandy gravelly CLAY; low plasticity clay, brown, fine to coarse sand, trace of fine to coarse, angular to sub-angular gravel, dry of plastic limit, stiff.

The depth intervals of encountered soil in each borehole are shown in Table 4-2.

Table 4-2: Depth Interval of Each Soil Unit in Each Borehole

Unit	Unit Description	Depth Interval Below Ground Level in Each Borehole (m)			
		BH01	BH02	BH03	BH04
Unit 1a	Fill	0.0 - 0.6	0.0 – 1.0	0.0 – 0.2	-
Unit 2b		0.6 – 1.0	-	-	-
Unit 3c		-	-	0.2 – 1.0	0.0 – 0.2
Unit 4d		1.0 – 1.25	1.0 - 1.5	1.0 – 1.25	0.2 – 1.25

4.2 GROUNDWATER

Groundwater was not encountered in the boreholes and the soils were mostly moist. Permanent groundwater is not expected within at least 3m depth of existing ground surface levels. However, temporary, perched seepages could be encountered within the more pervious alluvial soils following rainfall.

4.3 DYNAMIC CONE PENETROMETER (DCP) TESTING

To assess the soil density and compaction, four (4) Dynamic Cone Penetrometer (DCP) tests were conducted, in accordance with AS1289.6.3.2 “determination of the penetration resistance of soil – 9kg dynamic cone penetrometer test”. The soil profile at the location of DCP tests comprises clayey fill material. Table 1 shows the DCP results.

Table 4-3: DCP Test Results

Depth Below Base of Footing Excavation	Blows per 100mm Penetration from Ground Surface			
	DCP 1	DCP 2	DCP 3	DCP 4
0mm – 100mm	15	23	20	5
100mm – 200mm	16	12	8	7
200mm – 300mm	16	6	12	8
300mm – 400mm	20	10	15	5
400mm – 500mm	Refusal	9	19	3
500mm – 600mm	-	7	8	4
600mm – 700mm	-	8	13	3
700mm – 800mm	-	15	6	4

Depth Below Base of Footing Excavation	Blows per 100mm Penetration from Ground Surface			
	DCP 1	DCP 2	DCP 3	DCP 4
800mm – 900mm	-	9	9	5
900mm – 1000mm	-	7	6	12
1000mm – 1100mm	-	6	7	15
1100mm – 1200mm	-	9	4	15
1200mm – 1300mm	-	10	5	Refusal
1300mm – 1400mm	-	Refusal	5	-
1400mm – 1500mm	-	-	5	-
1500mm – 1600mm	-	-	5	-

Based on the DCP test results, the fill material has the density of stiff/medium dense to very stiff/dense in most sections, which would correspond to an allowable bearing pressure of ~50kPa.

5 DISCUSSION & RECOMMENDATIONS

5.1 GEOTECHNICAL PARAMETERS

Table 5-1 shows the estimated geotechnical parameters of the soil units based on our visual assessment.

Table 5-1: Estimated Geotechnical Parameters

Unit	Typical Interval Depth	Bulk Density γ_b (kN/m ³)	Cu (kPa)	ϕ' (degrees)	Young's Modulus (MPa)	Poisson's Ratio	K_a	K_o	K_p
Unit 1: Fill	0.0 – >1.25/1.5m	19	15	25	10	0.4	0.41	0.58	2.5

Where,

γ_b	=	in-situ, dry unit weight, in kN/m ³
Cu	=	undrained cohesion, in kPa
C'	=	effective drained cohesion, in kPa
ϕ'	=	effective internal friction angle, in degrees
K_a	=	active pressure coefficient
K_o	=	at rest coefficient
K_p	=	passive pressure coefficient

The above values can be used in software programs for design of piles and retaining walls; however, it is recommended that the values for lateral earth pressures in Section 5.5 be used as a minimum for retaining wall design.

5.2 SITE CLASSIFICATION

Due to the presence of uncontrolled fill materials exceeding 1.5m depth, the site is designated as a Class "P" (problem) site in accordance with AS2870. If a controlled fill certification can be obtained, then the 'uncontrolled fill' could be re-classified as 'controlled fill', and the "P" classification could be removed.

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.

5.3 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.

For structures founded at existing grade, footings, including thickened sections of slabs forming footings should be founded in residual soil or weathered bedrock below any uncontrolled fill. A depth of >1.25/3.75m 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 uncontrolled fill material (see Section 5.6).

Shallow excavations are expected to expose uncontrolled fill material over the foundation, and suitable footings include bored piers founded on the stiff natural soil or bedrock.

If any foundation is to be placed on the uncontrolled fill material, the allowable bearing pressure of the fill material can be considered 50kPa.

If designing footings based on engineering principles, recommended allowable end-bearing pressures for various footing systems and likely foundation materials are provided in Table 5-2.

Table 5-2: Recommended Allowable End-Bearing Pressures for Footings

Foundation Material Type	Unit	Depth Below Existing Surface Level	Allowable End-Bearing Pressure			Allowable Shaft Adhesion on Piles	
			Strips	Pads	Piles	Downward Loading	Uplift
Newly Placed Controlled Fill (Section 5.7)	-	-	100kPa	125kPa	N.A.	N.A.	N.A.
Uncontrolled Fill	Unit 1	~1.25m / 3.75m	50 kPa	50 kPa	50kPa	N.A.	N.A.

At allowable bearing pressure foundation settlement would be less than 1% of the footing width.

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, following the removal of any topsoil and loose material. Following excavation to required level, slab areas on soil should be test 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.

If required for design of ground slabs, a modulus of subgrade reaction of 50kPa/mm can be assumed for a natural soil or controlled fill foundation, and 100kPa/mm for a bedrock foundation.

5.4 CONTROLLED FILL CONSTRUCTION

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

- Areas be fully stripped of all uncontrolled fill and topsoil. A stripping depth of ~1.25m/3.75m may be required. Stripped foundations should be test 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. If a controlled fill certification can be obtained, then the 'uncontrolled fill' could be re-classified as 'controlled fill', and would not need to be stripped off.

- 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 or 2 involvement of AS3798 – 2007 "Guidelines on Earthworks for Commercial & Residential Developments".

5.5 DESIGN CBR VALUES

On-grade carpark, and access ramp subgrades should be stripped of all unsuitable material (uncontrolled fill/topsoil), and soil subgrades then test 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.

Carpark and access road pavements are expected to comprise controlled fill or residual soils, and possibly weathered bedrock, and pavements can be designed for a subgrade CBR value of 3% (for high plasticity clay subgrades), 5% (for low and medium plasticity clay subgrades) and 10% (for weathered bedrock subgrades), when compacted to 95%ModMDD. A geotechnical engineer should inspect prepared subgrades to confirm design values, and preferably view a test roll to identify any soft spots or other weaknesses.

5.6 GROUNDWATER CONTROL

Groundwater was not encountered in the test pits 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.

5.7 EARTHQUAKE SITE FACTOR

Table 2.3 of AS1170.4 "Minimum Design Loads on Structures - Part 4: Earthquake Loads" lists the earthquake acceleration coefficients for major centers to be considered in structural design. The Canberra area 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_e – Shallow Soil Site".

5.8 GEOTECHNICAL INSPECTIONS

The following should be used as a guideline for hold points that require geotechnical inspections:

- All Footing excavations prior to pouring concrete
- All groundslabs to confirm the soil profile and bearing in adequate material.

- All unsupported excavations deeper than 1.5m to ensure batter stability
- Between 10% and 20% of all ground anchors be fully logged by a geotechnical engineer to confirm the design assumption for bond stress are correct
- All mobile crane and concrete pump foundations prior to mobile crane setting up on site
- All scaffold and formwork foundations on soil
- Vibration monitoring where rock hammering for the basement excavation is being conducted
- All groundslab and pavement subgrade foundations

Fortify Geotech Pty Ltd

REFERENCES

Australia. Bureau of Mineral Resources, Geology and Geophysics. (1980). Canberra 1:10 000 engineering geology series.

Standards Australia, "AS2870 – 2011 - Residential Slabs & Footings".

Standards Australia, "AS3798 – 2007 - Guidelines on earthworks for commercial and residential developments".

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

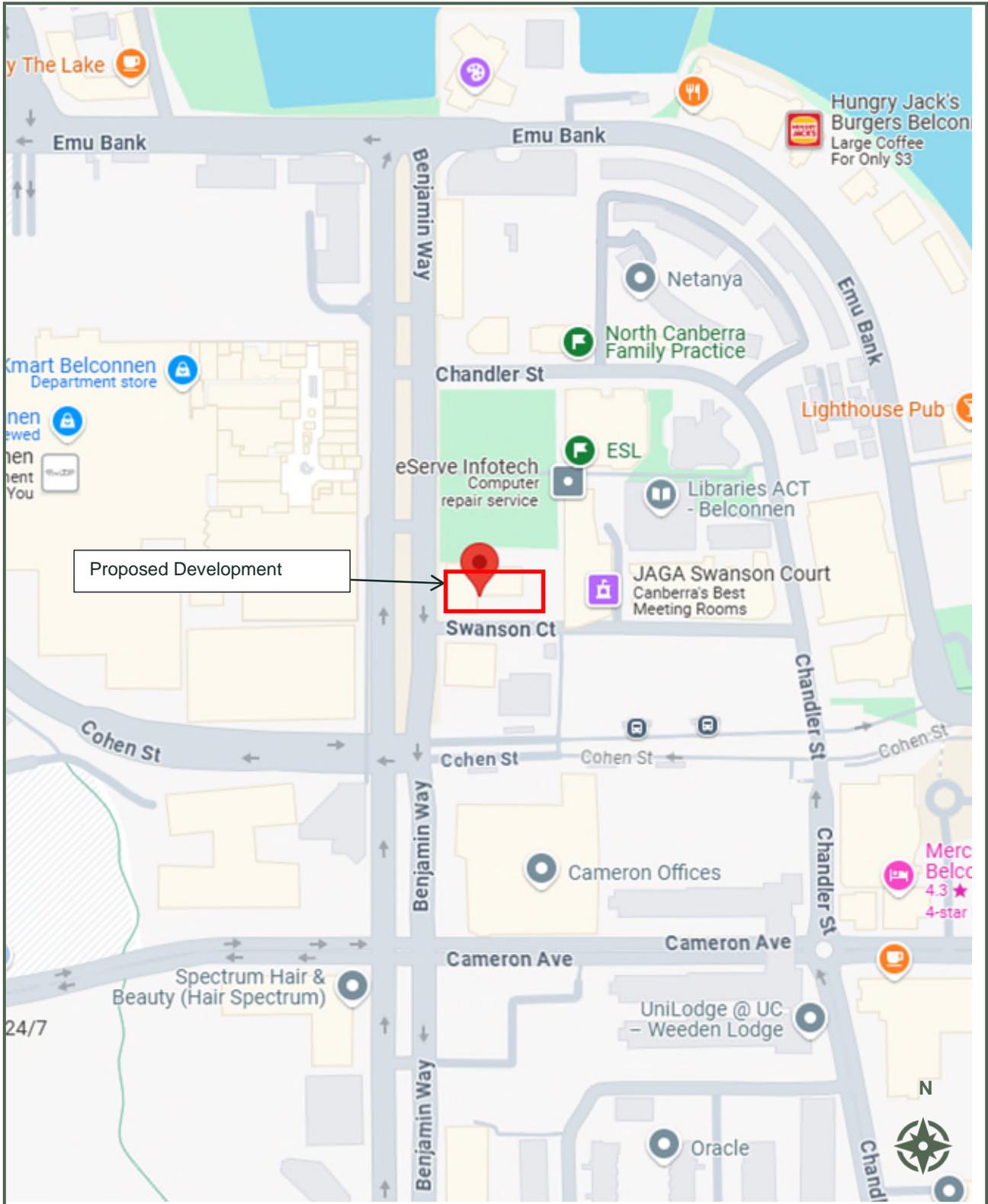
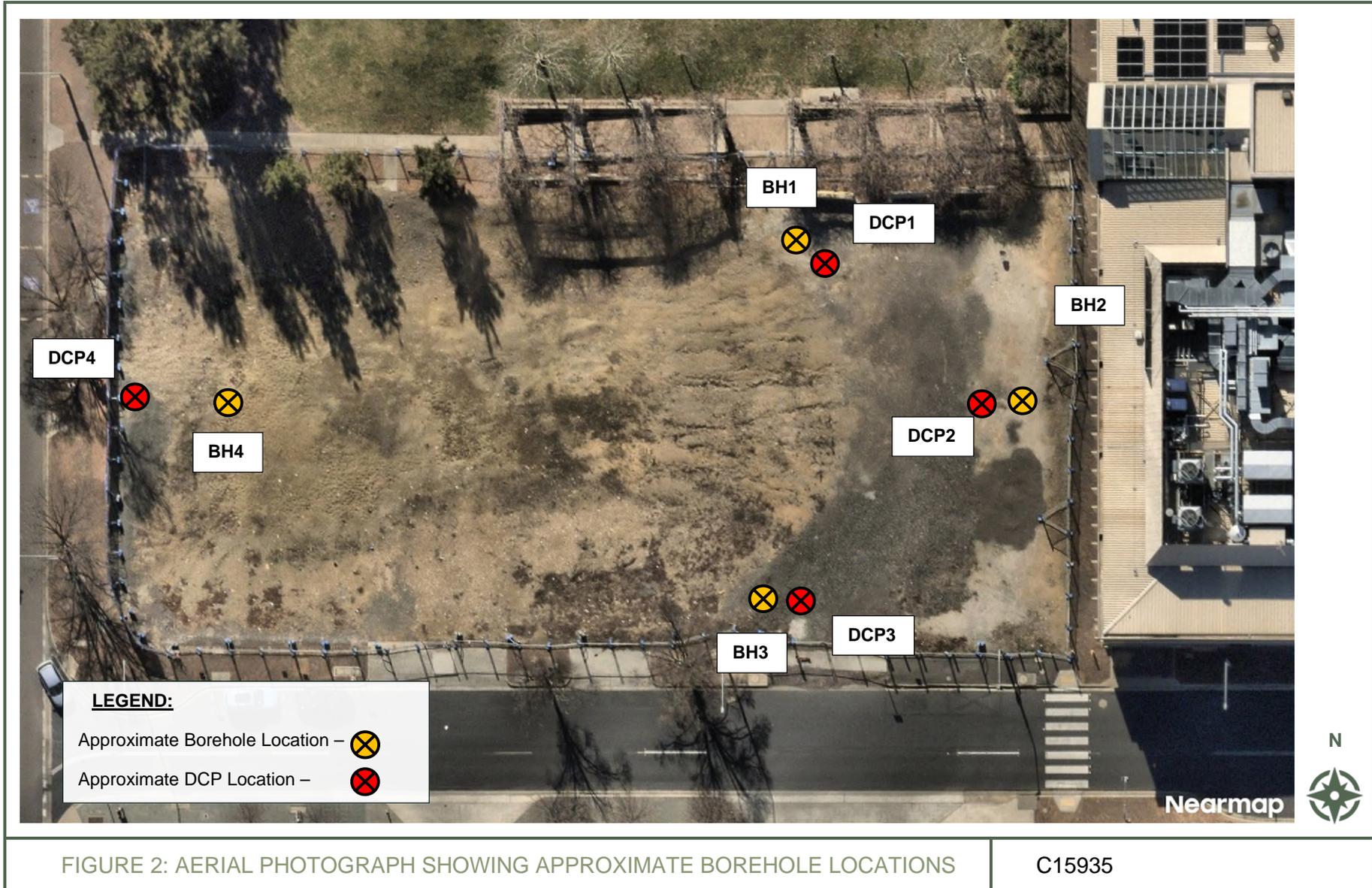


FIGURE 1: SITE LOCALITY

C15935





Appendix A

Borehole Logs BH1 to BH4

Borehole Log

Borehole No.	BH1
Sheet	1 of 1
Job No.	C15935
Location	: See Report
Collar Level	: Not Known
Angle From Vertical	: 0°
Bearing	: N.A.

CLIENT:	Projex Building
PROJECT	Proposed Hoarding 1 Swanson Court, Belconnen ACT 2617
Equipment Type	: Auger
Hole Diameter	: 250mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure <small>Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure</small>	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
		None Encountered AUGERING		0.5		SP-SC	Gravelly clayey SAND; fine to coarse sand, brown, fine to coarse, angular to sub angular gravel, low plasticity clay, dry, medium dense.	D	MD	Dynamic Cone Penetrometer Test Results in Blows per 100mm	FILL
				1.0		SP	Gravelly SAND; fine to coarse sand, dark brown, brown, fine to coarse, sub-rounded to sub-angular gravel, with low plasticity clay, moist, medium dense to dense.	M	MD-D		
				1.25		CL	Sandy gravelly CLAY; low plasticity clay, brown, fine to coarse sand, trace of fine to coarse, angular to sub-angular gravel, dry of plastic limit, stiff.	w<PL	St		
			2.0	BOREHOLE TERMINATED AT 1.25m Target Depth							

BOREHOLE/EXCAVATION LOG C15935.GPJ EXC.GDT 11/15/24

Logged By : AS	Date : 11/11/24	Checked By : JM	Date : 11/14/24
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Borehole Log

Borehole No.	BH2
Sheet	1 of 1
Job No.	C15935
Location	: See Report
Collar Level	: Not Known
Angle From Vertical	: 0°
Bearing	: N.A.

CLIENT:	Projex Building
PROJECT	Proposed Hoarding 1 Swanson Court, Belconnen ACT 2617
Equipment Type	: Push tube
Hole Diameter	: 50mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure <small>Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure</small>	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
		None Encountered PUSH TUBE		1.0		GC	Sandy clayey GRAVEL; fine to coarse, angular to sub-angular gravel, brown, pale brown, fine to coarse sand, low plasticity clay, moist, medium dense.	M	MD	Dynamic Cone Penetrometer Test Results in Blows per 100mm	FILL
						CL	Gravelly sandy CLAY; low plasticity clay, brown, pale brown, fine to coarse sand, trace of fine to coarse, sub-rounded to sub-angular gravel, dry of plastic limit, stiff.	w<PL	St		23
											12
											6
											10
											9
											7
											8
											15
											9
										7	
				1.5						6	
										9	
										10	
				2.0			BOREHOLE TERMINATED AT 1.5m Target Depth				

BOREHOLE/EXCAVATION LOG C15935.GPJ EXC.GDT 11/15/24

Logged By : AS	Date : 11/11/24	Checked By : JM	Date : 11/14/24
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FORTIFY
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Appendix B

Definitions of Geotechnical Engineering Terms

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 facility 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 boring 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 borings, 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 borings 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 the submission of this report 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 Boring Logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the borings progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The boring 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 boring locations. Also, the passage of time may result in a change in the soil conditions at these boring 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, borings 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 firm be responsible for any construction activity on sites other than the specific site referred to in this report.

DESCRIPTION AND CLASSIFICATION OF SOIL

The methods of description and classification of soils used in this report are based on the Australian Standard 1726 – 2017, Geotechnical site investigations. In general, soils are described along the following characteristics: soil name, plasticity or behavioural or particle characteristics of the primary soil component, colour, secondary soil components' plasticity or behavioural or particle characteristics, condition, structure, inclusions, strength or density and origin.

GENERAL DEFINITION - SOIL

SOIL In engineering usage, soil is a natural aggregate of mineral grains which can be separated by gentle mechanical means as agitation in water, can be remoulded and can be classified according to the Unified Soil Classification System.

SOIL ORIGIN

Soil origins fall into the following categories:

- Residual soil:** Soils which have been formed in-situ by the chemical weathering of parent rock. These soils no longer retain any visible structure or fabric of the parent soil or rock material.
- Extremely weathered material:** Formed directly from in situ weathering of geological formations. Although this material of soil strength it retains the structure and/or fabric of the parent rock material.
- Alluvial soil:** Deposited by streams and rivers.
- Estuarine soil:** Deposited in coastal estuaries, and including sediments carried by inflowing rivers and streams, and tidal currents.
- Marine soil:** Deposited in a marine environment.
- Lacustrine soil:** Deposited in freshwater lakes.
- Aeolian soil:** Carried and deposited by wind.
- Colluvial soil:** Soil and rock debris transported down slopes by gravity, with or without the assistance of flowing water.
- Topsoil:** Mantle of surface and/or near-surface soil often but not always defined by high levels of organic material, both dead and living.
- Fill:** Any material which has been placed by anthropogenic processes.

SOIL CLASSIFICATION

PARTICLE SIZE DEFINITIONS

Soil components 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	Components	Subdivision	Particle Size (mm)
Oversize	Boulders		>200
	Cobbles		63 to 200
Coarse grained soil	Gravel	Coarse	19 to 63
		Medium	6.7 to 19
		Fine	2.36 to 6.7
	Sand	Coarse	0.6 to 2.36
		Medium	0.21 to 0.6
		Fine	0.075 to 0.21
Fine grained soil	Silt		0.002 to 0.075
	Clay		<0.002

MOISTURE CONDITION

Coarse Grained Soil		Fine Grained Soil	
Dry (D)	Non-cohesive and free-running.	Moist, dry of plastic limit ($w < W_p$)	Hard and friable or powdery.
Moist (M)	Soil feels cool, darkened in colour. Soil tends to stick together.	Moist, near plastic limit ($w \approx W_p$)	Soils can be moulded at a moisture content approximately equal to the plastic limit.
Wet (W)	As for moist, with free water forming when handled.	Moist, wet of plastic limit ($w > W_p$)	Soils usually weakened and free water forms on hands when handling.
		Wet, near liquid limit ($w \approx W_L$)	Near liquid limit.
		Wet, wet of liquid limit ($w > W_L$)	Wet of liquid limit.

CONSISTENCY/RELATIVE DENSITY

Cohesive soils are classified on the ease by which the soil can be remoulded and can be either assessed in the field by tactile means, by laboratory testing or through mechanical determination methods. Non-cohesive soils are classified on the basis of relative density, generally from the results of in-situ penetration tests and terms for both are defined as below:

Cohesive Soils			Non-cohesive Soils	
Consistency	Indicative Undrained Shear Strength s_u (kPa)	Field Guide to Consistency	Term	Relative Density (%)
Very soft (VS)	≤ 12	Exudes between the fingers when squeezed in hand.	Very Loose (VL)	≤ 15
Soft (S)	$> 12 - \leq 25$	Can be moulded by light finger pressure.	Loose (L)	$> 15 - \leq 35$
Firm (F)	$> 25 - \leq 50$	Can be moulded by strong finger pressure.	Medium Dense (MD)	$> 35 - \leq 65$
Stiff (St)	$> 50 - \leq 100$	Cannot be moulded by fingers.	Dense (D)	$> 65 - \leq 85$
Very Stiff (VSt)	$> 100 - \leq 200$	Can be indented by thumb nail.	Very Dense (VD)	> 85
Hard (H)	> 200	Can be indented with difficulty by thumb nail.		
Friable (Fr)	-	Can be easily crumbled or broken into small pieces by hand.		

MINOR COMPONENTS

Descriptive Term	Assessment Guide	Proportion of minor component in:
With	Easily detectable by visual or tactile means and little difference between general properties and properties of primary component.	Coarse grained soils: Fines – 5 to 12% Accessory coarse component – 15 to 30% Fine grained soils: Coarse component - 15 to 30%
Trace	Detectable by visual or tactile means but little or no difference between general properties and properties of primary component.	Coarse grained soils: Fines – <5% Accessory coarse component – <15% Fine grained soils: Coarse component - <15%

CEMENTATION

Where cementation is present in soils, they can be either weakly cemented where they are easily disaggregated by hand in air or water or moderately cemented where effort is required to disaggregate the soil by hand in air or water.

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" – Test No. F3.1.

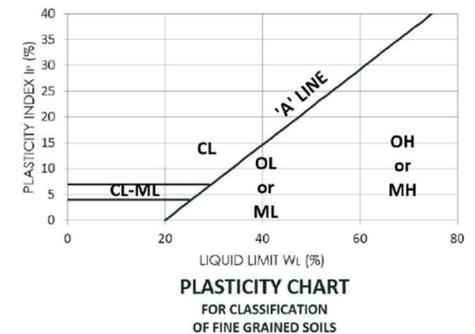
The standard penetration test is carried out by driving a 50mm diameter split tube penetrometer of standard dimensions under the impact of a 63kg hammer having a free fall of 750mm.

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.

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	% < 0.075 mm	PLASTICITY OF FINE FRACTION	Coefficient of Uniformity C _u	Coefficient of Curvature C _c	Notes														
					GRADATIONS	NATURE OF FINES	DRY STRENGTH																				
COARSE GRAINED SOILS	GRAVELS More than 50% of coarse grains are greater than 2.36mm.		GW	Well graded gravels and gravel-sand mixtures, little or no fines	Give soil name, indicate approximate percentages of sand and gravel, particle characteristics including particle size subdivision, particle shape, colour, secondary component characteristics and other pertinent descriptive information, symbols in parenthesis.	COARSE GRAINED SOILS	More than 65% of material less than 43mm is greater than 0.075mm.	A 0.075mm particle is about the smallest particle visible to the naked eye.	GOOD	Wide range in grain size	"Clean" materials (not enough fines to bond coarse grains)	None	GW	0-5	-	>4	Between 1 and 3	1. Identify fines by the method given for fine grained soils. 2. For fines contents between 5% and 12%, the soil shall be given a dual classification comprising the two group symbols separated by a dash, e.g. for a gravel with between 5% and 12% silt fines, the classification is GP-GM. 3. Soils that are dominated by boulders, cobbles or peat (Pt) are described separately and are not classified.									
			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			
			GM	Silty gravels, gravel-sand-silt mixtures															GOOD TO FAIR	"Dirty" materials (Excess of fines)	Fines are silty (1)	None to medium	GM	12-50	Below 'A' line and I _p > 7	-	-
			GC	Clayey gravels gravel-sand-clay mixtures															Fines are clayey (1)	Medium to high	GC	12-50	Above 'A' line and I _p > 7	-	-	-	
	SANDS More than 50% of coarse grains are less than 2.36mm.		SW	Well graded sands and gravelly sands, little or no fines	For undisturbed soil add information on structure including zoning, defects and cementing, moisture condition, and relative density. Example: (SP) SAND, trace silt, grey, medium grained, medium dense; dry, Tomago Sand Beds.	COARSE GRAINED SOILS	More than 65% of material less than 43mm is greater than 0.075mm.	A 0.075mm particle is about the smallest particle visible to the naked eye.	GOOD	Wide range in grain size	"Clean" materials (not enough fines to bond coarse grains)	None	SW	0-5	-	>6	Between 1 and 3										
			SP	Poorly graded 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 silty (1)	None to medium	SM	12-50	Below 'A' line or I _p < 4	-	-
			SC	Clayey sands, sand-clay mixtures															Fines are clayey (1)	Medium to high	SC	12-50	Above 'A' line and I _p > 7	-	-	-	
FINE GRAINED SOILS	Liquid Limit less than 50%.		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.	Give soil name, indicate degree and character of plasticity, colour, secondary component characteristics other pertinent descriptive information, symbols in parenthesis. For undisturbed soil add information on structure including zoning, defects and cementing, moisture condition, and consistency. Example: (CI) CLAY, with gravel, red-brown, medium plasticity, very stiff; gravel 20%, fine to medium, sub-rounded; moist, with desiccation cracks; residual.	FINE GRAINED SOILS	More than 35% of material less than 43mm is smaller than 0.075mm.	A 0.075mm particle is about the smallest particle visible to the naked eye.	SILT AND CLAY FRACTION			Use the gradation curve of material passing 43mm for classification of fractions according to criteria for major component.	More than 35% of material is less than 63mm passing 0.075mm.	Below 'A' line													
			Fraction smaller than 0.2 mm AS sieve size						ML																		
			DRY STRENGTH	DILATANCY						TOUGHNESS	None to low				Slow to rapid	Low											
			Medium to high	None to slow						Medium	CL, CI																
			Low to medium	Slow						Low	OL																
	Low to medium	None to slow	Low to medium	MH																							
	Liquid Limit more than 50%.		CH	Inorganic clays of high plasticity, fat clays	Give soil name, indicate degree and character of plasticity, colour, secondary component characteristics other pertinent descriptive information, symbols in parenthesis. For undisturbed soil add information on structure including zoning, defects and cementing, moisture condition, and consistency. Example: (CI) CLAY, with gravel, red-brown, medium plasticity, very stiff; gravel 20%, fine to medium, sub-rounded; moist, with desiccation cracks; residual.	FINE GRAINED SOILS	More than 35% of material less than 43mm is smaller than 0.075mm.	A 0.075mm particle is about the smallest particle visible to the naked eye.	High to very high	None	High	CH	Above 'A' line														
			OH	Organic clays of medium to high plasticity										None to very slow	Low to medium	OH	Below 'A' line										
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays														ML									
			OL	Organic silts and organic silty clays of low plasticity															CL								
MH			Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts	MH																							
OH	Organic clays of medium to high plasticity	OH																									
PT	Peat muck and other highly organic soils		Readily identified by colour, odour, spongy feel and generally fibrous texture		PT	* Effervescence with H ₂ O ₂																					



DESCRIPTION AND CLASSIFICATION OF ROCK

The methods of description and classification of rock used in this report are based on the Australian Standard 1726 – 2017, Geotechnical site investigations. In general, descriptions cover the following properties for rock – rock name, grain size, colour, fabric and texture, inclusions or minor components, moisture content, durability, rock material condition including strength and weathering and/or alteration, defects and geological description.

GENERAL DEFINITIONS – ROCK

ROCK In engineering usage, rock is a natural aggregate of minerals connected by strong and permanent cohesive forces. Since “strong” and “permanent” are subject to different interpretations, the boundary between rock and soil is necessarily an arbitrary one. Rock material is intact rock that is bounded by defects.

DEFECT Discontinuity, fracture, break or void in the material or materials across which there is little or no tensile strength.

STRUCTURE The nature and configuration of the different defects within the rock mass and their relationship to each other.

ROCK MASS The entirety of the system formed by all of the rock material and all the defects that are present.

DESCRIPTIVE TERMS

ROCK NAME Simple rock names are used rather than precise geological classification. Rock names fall into category types of sedimentary rocks, igneous rocks, metamorphic rocks and duricrust rocks.

PARTICLE SIZE

Grain size terms for sedimentary rocks with predominantly sand sized grains are:

Coarse grained – mainly 0.6mm to 2mm.

Medium grained – mainly 0.2mm to 0.6mm.

Fine grained – mainly 0.06mm (just visible) to 0.2mm.

In igneous and metamorphic rock types, where significant, the following terms are used to describe the dominant or average grain size and/or the grain size may be recorded in millimetres:

Coarse grained – mainly greater than 2mm.

Medium grained – mainly 0.06mm to 2mm.

Fine grained – mainly less than 0.06mm (just visible).

If readily identifiable, the minerals should be described.

FABRIC

When the arrangement of grains shows an alignment, a preferred orientation or a layering that is visible, descriptive terms for sedimentary rocks are bedding and lamination. Bedding is layering produced by changes in sedimentation. Lamination is similar to bedding but developed in layer thicknesses of less than 20mm. Fabric descriptive terms for metamorphic rocks are foliation, which is the parallel arrangement of minerals due to metamorphic processes and cleavage, which is a type of foliation developed in fine grained metamorphic rocks such as slates. For igneous rocks, flow banding is a layering produced during flow of a partially solidified igneous rock that causes crystals to become oriented.

INDISTINCT FABRIC

Where layering or fabric is just visible. There is little effect on strength properties.

DISTINCT FABRIC

Where layering or fabric is easily visible. The rock may break more easily parallel to the fabric.

ROCK WEATHERING DEFINITIONS

Extremely Weathered (XW)	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 Soil 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 limonite, has taken place. The colour and texture of 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 of low strength, 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.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index ($I_{s(50)}$) 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 Strength Index $I_{s(50)}$ MPa	Field Guide	Approx Unconfined Compressive Strength MPa*
Very Low Strength (VL)	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.	0.6 to 2
Low Strength (L)	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.	2 to 6
Medium Strength (M)	0.3 to 1	Readily scored with a knife; a piece of core 150mm long x 50mm dia. can be broken by hand with difficulty.	6 to 20
High Strength (H)	1 to 3	A piece of core 150mm long x 50mm dia. cannot be broken by hand but can be broken by a pick with a single firm blow, rock rings under hammer.	20 to 60
Very High Strength (VH)	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.	60 to 200
Extremely High Strength (EH)	more than 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.	more than 200

ROCK DEFECT TYPES

This classification applies to the range of possible rock defect types that are 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	Diagram
Parting		A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering (e.g. bedding) or a planar anisotropy in the rock material (e.g. cleavage). May be open or closed.	
Joint		A surface or crack with no apparent shear displacement across which the rock has little or no tensile strength, but which is not parallel to layering or to planar anisotropy in the rock material. May be open or closed.	
Sheared Surface		A near planar, curved or undulating surface which is usually smooth, polished or slickensided and which shows evidence of shear displacement.	
Sheared Zone		Zone of rock material with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	
Seams	Sheared Seam	Seam of soil material with roughly parallel almost planar boundaries, composed of soil materials with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge-shaped blocks.	
	Crushed Seam	Seam of soil material with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock material which may be more weathered than the host rock. The seam has soil properties.	
	Infilled Seam	Seam of soil material usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as a veneer or coating on a joint surface.	
	Extremely Weathered Seam	Seam of soil material, often with gradational boundaries. Formed by weathering of the rock material in place.	

The spacing, length (sometimes called persistence), aperture (openness), and seam thickness should generally be described directly in millimetres or metres.

ROCK DEFECT DESCRIPTIONS

DEFECT ROUGHNESS TERMS		DEFECT SHAPE TERMS		DEFECT COATING TERMS	
Term	Description	Term	Description	Term	Description
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.	Planar	The defect does not vary in orientation.	Clean	No visible coating.
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.	Curved	The defect has a gradual change in orientation.	Stained	No visible coating but surfaces are discoloured.
Smooth	Smooth to touch. Few or no surface irregularities.	Undulating	The defect has a wavy surface.	Veneer	A visible coating or soil or mineral, too thin to measure; may be patchy.
Polished	Shiny smooth surface.	Stepped	The defect has one or more well defined steps.	Coating	A visible coating up to 1mm thick. Thicker soil material should be described using appropriate defect terms (e.g. infilled seam). Thicker rock strength material should be described as a vein.
Slickensided	Grooved or striated surface, usually polished.	Irregular	The defect has many sharp changes of orientation.		

FORTIFY

GEOTECH