GEOTECHNICAL INVESTIGATION REPORT

FORTIFY
GEOTECH

Proposed Batemans Bay Community Health

CLIENT

BD Infrastructure

ADDRESS

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Batemans Bay,
NSW

DATE

April 2024

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2 July 2024
Our ref: UK/C15142

BD Infrastructure

Via email: ANTHONY.COSTA@BDINFRASTRUCTURE.COM

Attention: Mr Anthony Costa

Proposed Batemans Bay Community Health
7 Pacific Street, Batemans Bay, NSW
Geotechnical Investigation Report

We are pleased to present our geotechnical investigation report for the proposed Batemans Bay Community Health project at 7 Pacific Street, Batemans Bay, NSW.

The report outlines the methods and results of exploration, describes site subsurface conditions and provides recommendations for building footing design, excavation conditions, excavation support, preparation of subgrades, stability of cut and fill batters, retaining wall design, designed CBR values, 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 Batemans Bay Community Health – 7 Pacific Street, Batemans Bay, NSW

QUALITY INFORMATION

Revision history

Reference/ Revision	Description	Date	Author	Reviewer
UK/C15142	For issue – Geotechnical Investigation	10/05/2024	UK	JM

BD Infrastructure

Proposed Batemans Bay Community Health – 7 Pacific Street, Batemans Bay, NSW

Geotechnical Investigation Report

1 INTRODUCTION

At the request of the client, Fortify Geotech Pty Ltd carried out a geotechnical investigation for the proposed Batemans Bay Hospital Community Health project at 7 Pacific Street, Batemans Bay, NSW.

The project will involve the construction of a ~60m x 20m building at the southern end of the site, and associated carparking. 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) Advise on excavation conditions and suitability of excavated material for use as structural fill.

v) Advice on preparation of subgrades for building slabs, vehicle pavements and carpark.

vi) Provide subgrade CBR value(s) for pavement design.

vii) Provide guidelines for construction of controlled fill platforms.

viii) Advise on stable batter slopes.

ix) Provide retaining wall design parameters & shear strength parameters for each soil/ rock layer.

x) Provide earthquake classification of this site.

xi) Drainage and other geotechnical advice.

2 SITE DESCRIPTION & GEOLOGY

2.1 SITE LOCATION AND SITE DESCRIPTION

The investigation site is legally registered as Lot 22, DP1152713, (7 Pacific Street), in Batemans Bay, NSW. The area of the proposed community health building is approximately 1200m^2. The site is presently a carpark and loading dock for the hospital. Figure 1 shows the site locality, while Figure 2 is a recent aerial photo showing the present site layout with borehole location.

2.2 TOPOGRAPHY AND DRAINAGE

The existing ground surface is relatively flat but is founded on top of a hill sloping down east. The investigation site is covered in loose gravel and asphalt of the existing carpark and ambulance bay. There are some mature trees within the investigation area and the expected building footprint is founded on an embankment with ~60° slope. Drainage in surrounding streets is expected to be through pits and pipe network via street guttering.

2.3 REGIONAL GEOLOGY

The MinView NSW Seamless Geology Map documents the site to be underlain by Early Ordovician age Abercombie Formation bedrock, comprising brown and buff to grey, thin to thick bedded, fine to coarse grained mica quartz (±feldspar) sandstone, interbedded with laminated siltstone and mudstone. Sporadic chert rich units. Plate 2-1 is an extract from MinView geology map showing the site in green circle.

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

The NSW Acid Sulfate soil probability map documents the site as a Class L2: Low probability 1-3m below ground surface. Plate 2-2 is an extract of the ASS probability map with the approximate site location shown in a green circle.

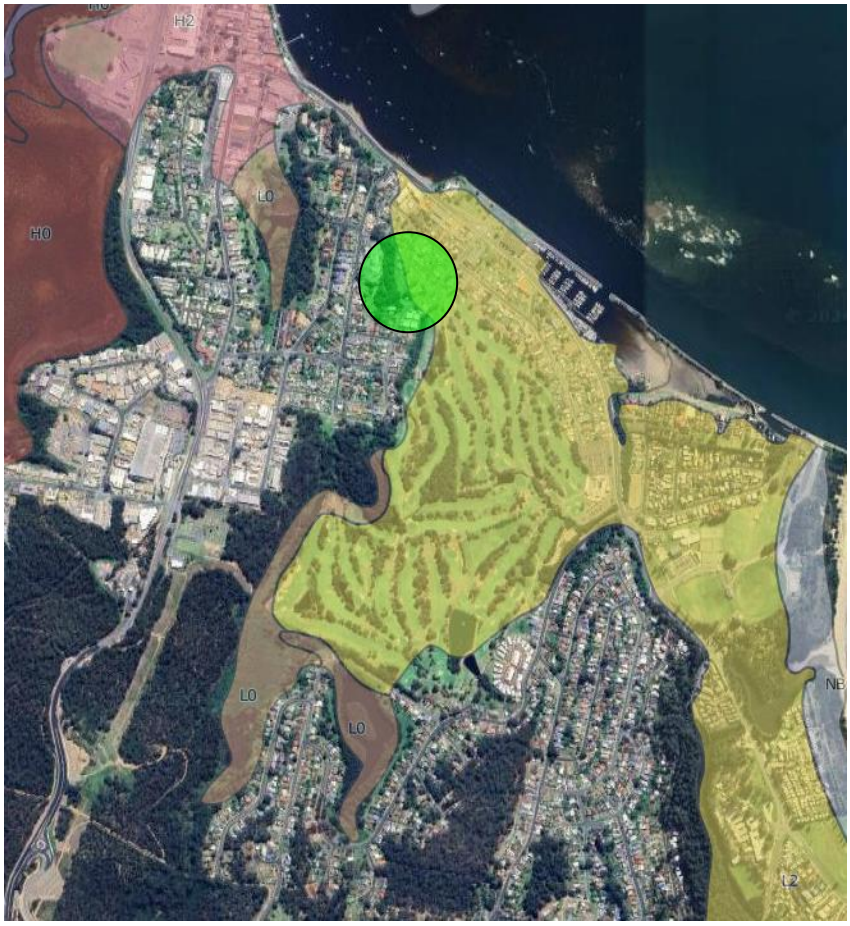

Plate 2-2: Acid Sulphate Soil Probability Map Showing Location of the Site. Yellow area indicates Class L2 soils.

3 INVESTIGATION METHODS

To establish the subsurface conditions, a track mounted drill-rig was used to drill six (6) boreholes, designated BH1 to BH6, on 08 April 2024. The boreholes were drilled to 3m target depth from existing ground level, except for one borehole (BH4), which was drilled to 7m target 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.

Two (2) disturbed soil samples were collected from BH2 and BH4 for CBR (California Bearing Ratio) testing, two (2) disturbed soil samples were collected from BH1 and BH5 for Atterberg Limits testing and four (4) disturbed soil samples were collected from BH1, BH2, BH5 and BH6 for sulphate content testing. Results of testing are presented in Section 4.3 and NATA Test Certificates are shown in Appendix B.

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

4 INVESTIGATION RESULTS

4.1 SUBSURFACE CONDITIONS

The subsurface conditions of the proposed development were investigated by six (6) boreholes. In summary, the results of the investigation indicate that the subsurface profile across the site comprises topsoil and fill to 0.15m/0.55m depth, over colluvial and residual soil to >7m depth. Bedrock was not found within the investigation depths.

The logs in Appendix A can be referred to for more detail. The investigation by 6 boreholes found the subsurface profile to comprise as shown in Table 4-1.

Table 4-1: Subsurface Profile Summary

Geological Profile	Unit	Description
TOPSOIL	Unit 1: Silty SAND	**Silty SAND;** fine to coarse grained sand, low plasticity silt, brown, trace of grass roots, dry, loose.
FILL	Unit 2a: DGB / Asphalt	**DGB20;** loose gravel, dry, loose to medium dense. OR **ASPHALT**
	Unit 2b: Clayey SAND / Silty Gravelly SAND / Gravelly SAND / Sandy GRAVEL	**Clayey SAND / Silty Gravelly SAND / Gravelly SAND / Sandy GRAVEL;** fine to coarse grained sand, low plasticity fines, fine to coarse grained, subangular to subrounded gravel, dark brown, pale brown, pink-brown, dry, loose.
COLLUVIAL SOIL	Unit 3	**Silty Gravelly SAND / Silty Clayey SAND;** fine to coarse grained sand, low plasticity fines, fine to coarse grained, subangular to subrounded gravel, brown, pale brown, orange-brown, dry, medium dense.
RESIDUAL SOIL	Unit 4: Silty Clayey SAND	**Silty Clayey SAND;** fine to coarse grained sand, low plasticity fines, orange-brown, dry, medium dense.

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

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

Unit	Unit Description	Depth Interval Below Ground Level in Each Borehole (m)					
		BH01	BH02	BH03	BH04	BH05	BH06
Unit 1	TOPSOIL	0.0 - 0.15	-	-	-	-	-
Unit 2a	FILL	-	0.0 – 0.1	0.0 – 0.05	0.0 – 0.1	0.0 – 0.1	0.0 – 0.1
Unit 2b	FILL	-	0.1 – 0.3	0.05 – 0.4	-	0.1 – 0.2	0.1 – 0.55
Unit 3	Colluvial Soil	0.15 - >3.0	0.3 - >3.0	0.4 – 1.5	0.1 - >7.0	0.2 - >3.0	0.55 - >3.0
Unit 4	Residual Soil	-	-	1.5 - >3.0	-	-	-
Refusal Depth		>3.0	>3.0	>3.0	>7.0	>3.0	>3.0

4.2 GROUNDWATER

Groundwater was not encountered in the boreholes and the soils were mostly moist. Permanent groundwater is not expected within at least 7m depth of existing ground surface levels. However, temporary, perched seepages could be encountered within the more pervious alluvial soils following rainfall.

4.3 LABORATORY RESULTS

4.3.1 California Bearing Ratio (CBR) Testing

Subgrade materials from two boreholes (BH2 and BH4) were tested for Standard Compaction, and California Bearing Ratio (CBR) (4-day soak). Results are summarized in Table 4-3 below. The NATA test certificates are included in Appendix B.

Table 4-3: Summary of CBR Test Results

Sample Reference	Borehole & Depth (m)	Optimum Moisture Content (%)	MDD (t/m^3)	CBR Swell (%)	CBR @98%StdMDD (%)
CS10398B	BH2 (0.5m-1.0m)	10.5	2.02	0.5	15
CS10398D	BH4 (0.5m-1.0m	14.5	1.77	2.5	3.0

Table Notes:
OMC: Optimum Moisture Content CBR: California Bearing Ratio MDD: Maximum Dry Density

4.3.2 Sulphate Content Test Results

Four (4) disturbed soil samples were collected from BH1, BH2, BH5 and BH6 for sulphate content testing. Table 4-4 summarizes the results of the acid sulphate testing results. NATA lab certificates are provided in Appendix B.

Table 4-4: Sulphate Content Test Results

Borehole No.	Depth (m)	SO_4 % as SO_3
BH1	1.0-1.5	0.007
BH2	1.0-1.5	0.003
BH5	1.0-1.5	<0.001
BH6	0.5-1.0	0.021

4.3.3 Atterberg Limits Testing

Two (2) disturbed soil samples were collected from BH1 and BH5 for Atterberg Limits (Liquid Limit, Plastic Limit, Plasticity Index, and Linear Shrinkage) testing. Laboratory tests performed on the site foundation soils are summarized in Table 4-5 below. The NATA test certificates are included in Appendix B.

Table 4-5: Summary of Atterberg Limits Testing

Sample Reference	CS10398A	CS10398E
Borehole & Depth Interval	BH1 (1.0m-1.5m)	BH5 (0.5m-1.0m)
Material Description	Silty Clayey SAND	Silty Clayey SAND
USCS	CL	CL
Liquid Limit (%)	30	34
Plastic Limit (%)	19	21
Plasticity Index (%)	11	13
Linear Shrinkage (%)	4.0	5.0

5 DISCUSSION & RECOMMENDATIONS

5.1 GEOTECHNICAL PARAMETERS

Table 5-1 shows the estimated geotechnical parameters of the soil/rock 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)	C' (kPa)	Ø' (degrees)	Young's Modulus (MPa)	Poisson's Ratio	K_a	K_o	K_p
Unit 3 & 4: Colluvial Soil & Residual Soil	0.1/0.55m - >3.0/7.0m	19	**25**	5	25	20	0.35	0.40	0.57	2.46

Where,

γ_b	=	in-situ, dry unit weight, in kN/m^3
Cu	=	undrained cohesion, in kPa
C'	=	effective drained cohesion, in kPa
Ø'	=	effective internal friction angle, in degrees
K_a	=	active pressure coefficient
K_0	=	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 5.6 be used as a minimum for retaining wall design.

5.2 SITE CLASSIFICATION

Due to the presence of uncontrolled fill materials exceeding 0.4m 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 natural soils or weathered bedrock 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 and 40mm for the encountered subsurface profile described in Section 4. 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.

Normal moisture conditions are those caused by seasonal and regular climatic effects.

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 and the characteristic ground surface movement estimate of 20mm to 40mm.

For structures founded at existing grade, footings, including thickened sections of slabs forming footings should be founded in colluvial or residual soil below any uncontrolled fill. A depth of ~0.1/0.55m 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 5.7).

Shallow excavations are expected to expose stiff colluvial soils over the foundation, and suitable footings include shallow strip/pad footings foundations in the stiff colluvial soil.

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.
Colluvial and Residual Soils (Medium dense or better)	Unit 3 and 4	0.1m/0.55m See Table 4-2	125 kPa	150 kPa	250kPa	25kPa	15kPa

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 98%StdMDD.

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

5.4 EXCAVATION CONDITIONS & USE OF EXCAVATED MATERIAL

Proposed excavation depths have not been advised. The soils within the upper ~3.0/7.0m are readily diggable by backhoe and medium sized excavator; however, weathered bedrock could be encountered below ~7.0m depth, which may require ripping or rock harmering.

The low/medium plasticity colluvial and residual soils and any weathered bedrock found can be used in controlled fill construction of building platforms, although rock particles should be broken down to <75mm size. Any medium to high plasticity soil, and silty topsoil/alluvial material are not typically used in controlled fill construction, but the topsoil could be used in non-structural applications such as landscaping, while high plasticity clays could be used as a clay capping/lining material.

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.

5.5 STABLE EXCAVATION BATTERS

Temporary site excavations to 1.5m depth can be formed near vertical, although loose topsoil and 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. If steeper temporary cuts are required, reinforced shotcrete stabilization or soldier piles could be considered. 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.

5.6 LOW RETAINING WALLS

Low retaining walls (<3m high) constructed in open excavation, with the gap between the excavation face and the wall backfilled later, can be designed for an earth pressure distribution given by:

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

where,

σ_h is the horizontal earth pressure acting on the back of the wall, in kPa

K is the dimensionless coefficient of earth pressure; this can be assumed to be 0.4 when the top of the wall is unrestrained horizontally, and 0.5 when the top of the wall is restrained (i.e. by building slabs etc.)

γ' is the effective unit weight of the backfill, and can be assumed to be 20kN/m^3 for a lightly compacted soil backfill

h is the height of the backfill, in metres

q is any uniform distributed vertical surcharge acting on the top of the backfill, in kPa

Apart from structural restraints such as floor slabs, resistance to overturning and sliding of retaining walls is provided by frictional and adhesive resistance on the base, and by passive resistance at the toe of the wall. For a natural soil or controlled fill foundation, an ultimate base friction factor (tanδ) of 0.4, base adhesion (c) of 25kPa, and allowable passive earth pressure coefficient Kp=2.5 can be used for calculation of sliding resistance.

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

5.7 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 ~0.1m/0.55m 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 98%StdMDD at about OMC.

- Fill placement and control testing be overviewed and certified by a geotechnical engineer at Level 1 or 2 involvement of AS3798 – 2007 "Guidelines on Earthworks for Commercial & Residential Developments".

5.8 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 98%StdMDD.

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%, when compacted to 98%StdMDD. 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.

5.9 GROUNDWATER CONTROL

Groundwater was not encountered in the boreholes 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.

5.10 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 Batemans Bay 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”.

5.11 EXPOSURE CLASSIFICATION

Section 4.8 of AS3600-2009 “Concrete Structures” provides guidelines for exposure classification for soils. Table 4.8.1 under the above section lists soils above groundwater, with sulfates of <1000ppm as an exposure classification of A1.

5.12 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

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ISRM (1972), "Suggested Methods for Determining the Uniaxial Compressive Strength of Rock Materials and the Point Load Strength Index", Committee on Laboratory Tests - Document No.1, Int. Soc. Rock Mechanics.

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”.

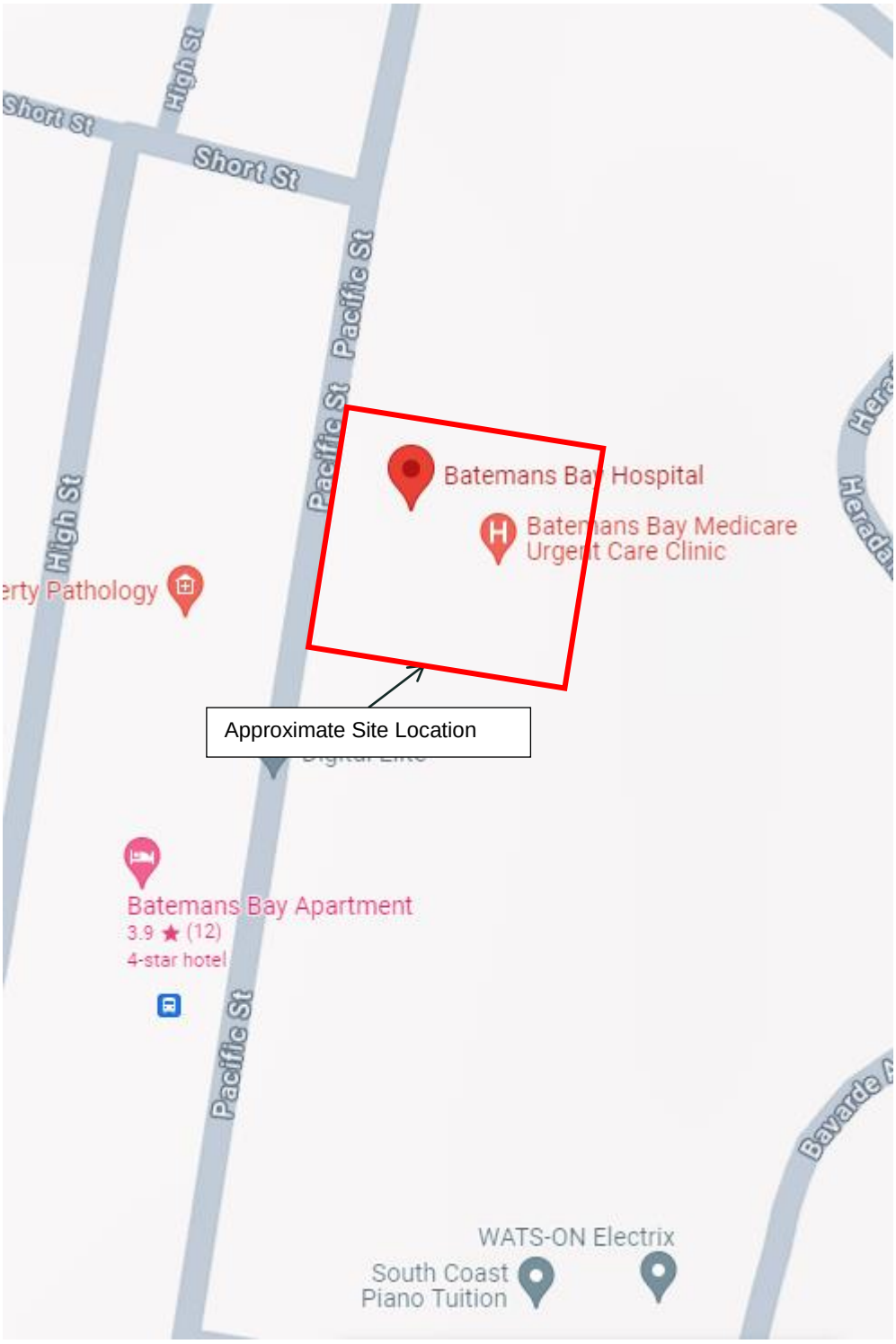
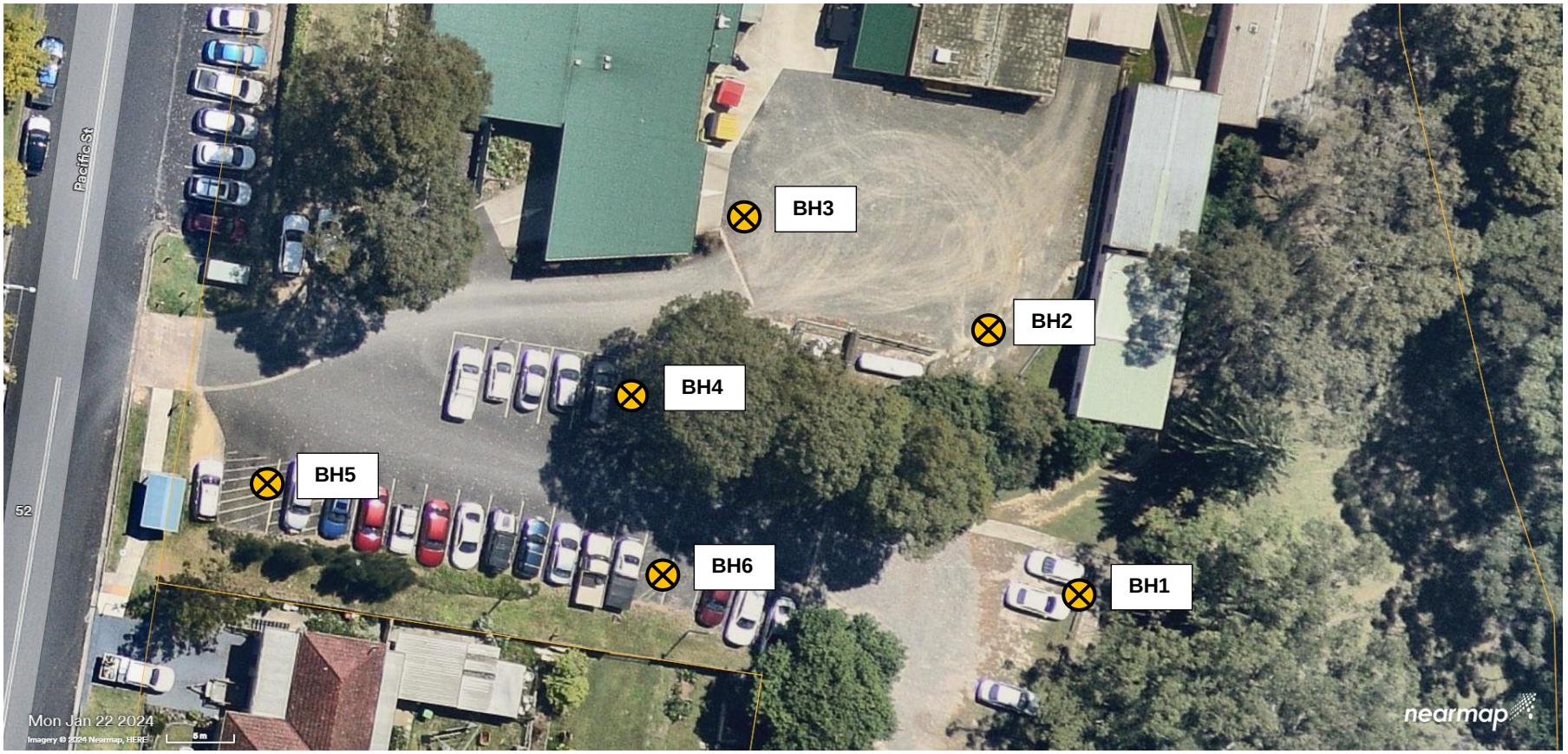


FIGURE 1: SITE LOCALITY	C15142



LEGEND:

Approximate Borehole Location – ⊗

N

FIGURE 2: AERIAL PHOTOGRAPH SHOWING APPROXIMATE BOREHOLE LOCATIONS | C15142

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Appendix A

Borehole Logs BH1 to BH6

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Borehole Log

Borehole No.	**BH01**
Sheet	1 of 1
Job No.	C15142

CLIENT: BD Infrastructure

PROJECT: Batemans Bay Community Health - 7 Pacific Street, Batemans Bay, NSW

Location : Existing Carpark

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Trailer Mounted Rig
Hole Diameter : 200mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
						SM	TOPSOIL; Silty SAND; fine to coarse grained sand, low plasticity silt, brown, trace of grass roots.	D	L		TOPSOIL
				0.15		SW-SM	Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to medium grained, sub-rounded to subangular gravel, brown.	D	MD		COLLUVIAL SOIL
	None Encountered			0.9 1.0		SC=SM	Silty Clayey SAND; fine to coarse grained sand, low plasticity fines, orange-brown. from 1.5m, changes colour to brown	D	MD		
				2 2.0		SC-SM	Silty Clayey SAND; fine to coarse grained sand, low plasticity fines, pale yellow-brown, orange-brown, with fine Extremely Weathered (XW) Sandstone gravel. from 2.5m, changes colour to yellow-brown, more Extremely Weathered (XW) Sandstone gravel.	D	MD-D		
				3 3.0			BOREHOLE TERMINATED AT 3m Target Depth				
				4.0							

Logged By : UK Date : 8/4/24 | Checked By : JM Date : 15/4/24

BOREHOLE/EXCAVATION LOG C15142 GINT.GPJ EXC.GDT 17/4/24

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Borehole Log

Borehole No.	**BH02**
Sheet	1 of 1
Job No.	C15142

CLIENT: BD Infrastructure

PROJECT: Batemans Bay Community Health - 7 Pacific Street, Batemans Bay, NSW

Location : Ambulance Bay

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Trailer Mounted Rig
Hole Diameter : 200mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered			0.1		GW	FILL; DGB20, loose gravel.	D	L		FILL
				0.3		SC	FILL; Clayey SAND; fine to coarse grained sand, low plasticity clay, dark brown.	D	L		
				1.0		SW-SM	Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to medium grained, sub-rounded to subangular gravel, yellow-brown, pale brown.	D	MD		COLLUVIAL SOIL
				1.8		SW-SC	Clayey Gravelly SAND; fine to coarse grained sand, low plasticity clay, fine to coarse grained, extremely weathered shale/sandstone gravel, brown.	D	MD		
				2.0		SW-SM	Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to coarse grained, sub-angular to subrounded gravel, brown.	D	MD		
				2.2		SW-SM	Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to medium grained, sub-rounded gravel, brown.	D	MD		
				3.0			BOREHOLE TERMINATED AT 3m Target Depth				
				4.0							

Logged By : UK Date : 8/4/24 | Checked By : JM Date : 15/4/24

BOREHOLE/EXCAVATION LOG C15142 GINT.GPJ EXC.GDT 17/4/24

Fortify Geotech

FORTIFY GEOTECH

Borehole Log

Borehole No.	**BH03**
Sheet	1 of 1
Job No.	C15142

CLIENT: BD Infrastructure

PROJECT: Batemans Bay Community Health - 7 Pacific Street, Batemans Bay, NSW

Location : Ambulance Bay

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Trailer Mounted Rig
Hole Diameter : 200mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered		0.05			GW	FILL; DGB20, loose gravel.	D	L		FILL
			0.15			SW-SM	FILL; Silty Gravelly SAND; fine to medium grained sand, low plasticity silt, fine to coarse grained, subangular gravel, pink-brown.	D	L		
						SW		D	L		
			0.4			SW-SM	FILL; Gravelly SAND; fine to coarse grained sand, fine to coarse grained, sub-angular gravel, pale brown.	D	MD		COLLUVIAL SOIL
				1.0			Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to coarse grained, sub-rounded to subangular gravel, pale brown.				
			1.5			SC-SM	Silty Clayey SAND; fine to coarse grained sand, low plasticity fines, orange-brown.	D	MD		RESIDUAL SOIL
				2.0			at 2m, trace of roots.				
				3.0			BOREHOLE TERMINATED AT 3m Target Depth				
				4.0							

Logged By : UK Date : 8/4/24 | Checked By : JM Date : 15/4/24

BOREHOLE/EXCAVATION LOG C15142 GINT.GPJ EXC.GDT 17/4/24

FORTIFY GEOTECH

Borehole Log

Borehole No.	**BH04**
Sheet	1 of 2
Job No.	C15142

CLIENT: BD Infrastructure

PROJECT: Batemans Bay Community Health - 7 Pacific Street, Batemans Bay, NSW

Location : Existing Carpark

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Trailer Mounted Rig
Hole Diameter : 200mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
			0.1				ASPHALT	D	L		ASPHALT
	None Encountered			1.0		SW-SM	Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to medium grained, sub-rounded to subangular gravel, pale brown.	D	MD		COLLUVIAL SOIL
				2.0							
				3.0							
			4.0								

Logged By : UK Date : 8/4/24 | Checked By : JM Date : 15/4/24

BOREHOLE/EXCAVATION LOG C15142 GINT.GPJ EXC.GDT 17/4/24

FORTIFY GEOTECH

Borehole Log

Borehole No.	**BH04**
Sheet	2 of 2
Job No.	C15142

CLIENT: BD Infrastructure

PROJECT: Batemans Bay Community Health - 7 Pacific Street, Batemans Bay, NSW

Location : Existing Carpark

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Trailer Mounted Rig
Hole Diameter : 200mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered			5.0		SW-SM	Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to medium grained, sub-rounded to subangular gravel, pale brown. from 4.0m, colour change to orange-pink-brown, with fine to coarse grained, subangular to sub-rounded sandstone gravel.	D	MD-D		COLLUVIAL SOIL
				6.0							
				7 7.0			BOREHOLE TERMINATED AT 7m Target Depth				
				8.0							

Logged By : UK Date : 8/4/24 | Checked By : JM Date : 15/4/24

BOREHOLE/EXCAVATION LOG C15142 GINT.GPJ EXC.GDT 17/4/24

FORTIFY GEOTECH

Borehole Log

Borehole No.	**BH05**
Sheet	1 of 1
Job No.	C15142

CLIENT: BD Infrastructure

PROJECT: Batemans Bay Community Health - 7 Pacific Street, Batemans Bay, NSW

Location : Existing Carpark

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Trailer Mounted Rig
Hole Diameter : 200mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
	None Encountered			0.1			ASPHALT	D	L		ASPHALT
				0.2		GW	FILL; Sandy GRAVEL; fine to coarse grained, sub-angular to sub-rounded gravel, fine to coarse grained sand, pink brown.	D	L		FILL
						SW-SM	Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to medium grained, sub-rounded to subangular gravel, yellow-brown.	D	MD		COLLUVIAL SOIL
				1.0			from 1.1m, colour changes to orange-brown.				
				2.0			from 2.5m, fine to coarse grained, sandstone gravel.		MD-D		
				3.0			BOREHOLE TERMINATED AT 3m Target Depth				
				4.0							

Logged By : UK Date : 8/4/24 | Checked By : JM Date : 15/4/24

BOREHOLE/EXCAVATION LOG C15142 GINT.GPJ EXC.GDT 17/4/24

FORTIFY GEOTECH

Borehole Log

Borehole No.	**BH06**
Sheet	1 of 1
Job No.	C15142

CLIENT: BD Infrastructure

PROJECT: Batemans Bay Community Health - 7 Pacific Street, Batemans Bay, NSW

Location : Existing Carpark

Collar Level : Not Known
Angle From Vertical : 0°
Bearing : N.A.

Equipment Type : Trailer Mounted Rig
Hole Diameter : 200mm

Sample No.	Water	Method/ Casing	RL (m)	Depth (m)	Graphic Log	U.S.C.S.	Material Description, Structure Soil Type: Plasticity or Particle Characteristics, Colour, Secondary and Minor Components, Moisture, Structure	Moisture Condition	Consistency or Relative Density	Field Test Results	Geological Profile
			0.1				ASPHALT	D			ASPHALT
						SW	FILL; Gravelly SAND; fine to coarse grained sand, fine to coarse grained, sub-angular gravel, pink-brown.	D	L		FILL
	None Encountered		0.55			SW-SM	Silty Gravelly SAND; fine to coarse grained sand, low plasticity silt, fine to medium grained, sub-rounded to subangular gravel, yellow-brown.	D	MD		COLLUVIAL SOIL
				1.0							
				2.0			from 2.5m, colour changes to orange-brown, fine to coarse grained, sub-angular to sub-rounded sandstone gravel.		MD-D		
				3.0			BOREHOLE TERMINATED AT 3m Target Depth				
				4.0							

Logged By : UK Date : 8/4/24 | Checked By : JM Date : 15/4/24

BOREHOLE/EXCAVATION LOG C15142 GINT.GPJ EXC.GDT 17/4/24

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Appendix B

NATA Laboratory Test Certificates

Material Test Report

J & A Geotech Testing Pty Ltd

Canberra Laboratory
Unit 2, 25 Dacre Street Mitchell ACT 2911
Phone: (02) 6255 5363
Email: scott.miller@jageotech.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Scott Miller
Lab Manager

NATA Accredited Laboratory Number: 19979

Report Number:	**CP241893-1A**
Issue Number:	1
Date Issued:	06/05/2024
Client:	Fortify Geotech Pty Ltd
	39 Sydenham Rd, Marrickville NSW 2204
Contact:	Jeremy Murray & Allison Baillie
Project Number:	CP241893
Project Name:	Proposed Batemans Bay Hospital Redevelopment
Project Location:	Batemans Bay NSW
Work Request:	10398
Sample Number:	CS10398A
Date Sampled:	15/04/2024
Dates Tested:	16/04/2024 - 18/04/2024
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Site Selection:	Selected by Client
Sample Location:	**BH1, Depth: 1.0m-1.5m**

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	30		
Plastic Limit (%)	19		
Plasticity Index (%)	**11**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**4.0**		
Cracking Crumbling Curling	Cracking		

This document shall not be reproduced except in full without approval of the laboratory.
Results relate only to the items tested/sampled.

Material Test Report

J & A Geotech Testing Pty Ltd

Canberra Laboratory
Unit 2, 25 Dacre Street Mitchell ACT 2911
Phone: (02) 6255 5363
Email: scott.miller@jageotech.com.au

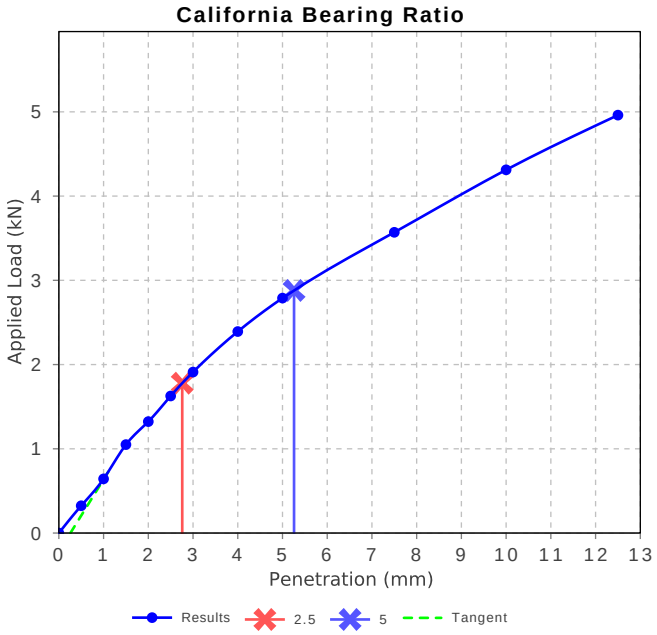
Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Scott Miller
Lab Manager

NATA Accredited Laboratory Number: 19979

Report Number:	**CP241893-1A**
Issue Number:	1
Date Issued:	06/05/2024
Client:	Fortify Geotech Pty Ltd
	39 Sydenham Rd, Marrickville NSW 2204
Contact:	Jeremy Murray & Allison Baillie
Project Number:	CP241893
Project Name:	Proposed Batemans Bay Hospital Redevelopment
Project Location:	Batemans Bay NSW
Work Request:	10398
Sample Number:	CS10398B
Date Sampled:	15/04/2024
Dates Tested:	16/04/2024 - 23/04/2024
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Site Selection:	Selected by Client
Sample Location:	**BH2, Depth: 0.5m-1.0m**

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**15**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	2.02		
Optimum Moisture Content (%)	10.5		
Laboratory Density Ratio (%)	98.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.97		
Field Moisture Content (%)	5.9		
Moisture Content at Placement (%)	10.5		
Moisture Content Top 30mm (%)	14.3		
Moisture Content Rest of Sample (%)	12.0		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	2.1		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	1.6		



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Material Test Report

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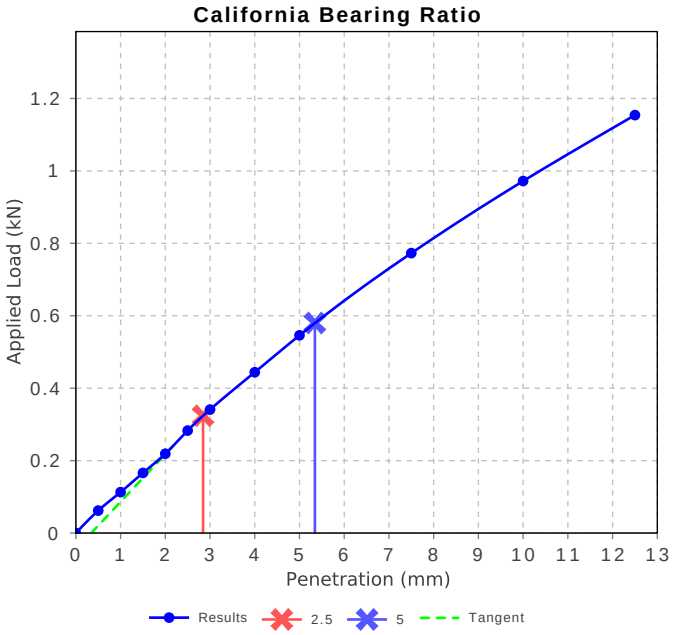
Approved Signatory: Scott Miller
Lab Manager
NATA Accredited Laboratory Number: 19979

Report Number:	**CP241893-1A**
Issue Number:	1
Date Issued:	06/05/2024
Client:	Fortify Geotech Pty Ltd
	39 Sydenham Rd, Marrickville NSW 2204
Contact:	Jeremy Murray & Allison Baillie
Project Number:	CP241893
Project Name:	Proposed Batemans Bay Hospital Redevelopment
Project Location:	Batemans Bay NSW
Work Request:	10398
Sample Number:	CS10398D
Date Sampled:	15/04/2024
Dates Tested:	16/04/2024 - 23/04/2024
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Site Selection:	Selected by Client
Sample Location:	**BH4, Depth: 0.5m-1.0m**

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**3.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	1.77		
Optimum Moisture Content (%)	14.5		
Laboratory Density Ratio (%)	97.5		
Laboratory Moisture Ratio (%)	99.5		
Dry Density after Soaking (t/m^3)	1.68		
Field Moisture Content (%)	9.2		
Moisture Content at Placement (%)	14.7		
Moisture Content Top 30mm (%)	24.6		
Moisture Content Rest of Sample (%)	20.8		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	2.1		
Swell (%)	2.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



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Material Test Report

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Approved Signatory: Scott Miller
Lab Manager

NATA Accredited Laboratory Number: 19979

Report Number:	**CP241893-1A**
Issue Number:	1
Date Issued:	06/05/2024
Client:	Fortify Geotech Pty Ltd
	39 Sydenham Rd, Marrickville NSW 2204
Contact:	Jeremy Murray & Allison Baillie
Project Number:	CP241893
Project Name:	Proposed Batemans Bay Hospital Redevelopment
Project Location:	Batemans Bay NSW
Work Request:	10398
Sample Number:	CS10398E
Date Sampled:	15/04/2024
Dates Tested:	16/04/2024 - 18/04/2024
Sampling Method:	Sampled by Client
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and Preparation of Soils
Site Selection:	Selected by Client
Sample Location:	**BH5, Depth: 0.5m-1.0m**

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	34		
Plastic Limit (%)	21		
Plasticity Index (%)	**13**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**5.0**		
Cracking Crumbling Curling	Cracking		

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Results relate only to the items tested/sampled.

SYDNEY ANALYTICAL LABORATORIES

Office:
PO BOX 48
ERMINGTON NSW 2115

Laboratory:
1/4 ABBOTT ROAD
SEVEN HILLS NSW 2147
Telephone: (02) 9838 8903
Fax: (02) 9838 8919
A.C.N. 003 614 695
A.B.N. 81 829 182 852
NATA No: 1884

ANALYTICAL REPORT for:

J&A GEOTECH TESTING

2/25 DACE STREET
MITCHELL ACT 2911

ATTN: JUSTIN SMITH

JOB NO: SAL28854B

CLIENT ORDER: CP241893

DATE RECEIVED: 22/04/24

DATE COMPLETED: 06/05/24

TYPE OF SAMPLES: AGGREGATES

NO OF SAMPLES: 4

NATA Accredited for compliance with ISO/IEC 17025 Testing

.....
Issued on 06/05/24
Lance Smith
(Chief Chemist)

ANALYTICAL REPORT

JOB NO: SAL28854B
CLIENT ORDER: CP241893

	SAMPLES	SO4 % as SO3
1	BH1/1.0-1.5m	0.007
2	BH2/1.0-1.5m	0.003
3	BH5/1.0-1.5m	<0.001
4	BH6/0.5-1.0m	0.021

MDL	0.001
Method Code	C34
Preparation	P5

RESULTS ON DRY BASIS, WR10399
CLIENT: FORTIFY GEOTECH PTY LTD
PROJECT: PROPOSED BATEMANS BAY HOSPITAL REDEVELOPMENT
DATE OF COLLECTION: 15/04/24

ANALYTICAL REPORT

JOB NO: SAL28854B
CLIENT ORDER: CP241893

METHODS OF PREPARATION AND ANALYSIS

The tests contained in this report have been carried out on the samples as received by the laboratory. In the case where an analyte or group of analytes are received outside of recommended holding times, the analysis will proceed and the report annotated. Analysis is carried out within analyte holding times where possible.

P5	Sample dried, split and crushed to -150um
C34	Acid Soluble Sulphate - RMS T219

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Appendix C

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 observes 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 such 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≈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≈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 - ≤25	Can be moulded by light finger pressure.	Loose (L)	>15 - ≤35
Firm (F)	>25 - ≤50	Can be moulded by strong finger pressure.	Medium Dense (MD)	>35 - ≤65
Stiff (St)	>50 - ≤100	Cannot be moulded by fingers.	Dense (D)	>65 - ≤85
Very Stiff (VSt)	>100 - ≤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.

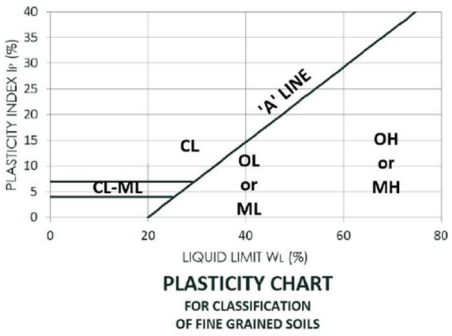
The “N” value is determined as the number of blows to achieve 300mm of penetration (generally after disregarding the first 150mm penetration through possibly disturbed material). The results of these tests can be related empirically to the engineering properties of the soil.

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.

FORTIFY GEOTECH

Unified Soil Classification System (Metricated)
Data for Description Identification and Classification of Soils

MAJOR DIVISIONS			DESCRPTION				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	More than 65% by dry mass, less than 63mm is greater than 0.075mm.	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. 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 63mm 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	Use the gradation curve of material passing 63mm for classification of fractions according to criteria for major component.	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	
		GRAVELLY SOILS	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			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	
		SANDY SOILS	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	More than 35% by dry mass, less than 63mm is less than 0.075mm.	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: (Cl) 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 63mm is smaller than 0.075mm.	SILT AND CLAY FRACTION Fraction smaller than 0.2 mm AS sieve size												
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			DRY STRENGTH	DILANTANCY	TOUGHNESS		ML		More than 35% of material is less than 63mm passing 0.075mm.	Below 'A' line		
			OL		Organic silts and organic silty clays of low plasticity			None to low	Slow to rapid	Low		CL, CI			Above 'A' line		
		Liquid Limit more than 50%.	MH		Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			Medium to high	None to slow	Medium		OL			Below 'A' line		
			CH		Inorganic clays of high plasticity, fat clays			Low to medium	Slow	Low		MH			Below 'A' line		
			OH		Organic clays of medium to high plasticity			Low to medium	None to slow	Low to medium		CH			Above 'A' line		
								High to very high	None	High		OH			Below 'A' line		
			Pt		Peat muck and other highly organic soils			High to high	None to very slow	Low to medium		PT			* Effervescence with H_2O_2		



PLASTICITY CHART
FOR CLASSIFICATION
OF FINE GRAINED SOILS

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 (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 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 an 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, cuved 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.		

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