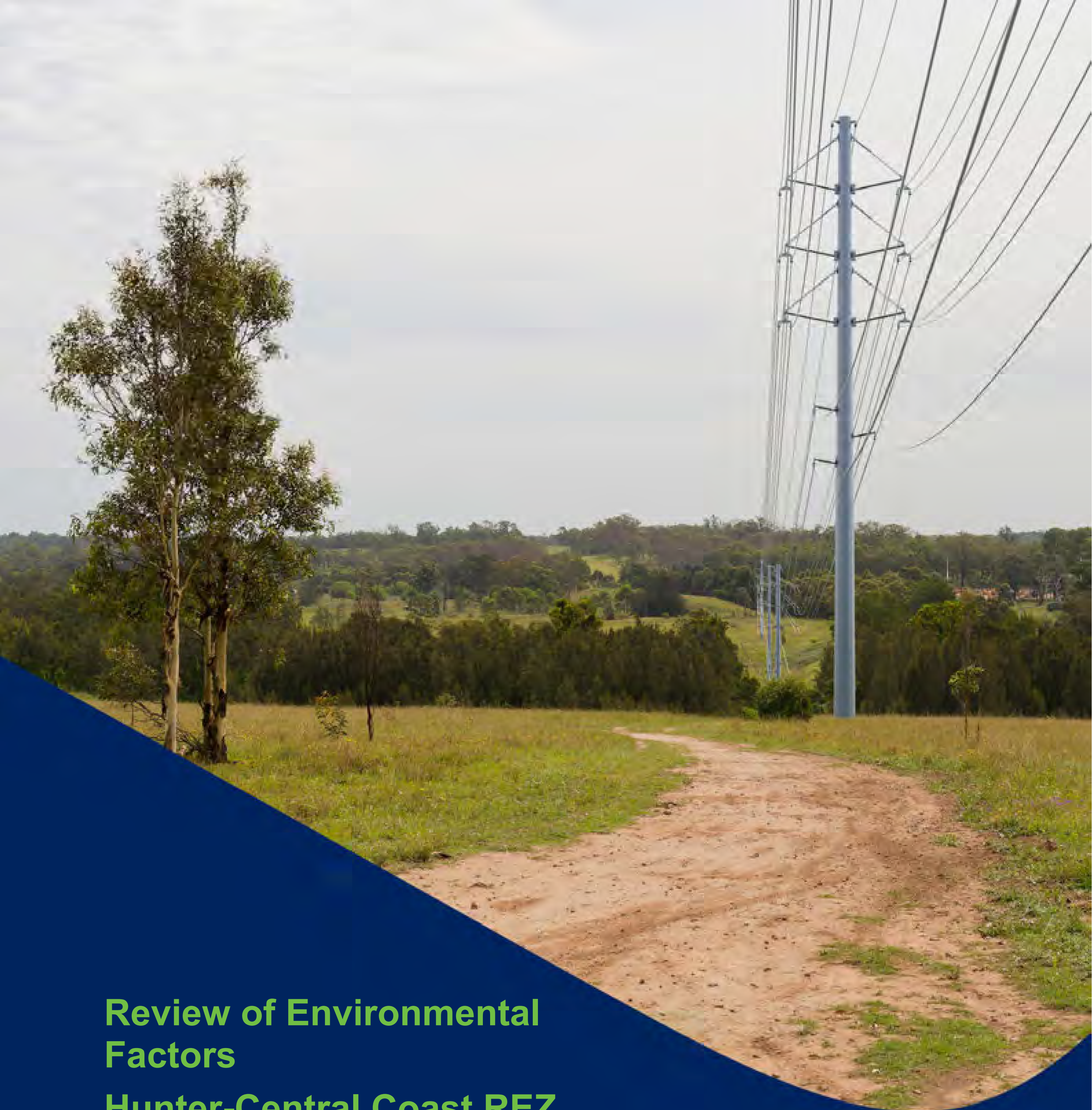

Review of Environmental Factors

Hunter-Central Coast REZ Network Infrastructure

Appendix G - Geotechnical Investigations

Wired for good.

Ausgrid

Douglas Partners
GROUNDED EXPERTISE

Report on Geotechnical Investigation

Hunter Pole Replacement Program

Hebdon Road, Muswellbrook NSW

Prepared for Ausgrid

Project 226603.00

21 August 2024

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

Signature		Date
Author		21 August 2024
Reviewer		21 August 2024

Table of Contents

Report on Geotechnical Investigation
Hunter Pole Replacement Program
Hebdon Road, Muswellbrook NSW

1. Introduction

This report presents the results of a geotechnical investigation undertaken for Hunter pole replacement program at Hebdon Road, Muswellbrook NSW. The investigation was commissioned in a purchase order form Ausgrid PO 4501072672 and was undertaken in accordance with Douglas' proposal 226603.00.Rev1 dated 1 December 2024.

It is understood that the proposed development includes replacement of a number of existing timber transmission poles along the alignment.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to provide:

- A summary of investigation methods (eg subsurface strata, groundwater, rock levels, etc.);
- Borehole logs or cone penetration test plots as well as test location plan;
- Summarised subsurface conditions, noting rock and groundwater depths, if encountered;
- Geotechnical parameters for soil units, including density, friction angle and cohesion and lateral bearing pressure / modulus of subgrade reaction;
- Estimate of unconfined compressive strength of rock, where appropriate; and
- Observation of possible areas of contamination and recommendations for laboratory testing.

The investigation included the drilling of boreholes, cone penetration testing and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the items listed above.

2. Site Description

The transmission alignment extends from Kurri Kurri to Muswellbrook (refer Figure 1).

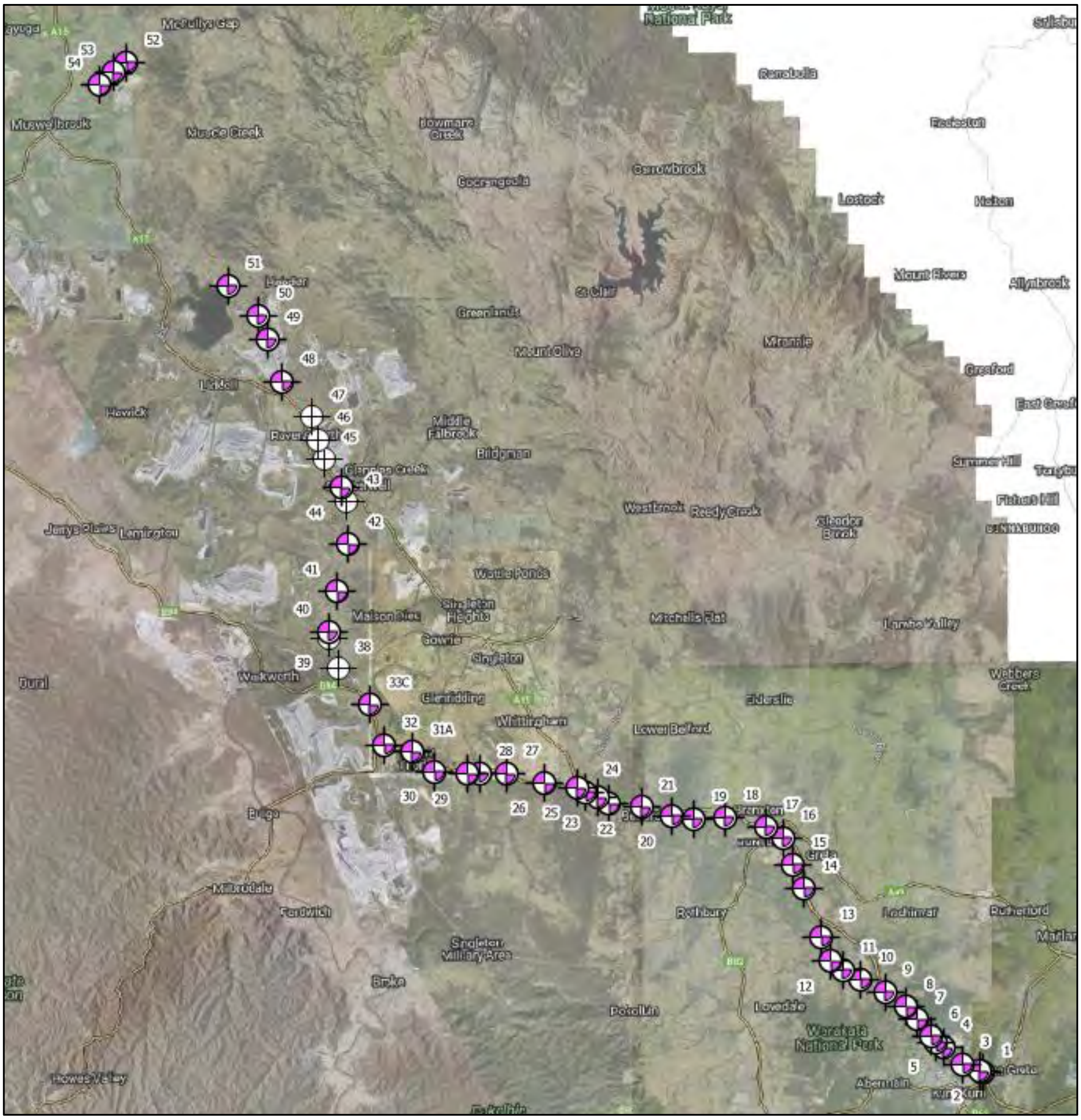

Figure 1: Approximate extent of alignment (with bore and CPT locations)

The alignment is generally described as follows:

- Near Main Road, Kurri Kurri to near old Maitland Road, Sawyers Gully (Bores 1 to 9) – generally follows the New England Highway and is mostly within or in close proximity to the road reserve. Bore locations are generally either within grassed areas or cleared easements within forested areas;
- Near old Maitland Road, Sawyers Gully to Lovedale Road, Allandale (Bores 10 to 13) – generally within an existing cleared easement through rural property;

- Lovedale Road, Allandale to Golden Highway (Bores 14 to 24) - generally follows the New England Highway and to the south or west of the road reserve Bore locations are generally either within grassed areas or cleared easements within forested areas;

- Golden Highway to Putty Road, Mount Thorley (Bores 25 to 30) – generally follows the Golden Highway, and is within or in close proximity to the road reserve. The majority of the bores are within cleared paddocks.

- Putty Road to Jerrys Plains Road, Mount Thorley (Bores 31a and 32) – either within the road reserve, near an existing creek crossing (Bore 31a) or within a vegetated area within the intersection of Putty Road and Jerrys Plains Road;

- Jerrys Plains Road (Bore 33c) – on the eastern side of Jerrys Plains Road, in a cleared paddock;

- Jerrys Plains Road to New England Highway, Camberwell (Bore 40, 41, 42 and 44, and CPTs 38, 39 and 43) – through cleared paddocks with several locations near existing creeklines;

- New England Highway, Camberwell to New England Highway, Ravensworth (CPTs 45 to 47) – within cleared paddocks on the eastern side of the New England Highway, and in proximity to existing creeklines;

- New England Highway, Ravensworth to Hebden Road, Hebden (Bores 48 to 51) – generally within mine land which has possibly been disturbed by mining activities. Bore 51 is north of Lake Lidell in a cleared paddock;

- Muswellbrook (Bores 52 to 54) – located north-west of Muswellbrook Coal mine and south-west of the existing Muswellbrook substation, generally within a cleared easement in lightly forested areas.

3. Published Data

3.1 Acid Sulfate Soil Mapping

A review of acid sulfate mapping indicate that all towers are in areas mapped as having no known occurrence of acid sulfate soils.

3.2 Geology Mapping

The NSW Geology Mapping, overlayed by the borehole locations are presented in Figure 2 below. A summary of this information is also provided in Table 1 below.

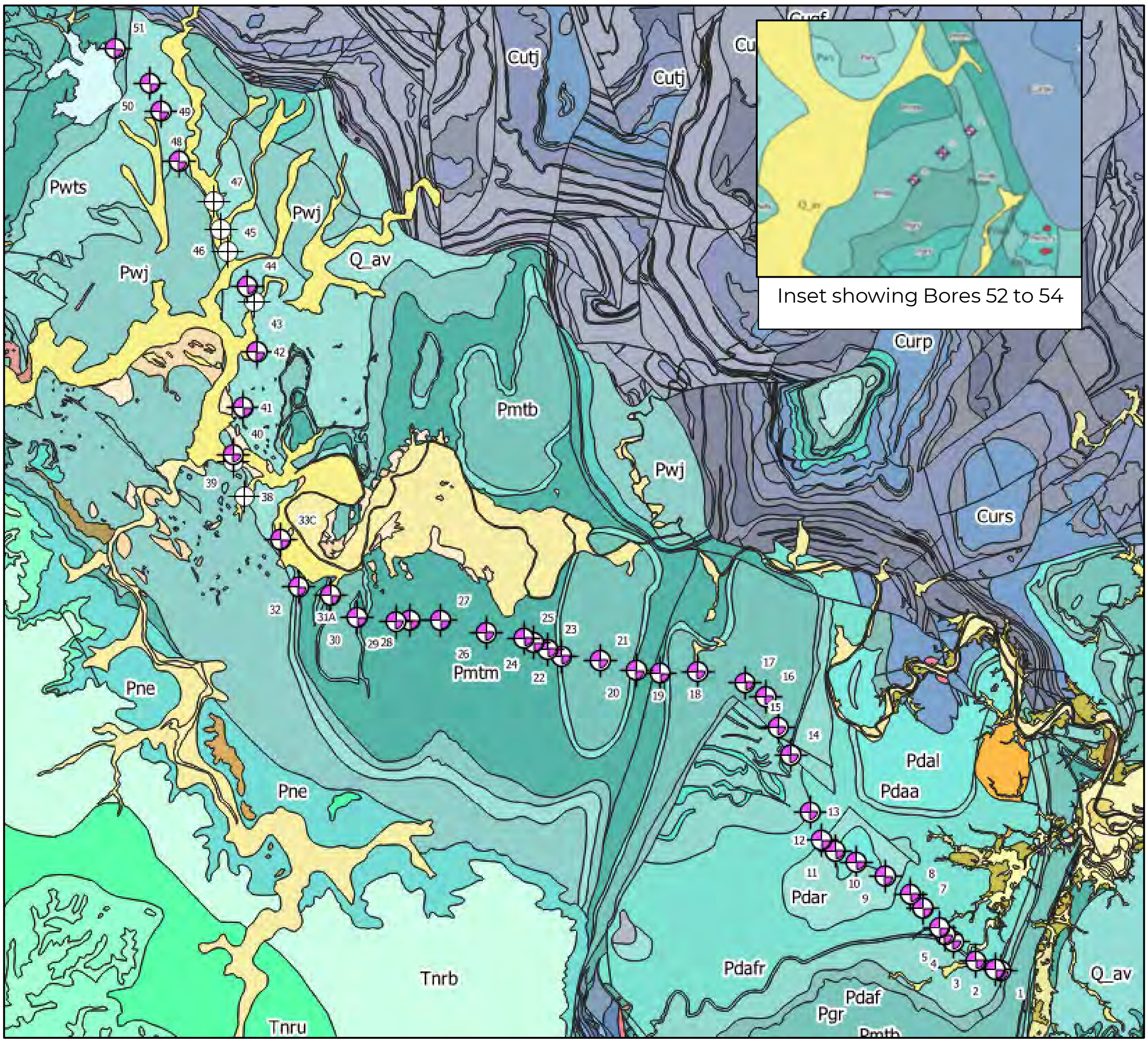

Figure 2: Mapped geology along alignment

Table 1: Summary of Brief Desktop Review

Pole Location	Geology Code	Geological Name	Soil Landscape Group
1	Pdaf	Farley Formation	Neath
2	Pdar	Farley Formation	Neath
3	Pdar	Rutherford Formation	Neath
4	Pdar	Rutherford Formation	Neath
5	Pdar	Rutherford Formation	Neath
6	Pdar / Q_av	Rutherford Formation (near Alluvial valley deposits)	Neath
7	Pdar	Rutherford Formation	Branxton
8	Pdar	Rutherford Formation	Branxton
9	Pdaa	Allandale Formation	Branxton
10	Pdal / Pdaa	Lochinvar Formation (near Allandale Formation)	Branxton
11	Pdal	Lochinvar Formation	Rothbury
12	Pdar / Pdaa	Rutherford Formation (near Allandale Formation)	Branxton
13	Pdar / Pdaf	Rutherford Formation (near Farley Formation)	Rothbury
14	Pdaf	Farley Formation	Branxton
15	Pmtb	Branxton Formation	Branxton
16	Pmtb	Branxton Formation	Branxton
17	Pmtb	Branxton Formation	Branxton
18	Pmtb / Q_a	Branxton Formation (near Quaternary alluvium)	Branxton
19	Pmtm	Mulbring Siltstone	Rothbury
20	Pmtm / Pmtu	Mulbring Siltstone (near Muree Siltstone)	Rothbury
21	Pmtb	Branxton Formation	Branxton
22	Pmtb / Pmtu	Branxton Formation (near Muree Siltstone)	Rothbury
23	Pmtm	Mulbring Siltstone	Branxton
24	Pmtm	Mulbring Siltstone	Branxton
25	Pmtm	Mulbring Siltstone	Rothbury
26	Pmtm	Mulbring Siltstone	Hunter
27	Pmtm	Mulbring Siltstone	Rothbury
28	Pmtm	Mulbring Siltstone	Branxton
29	Pmtm	Mulbring Siltstone	Rothbury
30	Pmtm / Pmtu	Mulbring Siltstone (near Muree Siltstone)	Rothbury
31a	Pmtb	Branxton Formation	Branxton
32	Pwts	Saltwater Creek Formation	Branxton
33c	Pwv / Q_av	Vane Subgroup (near Alluvial valley deposits)	Hunter
38	Q_av	Alluvial valley deposits	Branxton

Table 1: Summary of Brief Desktop Review (continued)

Pole Location	Geology Code	Geological Name	Soil Landscape Group
39	Q_av / Pwj	Alluvial valley deposits (near Jerrys Plains Subgroup)	Hunter
40	Q_av	Alluvial valley deposits	Hunter
41	Pwv	Vane Subgroup	Roxburgh
42	Pwv	Vane Subgroup	Roxburgh
43	Q_av	Alluvial valley deposits	Hunter
44	Pwv	Vane Subgroup	Bayswater
45	Q_av	Alluvial valley deposits	Hunter
46	Q_av	Alluvial valley deposits	Hunter
47	Q_av	Alluvial valley deposits	Hunter
48	Pwj	Jerrys Plains Subgroup	Lidell
49	Pwv	Vane Subgroup	Lidell
50	Pwv	Vane Subgroup	Lidell
51	Pwts	Saltwater Creek Formation	Lidell
52	Pmtb	Branxton Formation	Roxburgh
53	Pmtb	Branxton Formation	Roxburgh
54	Pgrr / Pmtb	Rowan Formation (near Branxton Formation)	Roxburgh

Notes to table: Where bores are mapped as being underlain by alluvium or in close proximity to alluvium they have been shaded as per alluvium

The mapped geological units are characterised as follows:

Neath	micaceous sandy siltstone, silty sandstone, mudstone and shale, sporadic thin limestone.
Rutherford Formation	siltstone, marl and minor sandstone.
Allandale Formation	conglomerate, lithic sandstone.
Lochinvar Formation	basalt, siltstone and sandstone.
Branxton Formation	conglomerate, sandstone and siltstone.
Saltwater Creek Formation	quartz-lithic sandstone, siltstone, tuffaceous claystone, thin coal piles.
Vane Subgroup	quart-lithic sandstone, laminated siltstone, carbonaceous claystone, tuffaceous claystone and mudstone, paraconglomerate, coal seams.
Jerrys Plains Subgroup	sandstone, lithic sandstone, mudstone, coal, carbonaceous claystone, siltstone and paraconglomerate.
Rowan Formation	sandstone, siltstone, claystone, coal and minor conglomerate.
Quaternary Alluvium	silty clay, lithic silt, quartz rich sand, gravel, sporadic palaeosol.

The mapped soil landscape groups are noted as having the following limitations:

Neath	Undulating low rises and swamps, local relief is under 30 m, slopes up to 3%. Characteristics include very poorly drained, high flood hazard, low to moderate soil salinity, low to high erodibility, very high erosion hazard and nil mass movement hazard.
Branxton	Undulating rises to low hills and creek flats, slopes from 3 to 5%, local relief is 10 m to 40 m. Characteristics include imperfectly to moderately well drained, low flood hazard, low to high soil salinity, low to high erodibility, high erosion hazard and nil mass movement hazard.
Rothbury	Undulating low hills and undulating hills, slopes are 0 to 10%, local relief is 60 m to 120 m. Characteristics include hardsetting, low flood hazard, low soil salinity, low to moderate erodibility, high to very high erosion hazard and low mass movement hazard.
Hunter	Level plains and river terraces, slope are 0 to 3%, local relief is generally less than 10 m. Characteristics include imperfectly to moderately well drained, moderate flood hazard, low to moderate salinity, low to moderate erodibility, moderate to high erosion hazard and nil mass movement hazard.
Roxburgh	Undulating low hills, slopes are 0 to 10%, local relief is 60 m to 120 m. Characteristics include hardsetting, imperfectly to moderately well drained, low flood hazard, low soil salinity, low to moderate erodibility, moderate to very high erosion hazard and low mass movement hazard.
Bayswater	Undulating low hills, slopes are 3 to 10%, local relief is 40 m to 60 m. Characteristics include hardsetting, poorly to well drained, low to moderate flood hazard, low to high salinity, moderate to high erodibility, moderate to extreme erosion hazard and low mass movement hazard.
Lidell	Undulating low hills, slopes are 4 – 7%, local relief is 60 m to 120 m. Characteristics include hardsetting, low to moderate flood hazard, high soil salinity, moderate to high erodibility, high to very high erosion hazard, low mass movement hazard.

4. Field Work

4.1 Field Work Methods

The field work was undertaken during the period extending from 21 December 2023 to 17 July 2024 and consisted of intrusive drilling investigation by a combination of test bores drilled using a truck or track mounted drilling rig and cone penetration test (CPT), as summarised in Table 2.

Table 2: Summary of Investigation Methods

Investigation Method	Locations
Cone Penetration Testing (CPT)	38, 39, 43, 45, 46 and 47
Bores	1 to 30, 31a, 32, 33c, 40 to 42, 44, 48 to 54

Bores

The intrusive drilling investigation comprised the drilling of forty-four (44) boreholes. The bores were drilled to depths ranging from 1.4 m to 7.6 m.

The bores were drilled by either a track or truck mounted drilling rig using a combination of continuous flight augers, wash boring methods and NMLC diamond tipped coring equipment. Coring of the encountered bedrock was undertaken in some bores where shallow bedrock was encountered, after consultation with Ausgrid representatives.

The subsurface conditions encountered at the test locations were logged by a geotechnical engineer from Douglas, who also retrieved regular samples for identification and laboratory testing purposes. Pocket penetrometer testing was undertaken on soil samples at selected depths and locations. Standard penetration testing was undertaken in soils and Point Load Strength Index ($I_{s(50)}$) tests were undertaken on recovered rock core.

Groundwater observations during auger drilling were noted on the bore logs. Where coring or wash boring was undertaken, drilling fluids prevented groundwater observations.

Cone Penetration Testing

A number of the locations which were mapped as being within an alluvial soil profile were undertaken on 20 December 2023 and 21 December 2023 using cone penetration tests (CPT) methods. The CPTs were taken to depths ranging from 3.26 m to 10.1 m. CPT involves pushing a truck-mounted instrumented cone and friction sleeve assembly, of about 35 mm diameter, into the ground. A computerised data acquisition system records continuous data on soil type and strength.

General

The bores and CPTs were drilled/undertaken at pole locations as nominated by the client. The bore/CPT positions, undertaken away from existing services, were marked in the field by Douglas using a differential GPS that is generally accurate to about ± 0.1 m. The coordinates are shown on the borehole logs and CPT plots.

The bore and CPT locations with respect to the corresponding structure number are presented in Table 2 in Section 4.2.

The test locations are shown on Drawings 1 to 37 in Appendix D. Key drawings (Drawings K1 to K4) are also included in Appendix D, which shows the location of the individual drawings relative to each other.

4.2 Results

Details of the conditions encountered in the boreholes are given in the log sheets which are included in Appendix B. These logs should be read in conjunction with the explanatory notes, which define the descriptive terms and classification methods.

The CPT plots are attached in Appendix B and should be read in conjunction with the preceding notes which explain the descriptive terms and classification methods.

The subsurface conditions encountered at the test locations have been broadly characterised into geotechnical units as follows:

- Fill — Near surface fill was encountered at a number of locations and was generally less than 1 m in depth, and consisted of clay or silty soils. Some areas of gravel fill were also encountered. Areas of deeper fill, up to 2 m were encountered at some locations.
- Topsoil — Generally sandy silt and clayey silt topsoil was encountered in a number of locations, and was generally less than 0.3 m depth.
- Alluvial Sand — Generally medium dense to dense, although some zones of loose and very dense. Some near surface cemented sand layers were also encountered at some locations.
- Alluvial Clay — Generally very stiff to hard (occasionally stiff) clay, sandy clay or silty clay in limited locations.
- Residual Clay — Very stiff to hard silty clay, sandy clay, clay and gravelly clay with varying proportions of gravel and sand. Occasionally, stiff to very stiff layers were encountered.
- Residual Soil (extremely weathered bedrock) — Generally characterised by hard clay or sandy clay, which has been weathered from the underlying bedrock but has strength consistent with soil.
- Bedrock — Typically coal measures sedimentary rock consisting of coal, sandstone, siltstone and claystone but volcanics (basalt) was also encountered at Bores BH10 and BH11 associated with the Lochinvar Formation. Where coring was not undertaken the strength of the bedrock was estimated from resistance to the auger string. Where penetration using a TC bit was achievable the rock is likely to be of very low to low strength, although this cannot be confirmed without retrieval of rock core. Within the bores which were continued using coring techniques, the rock strength ranged from very low to very high. Reference should be made to the logs for each location for more detail.

A summary of the subsurface conditions encountered during the investigation is presented in Table 3.

Table 3: Summary of Subsurface Conditions

Borehole Number / Structure Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Easting		359452	359162	358181	356953	356511	356228	355348	354670	353315	351791	350659	349938	349314	348261	347589
Northing		6369180	6369316	6369733	6370773	6371102	6371481	6372522	6373322	6374258	6375028	6375603	6376180	6377696	6380727	6382209
Surface Elevation (AHD)		16.6	14.6	17.5	14.2	31.0	16.9	55.3	32.5	57.0	58.8	103.9	91.7	131.3	76.8	58.4
Mapped Geology		Pdaf	Pdafr	Pdar	Pdar	Pdar	Q_av	Pdar	Pdar	Pdaa	Pdal	Pdal	Pdar	Pdar	Pdaf	Pmtb
Interpreted Alluvial / Residual		Res	Res	Res	Res	Res	Res	Res	Res	Res	Res	Res	Res	Res	Res	Alv
Unit	Material type	Depth Range (m)														
Unsuitable Soils	Topsoil	-	-	-	0.0 – 0.1	-	-	-	-	-	0.0 - 0.2	-	0.0 - 0.2	-	-	-
	Colluvial Clay	-	-	-	-	-	-	-	-	0.0 - 0.2	-	-	-	-	-	-
Special Soils (Cu<25kPa)	FILL	0.0 - 0.2	0.0 - 1.5	0.0 - 0.5	-	0.0 - 1.3	0.0 - 1.3	-	0.0 - 0.4	-	-	0.0 - 0.6	-	0.0 - 0.2	-	-
Very Poor Soils (25kPa<Cu<50kPa)	Alluvial Sand or Colluvial Sand	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0 - 3.5
Poor Soils (50kPa<Cu<100kPa)	Stiff alluvial clay or stiff residual clay	0.2 - 1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Normal Soils (Cu>100kpa)	Very stiff to hard residual Clay (some layers of silty sand) or very stiff to hard alluvial clay	1.2 - 5.11	1.5 - 5.0	0.5 - 5.3	0.1 - 5.90	1.3 - 3.0	1.3 - 5.0	0.0 - 0.5	0.4 - 4.0	0.2 - 5.0	0.2 - 0.5	-	0.2 - 2.5	0.2 - 1.8	0.0 - 6.0	-
	Clay Sandy Clay (extremely weathered bedrock)	-	-	-	-	-	-	-	4.0 - 4.4	-	0.5 - 1.0	-	-	-	-	3.5 - 3.8
	Clayey Gravelly Sand or Silty Sand (extremely weathered rock)	-	-	-	-	-	-	-	-	-	-	0.6 - 2.0	-	1.8 - 2.55	-	-
Rock	Very Low Strength or Very Low to Low Strength	-	5.0 - 6.0	5.3 - 6.0	-	3.0 - 5.63	5.0 - 5.56	0.5 - 3.0	4.4 - 4.65	5.0 - 6.0	1.0 - 3.0	-	2.5 - 2.8	-	-	3.8 - 4.1
	Low to Medium Strength	-	-	-	-	-	-	-	4.65 - 4.81	-	-	2.0 - 2.8	-	-	-	-
	High Strength or stronger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Groundwater Observations		NFGWO	3.2	NFGWO	3.9	NFGWO	NFGWO	NFGWO	4.0	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO
Cored		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reason for Termination		TC bit	LOI	TC bit	TC bit	TC bit	SPT on inferred rock	LOI	LOI	LOI	TC bit	TC bit	TC bit	TC bit	LOI	SPT on inferred rock
Termination Depth		5.11	6.00	6.00	5.90	5.63	5.56	3.00	4.81	6.00	3.00	2.80	2.80	2.55	6.00	4.10

Notes to table NFGWO = No Free Groundwater Observed Geology codes defined in Section 2.1 Obscured = Groundwater observations obscured by drilling fluids - = Not Encountered Alv = alluvial Res = residual

Table 3: Summary of Subsurface Conditions (continued)

Borehole Number / Structure Number		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Easting		346921	345840	343308	341331	340014	338082	336058	335311	334580	334039	332021	329598	327952	327190	325151
Northing		6383862	6384575	6385172	6385057	6385241	6385778	6386011	6386366	6386714	6386979	6387273	6387883	6387898	6387845	6388029
Surface Elevation (AHD)		48.1	35.1	28.5	52.5	82.7	45.3	97.2	66.2	62.6	81.5	39.1	106.5	70.7	99.7	114.3
Mapped Geology		Pmtb	Pmtb	Pmtb	Pmtm	Pmtm	Pmtb	Pmtb	Pmtm	Pmtm	Pmtm	Pmtm	Pmtm	Pmtm	Pmtm	Pmtm
Interpreted Alluvial / Residual		Res	Res	Alv	Res	Res	Alv	Res	Res	Res	Res	Alv	Res	Alv	Res	Res
Unit	Material type															
Unsuitable Soils	Topsoil	0.0 - 0.1	-	-	0.0 - 0.1	-	-	0.0 - 0.1	0.0 - 0.1	0.0 - 0.1	-	-	0.0 - 0.1	-	0.0 - 0.1	-
	Colluvial Clay	-	-	-	0.1 - 0.3	-	0.0 - 0.2	0.1 - 0.3	-	0.1 - 0.3	-	-	-	0.6 - 3.5	-	-
Special Soils (Cu<25kPa)	FILL	-	0.0 - 0.3	-	-	0.0 - 0.2	-	-	-	-	0.0 - 0.6	-	-	0.0 - 0.6	-	0.0 - 0.3
Very Poor Soils (25kPa<Cu<50kPa)	Alluvial Sand or Colluvial Sand	-	-	3.3 - 4.7	-	-	2.5 - 4.0	-	-	-	-	-	-	-	0.1 - 0.3	-
Poor Soils (50kPa<Cu<100kPa)	Stiff alluvial clay or stiff residual clay	-	-	1.9 - 3.3	0.3 – 2.0	-	0.2 - 2.5	-	0.1 - 0.3	-	-	-	-	-	-	-
Normal Soils (Cu>100kpa)	Very stiff to hard residual Clay (some layers of silty sand) or very stiff to hard alluvial clay	0.1 - 1.7	0.3 - 3.6	0.0 - 1.9	2.0 - 3.7	0.2 - 2.1	4.0 - 4.9	0.3 - 0.5	0.3 - 2.2	0.3 - 2.2	0.6 - 1.0	0.0 - 1.8	0.1 - 0.9	3.5 - 5.6	0.3 - 1.8	0.3 - 2.7
	Clay Sandy Clay (extremely weathered bedrock)	-	-	-	3.7 - 5.2	-	-	-	-	-	-	-	0.9 - 2.5	-	-	-
	Clayey Gravelly Sand or Silty Sand (extremely weathered rock)	1.7 - 2.1	-	-	-	2.1 - 2.52	-	0.5 - 1.86	-	-	-	-	-	5.6 - 6.0	1.8 - 2.5	-
Rock	Very Low Strength or Very Low to Low Strength	2.1 - 2.5	-	-	5.2 - 5.53	-	-	-	2.2 - 5.02	2.2 - 2.65	1.0 - 1.4	-	4.8 - 5.19	-	-	2.7 - 4.48
	Low to Medium Strength	2.5 - 6.4	-	-	-	-	-	1.86 - 2.0	5.02 - 6.5	2.65 - 5.3	-	-	2.5 - 4.8	-	2.5 - 3.6	4.48 - 6.1
	High Strength or stronger	-	-	4.7 - 7.16	-	-	-	2.0 - 6.45	-	5.3 - 6.5	-	-	5.19 - 6.8	-	3.6 - 6.4	-
Groundwater Observations		NFGWO	NFGWO	4.5	NFGWO	NFGWO	4.1	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	4.7	NFGWO	NFGWO
Cored		-	-	-	-	-	-	-	-	2.65 - 6.5	-	-	2.5 - 6.8	-	2.5 - 6.4	2.9 - 6.1
Reason for Termination		LOI	LOI	LOI	SPT refusal	SPT on inferred rock	SPT on inferred rock	TC bit	LOI	LOI	TC bit	Ref on hard object	LOI	LOI	LOI	LOI
Termination Depth		6.40	3.60	7.16	5.53	2.52	4.90	6.45	6.50	6.50	1.40	1.80	6.80	6.00	6.40	6.10

Notes to table: NFGWO = No Free Groundwater Observed; Geology codes defined in Section 2.1; Obscured = Groundwater observations obscured by drilling fluid; - = Not Encountered

Table 3: Summary of Subsurface Conditions (continued)

Borehole Number / Structure Number		31A	32	33C	38	39	40	41	42	43	44	45	46	47
Easting		323734	0	321062	319090	318560	318525	319054	319754	319647	319278	319199	317856	317472
Northing		6389236	0	6392182	6394481	6396366	6396773	6399252	6402230	6404879	6405750	6407571	6408781	6410222
Surface Elevation (AHD)		45.2	0.0	50.8	53.4	51.2	52.3	92.4	65.4	57.5	104.1	67.2	72.4	79.2
Mapped Geology		Pmtb	Pwts	Q_av	Q_av	Q_av	CZ_athc	Pwv	Pwv	Q_av	Pwv	Q_av	Q_av	Q_av
Interpreted Alluvial / Residual		Res	Res	Res	Alv	Alv	Alv	Res	Alv/Res	Alv	Res	Alv	Alv	Alv
Unit	Material type													
Unsuitable Soils	Topsoil	-	-	0.0 - 0.2	-	-	0.0 - 0.1	0.0 - 0.1	0.0 - 0.1	-	0.0 - 0.1	-	-	-
	Colluvial Clay	-	-	-	-	-	-	-	-	-	0.1 - 0.8	-	-	-
Special Soils (Cu<25kPa)	FILL	0.0 - 0.3	-	-	-	-	-	-	-	-	-	-	-	-
Very Poor Soils (25kPa<Cu<50kPa)	Alluvial Sand or Colluvial Sand	-	-	-	0.0 – 1.75	0.0 – 1.03 6.06 -7.06 7.99 – 10.10	0.1 - 0.3	-	-	0.0 – 6.82	-	0.0 – 4.3	0.0 – 3.26	0.0 -3.96
Poor Soils (50kPa<Cu<100kPa)	Stiff alluvial clay or stiff residual clay	-	-	-			-	-	0.1 - 2.2	-	-	-	-	-
Normal Soils (Cu>100kpa)	Very stiff to hard residual Clay (some layers of silty sand) or very stiff to hard alluvial clay	0.3 - 4.1	0.0 - 0.4	0.2 – 5.0	1.75 – 8.88	1.03 – 6.06 7.06 – 7.99	0.3 - 6.0	0.1 - 0.8	-	-	-	-	-	-
	Clay Sandy Clay (extremely weathered bedrock)	4.1 - 5.7	0.4 - 1.8	-	-	-	-	-	-	-	-	-	-	-
	Clayey Gravelly Sand or Silty Sand (extremely weathered rock)	-	-	5.0 - 6.0	-	-	-	0.8 - 2.3	2.2 - 2.7	-	0.8 - 2.6	4.3 – 4.34	-	-
Rock	Very Low Strength or Very Low to Low Strength	-	1.8 - 2.6	-	-	-	-	2.3 - 4.0 4.38 - 6.0	2.7 - 5.0	-	2.6 - 4.85	-	-	-
	Low to Medium Strength	-	2.6 - 6.0	-	-	-	-	4.0 - 4.38	5.0 - 6.5	-	4.85 - 6.37	-	-	-
	High Strength or stronger	-	-	-	-	-	-	-	-	-	-	-	-	-
Groundwater Observations		NFGWO	NFGWO	NFGWO	NJFGWO	7.2	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO
Cored		-	2.5 - 6.0	-	-	-	-	4.0 - 6.0	-	-	2.6 - 6.37	-	-	-
Reason for Termination		LOI	LOI	LOI	LOI	LOI	LOI	LOI	LOI	LOI	LOI	LOI	LOI	LOI
Termination Depth		5.70	6.00	6.00	8.88	10.10	6.00	6.00	6.50	6.82	6.37	4.34	3.26	3.96

Notes to table: NFGWO = No Free Groundwater Observed

Table 3: Summary of Subsurface Conditions

Borehole Number / Structure Number		48	49	50	51	52	53	54
Easting		315622	314661	314100	312213	305846	305021	304184
Northing		6412380	6415043	6416551	6418412	6432372	6431724	6430929
Surface Elevation (m AHD)		104.1	120.0	142.2	129.5	210.4	231.4	176.0
Mapped Geology		Pwj	Pwv	Pwv	Pwts	Pmtb	Pmtb	Pgrr
Interpreted Alluvial / Residual		Res	Res	Fill/Res	Alv/Res	Res	Res	Res
Unit	Material type							
Unsuitable Soils	Topsoil	0.0 - 0.05	0.0 - 0.4	-	0.0 - 0.1	0.0 - 0.1	0.0 - 0.1	0.0 - 0.1
	Colluvial Clay	-	-	-	0.1 - 2.2	-	-	-
Special Soils (Cu<25kPa)	FILL	-	-	0.0 - 5.7	-	-	-	-
Very Poor Soils (25kPa<Cu<50kPa)	Alluvial Sand or Colluvial Sand	-	-	-	-	0.1 – 0.7	0.1 - 0.9	0.1 - 0.8
Poor Soils (50kPa<Cu<100kPa)	Stiff alluvial clay or stiff residual clay	-	-	-	-	-	-	4.6 - 6.0
Normal Soils (Cu>100kpa)	Very stiff to hard residual Clay (some layers of silty sand) or very stiff to hard alluvial clay	0.3 - 0.75	0.4 - 2.57	-	-	0.7 - 6.0	0.9 - 3.2	0.8 - 4.6
	Clay Sandy Clay (extremely weathered bedrock)	-	-	5.7 - 7.6	2.2 - 2.7	-	3.2 - 5.6	-
	Clayey Gravelly Sand or Silty Sand (extremely weathered rock)	-	-	-	-	-	-	-
Rock	Very Low Strength or Very Low to Low Strength	-	-	-	-	-	-	-
	Low to Medium Strength	0.75 - 3.8	2.57 - 7.0	-	2.7 - 5.67	-	-	-
	High Strength or stronger	-	-	-	-	-	-	-
Groundwater Observations		NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO
Cored		0.75 - 3.8	2.4 - 7.0	-	2.7 - 5.67	-	-	-
Reason for Termination		LOI	LOI	LOI	LOI	LOI	SPT on inferred rock	LOI
Termination Depth		3.80	7.00	7.60	5.67	6.00	5.60	6.00

Notes to table NFGWO = No Free Groundwater Observed

5. Laboratory Testing

5.1 Laboratory Methods

Laboratory testing was undertaken on a selection of samples of soil for aggressivity suite tests (pH, Electrical Conductivity, Chloride Ion Content, Sulphate Ion Content).

Table 4: Results of Aggressivity Laboratory Testing

Bore	Depth (m)	Description	Soil Condition	pH (concrete)	pH (steel)	Resistivity(1) (Ω.cm) (steel)	SO4 (ppm) (concrete)	Cl (ppm) (steel)
3	1-1.45	Silty Clay - grey	B	5.4	5.4	14286	100	10
4	1-1.45	Clay - grey mottled orange	B	7.4	7.4	667	730	2200
8	2.5-2.95	Silty Clay - grey brown mottled orange	B	8.1	8.1	1563	270	690
11	1-1.45	Clayey Gravelly SAND - orange brown	B	8.9	8.9	6667	46	92
13	1-1.45	Silty Clay - brown mottled red	B	5.8	5.8	5263	170	54
15	0.4-0.5	Silty Sand - pale brown to pale orange	B	7.3	7.3	66667	<10	<10
17	0.5-0.8	Sandy Clay - brown	B	5.2	5.2	1220	650	990
19	0.5-0.8	Silty Clay - dark grey mottled orange	B	4.5	4.5	1316	540	750
21	0.4-0.6	Sandy Clay - pale brown	B	6.6	6.6	47619	<10	<10
23	0.5-0.8	Silty Clay - red	B	4.8	4.8	1852	450	500
27	0.5-0.8	Silty Sand - pale brown	B	6.6	6.6	1695	240	640
28	1-1.45	Silty Clay - brown mottled dark brown	B	8.0	8.0	1299	660	590
29	0.5-0.8	Silty Clay - brown	B	5.3	5.3	2778	240	290
30	1-1.3	Silty Clay - brown mottled orange	B	8.9	8.9	3030	130	190
31A	2.5 - 2.95	Clay - orange brown	B	7.6	7.6	1190	240	1100

Notes to table

- Non-aggressive
- Mildly aggressive
- Moderately aggressive
- Severely Aggressive
- Very Severe

NT = Not tested
1. Resistivity calculated based on inverse of conductivity in aqueous solution results
Scale of aggressivity based on threshold values given in AS 2159 – 2009: Piling – Design and Installation

Table 4: Results of Aggressivity Laboratory Testing (continued)

Bore	Depth (m)	Description	Soil Condition	pH (concrete)	pH (steel)	Resistivity(1) (Ω.cm) (steel)	SO4 (ppm) (concrete)	Cl (ppm) (steel)
33c	2.5-2.95	Silty Clay - red brown	B	8.6	8.6	1205	33	1000
40	0.5-0.8	Sandy Clay - dark grey	B	7.6	7.6	8333	20	92
41	1-1.26	Silty Sand - pale grey mottled orange	B	5.3	5.3	1887	130	690
42	0.5-0.8	Silty Clay - brown	B	8.6	8.6	1587	100	660
44	1-1.3	Silty Sand - pale brown	B	9.1	9.1	7692	21	20
48	0.5	Sandy Clay - brown	B	6.4	6.4	11628	79	24
49	1-1.45	Silty Clay - grey	B	9.0	9.0	6667	55	110
50	1-1.45	FILL / Silty Clay - grey	B	9.4	9.4	5882	84	50
50	3.5-3.95	FILL / Coal Wash - black	B	7.5	7.5	1515	67	720
51	0.5-0.8	Silty Clay - grey brown	B	6.9	6.9	625	370	2100
53	0.5-0.8	Silty Sand - grey brown	B	5.3	5.3	17857	50	29

Notes to table

Non-aggressive
Mildly aggressive
Moderately aggressive
Severely Aggressive
Very Severe

NT = Not tested
1. Resistivity calculated based on inverse of conductivity in aqueous solution results
Scale of aggressivity based on threshold values given in AS 2159 – 2009: Piling – Design and Installation

6. Comments

6.1 General

To assist with design of the foundations, the subsurface conditions have been subdivided into soil and rock categories, as follows:

- Unsuitable soils – colluvial soils or topsoil;
- Special soils (Cu < 25 kPa);
- Very poor soils (25 kPa < Cu < 50 kPa for cohesive soils or loose for non-cohesive soils);
- Poor soils (50 kPa < Cu < 100 kPa for cohesive soils or medium dense for non-cohesive soils);
- Normal soils (Cu >100 kPa for cohesive soils or dense or denser non-cohesive soils); and
- Rock:
    - Very Low strength or very low to low strength;
    - Low to medium strength; and
    - High strength or stronger.

It is noted that cohesionless soils, particularly if below the groundwater, are at risk of collapse within bored pile excavations and hence have also been classified as "Unsuitable Soils".

6.2 Expected Foundation Conditions

Anticipated foundation conditions from available borehole data have been summarised in Table 3 in Section 4.2 above. The anticipated founding conditions for the towers are summarised in Table 5 below. These have been classified based on the conditions within the upper 2 m of the profile, noting that improved conditions are present at depths of greater than 2 m in a number of these locations. The remaining towers which are not listed in the table below encountered "normal" conditions.

Table 5: Summary of Tower Foundation Conditions

Founding Condition	Locations
Unsuitable	51
Special	2, 5, 6, 50
Very Poor	18, 21, 38, 39, 43, 45,46, 47
Poor	1, 40, 42, 54

6.3 Foundation Design Parameters

Geotechnical parameters for the preliminary design of pole or pile foundations are provided in Table 6 to Table 8 for the range of soils and rocks encountered. It is understood that final design of the foundations will occur during boring at each pole location. Note that the suggested parameters are presented for various soil/rock strengths rather than for each geological sector as there is likely to be a range of materials present within each sector.

It is recommended that additional geotechnical advice should be obtained for any non-specified Ausgrid structures along the route (eg any structures other than the transmission line poles) to confirm the appropriateness of any design parameters given herein.

The parameters presented in this section are typical values only and more detailed analysis may be required where adverse or different conditions are encountered.

6.3.1 Material and Strength Properties for Design

Table 6 outlines the generalised material and strength properties for the different types of soil and rock that were encountered along the alignment.

Table 6: Suggested Material and Strength Parameters

Material	Unit Weight (kN/m³)	Cohesion, c' (kPa)	Drained Angle of Friction, Φ' (degrees)	Undrained Shear Strength, cu (kPa)
Sand / Gravel				
- Medium Dense	17-20	0	32-36	0
- Dense	17-22	0	33-40[1]	0
Clay				
- Soft; "Special"	17-19	0	22-25	12-25
- Firm "Very Poor"	17-20	0-2	22-26	25-50
- Stiff "Poor"	18-21	2-4	24-28	50-100
- Very stiff "Normal"	19-22	4-7	25-29	100-200
- Hard including extremely weathered bedrock "Normal"	20-23	5-8	26-30	200-400
Volcanic / Sedimentary Rock				
- Very low strength	21-24	-	-	-
- Low strength	22-24	-	-	-
- Medium strength	23-25	-	-	-
- High strength	24-26	-	-	-

Notes to table:

1 - Douglas recommends a maximum Drained Angle of Friction of 36^0 for shaft resistance calculations in dense gravels and the lower bound values defines for medium dense where the unit contains layer of loose sand

Some comments on the applicability of the above material and strength parameters for various loading conditions is given in the following sections, together with design parameters specific to axial and lateral load cases.

6.3.2 Foundation Design

6.3.2.1 General

The design of pole foundations for transmission lines, from a geotechnical perspective, is typically governed by lateral loading (and moment) considerations.

Where the design of non-standard foundations is required, or where analysis and design will be carried out from 'first principles', it should be carried out in accordance with the relevant Australian Standards. In particular, pole foundation design should meet the requirement of the Piling Standard, (AS 2159, 2009).

With respect to AS2159-2009, the design geotechnical strength of a pile ($R_{d,g}$) is the ultimate geotechnical strength ($R_{d,ug}$) multiplied by the geotechnical strength reduction factor (Φ_g), such that:

$$R_{d,g} = \Phi_g \, . \, R_{d,ug}$$

The calculated value $R_{d,g}$ must equal or exceed the structural design action effect (E_d).

Selection of the geotechnical strength reduction factor (Φ_g) is based on a series of individual risk ratings (IRRs) which are weighted and lead to an average risk rating (ARR). The individual risk ratings and final value of the basic geotechnical strength reduction factor (Φ_{gb}) depend on the following factors:

- Site: the type, quantity and quality of testing;
- Design: design methods and parameter selection;
- Installation: construction control and monitoring;
- Pile testing regime: testing benefit factor based on percentage of piles tested and the type of testing; and
- Redundancy - whether other piles can take up load if a given pile settles or fails.

As per Clause 8.2.4(c)(i) of AS2159-2009, pile testing is generally required where Φ_g is greater than 0.4 and ARR is 2.5 or greater. On this basis, Douglas recommends a **Φ_g of 0.4** be adopted for design based on a low redundancy category, which would generally be appropriate for isolated pole foundations where relatively poor construction control often occurs.

It is Douglas's experience that transmission line foundations are commonly poured several days after they are drilled, at which time debris and seepage water have affected the integrity of the base and sidewalls of the pile/pole hole. The redundancy category could be reassessed by the structural engineer for more detailed design, if for example, a pile group is adopted.

The above recommendation assumes no static or high-strain dynamic testing of installed piles/pole foundations is undertaken, in which case Φ_g is taken as Φ_{gb} (i.e. Φ_g - Φ_{gb}). The Φ_g value could be increased if static or high-strain dynamic testing is carried out on a proportion of piles (the higher the proportion of piles tested, the higher Φ_g becomes). The value of testing would depend on a cost benefit analysis that compares the cost of testing to the potential savings in pile installation.

It is noted that integrity testing of cast-in-place piles does not improve the geotechnical strength reduction factor (Φ_g). However, Table 8.2.4(B) of AS2159-2009 requires that 5% to 15% of piles are subject to integrity testing if the adopted Φ_g exceeds 0.4 and the ARR is greater than 2.5, where the design is governed by geotechnical capacity. Furthermore, if at least 5% of piles are integrity tested, the maximum concrete placement factor (k=1) may be adopted in accordance with Table 5.3.2 of the piling standard.

6.3.2.2 **Axial Loading**

The design of bored pole / pile foundations for axial compression loading may be based on the maximum Limit State Design and modulus parameters given in Table 7 below.

Table 7: Pile Design Parameters for Axial Loading

Material	Limit State Design Values		
	Ultimate End Bearing(1)(2) (kPa)	Ultimate Shaft Adhesion(1)(3) (kPa)	Range of Young's Modulus(4) Ev (MPa)
Sand / Gravel			
-Medium Dense	2000	25	20-50
-Dense	4000	50	40-80
Clay			
- Soft; "Special"	60 - 200(5)	5-10	2 - 4
- Firm "Very Poor"	200 - 400	10 - 20	4 - 20
- Stiff "Poor"	400 - 800	20 - 40	8 - 40
- Very stiff "Normal"	800 - 1,500	40 - 60	16 - 80
-hard including extremely weathered rock "Normal"	1,500 - 3,000	60 - 80	32 - 160
Volcanic / Sedimentary Rock			
-Very low strength	3,000 - 6,000	100 - 150	100 - 300
-Low strength	6,000 - 20,000	300 - 600	200 - 600
-Medium strength	20,000 - 40,000	800 - 1,200	500 - 2,000
-High strength	40,000 - 80,000	1,500 - 2,500	2,000 - 4,000

Notes to table:

1 - Bearing pressure values assume a minimum embedment of one pile diameter into the relevant bearing stratum, with an overall foundation length of at least four pile diameters for soils.

2 - Ultimate end bearing parameters mobilized at large settlements (i.e. >5% of pile diameter).

3 - All shaft adhesion parameters are based on adequately clean and rough sockets of category "R2", or better.

4 - A range of values has been given for (vertical) Young's modulus (E_v), based on the range of strength appropriate for each defined material and also based on typical published correlations, as described below.

5 - Consolidation settlement and creep must be taken into account, Douglas recommends against founding in these soils.

A relatively wide range of (vertical) Young's modulus (E_v) values is given for the respective materials listed in Table 7. For cohesive (i.e. clay) soil materials, the following correlation between undrained shear strength (Cu) and E_v was adopted:

$$E_v = (160 \text{ to } 400)\ Cu$$

For rock materials, the principal factors that influence the rock mass modulus are the in-situ stresses, the intact (or rock substance) uniaxial compressive strength (UCS) and the degree of fracturing or defects, as expressed by the RQD or Geotechnical Strength Index (GSI). There are several published correlations available that reflect the dependence of the rock mass modulus (E_m) on UCS (or q_u) and the degree of fracturing, such as that of Hoek et al. (2002), viz:

$$E_m = 0.1\ q_u^{0.5} \times 10^{[(GSI - 10)/40]}$$

where GSI = Geotechnical Strength Index

In selecting a modulus value for the analysis of pole foundations (in rock), reference should be made to the degree of fracturing and defects indicated by any nearby boreholes. For example, the rock encountered in Bores 30, 41, 42, 44, 48 encountered generally very low to low strength rock with a low RQD of generally ranging from about 0% to 50%, but also significant sections of up to 90%. Therefore, a modulus value towards the lower to middle range would generally be appropriate here. Other bores, including Bores 16, 18 and 22 with an RQD generally ranging from about 80% to 100%. It is also noted that the degree of fracturing (RQD) is generally not able to be determined from the pile/hole boring (i.e. drilling) operation. From this perspective it is considered that unless nearby borehole information to the contrary is available, it should be assumed that the rock could be relatively fractured, with an RQD of not more than about 30% to 40%, and therefore adopting a lower modulus value.

Another important factor in the selection of modulus values is the duration and nature of loading. It is understood that the "governing" load case for transmission line foundations is often the 1 in 1000 year wind load that has a "maximum three seconds duration". The duration and frequency of this load would, on face value, suggest that a modulus value tending towards the upper end of the range would generally be appropriate. The cyclic nature of wind loading, however, is such that a cumulative degradation of the initial stiffness (or modulus) is known to occur. Therefore, due caution should be given to selecting higher moduli for short-term, infrequent wind loading cases.

The foundation design parameters presented in Table 7 assume that pole hole excavations are clean at the base and free of loose debris, with pile sockets (i.e. shafts) free of smear and adequately rough ("R2") prior to concrete placement, as defined in Pells et al (1998).

The above shaft adhesion parameters may be adopted for axial compression loading. For uplift or tension loading, 70% of the above shaft adhesion parameters may be adopted for design purposes. The rationale behind the reduction in shaft adhesion for uplift has both a technical and logical basis. The following researchers have advised that a reduction in shaft adhesion should apply for uplift loading due to the "Poisson's Effect" and other reasons; Jardine et al (2005), O'Neill (2001), Poulos et al (2002) and DeNicola and Randolph (1993).

Fellenius (1998) recommended a reduction in shaft adhesion for uplift loading on the grounds of logical consequence by noting that, *"If the capacity of a pile would be exceeded in compression loading, the result would normally show up as excessive differential settlement, crack development, and other undesirables affecting the serviceability of the structure. In contrast, exceeding the capacity of a pile in uplift could result in large continuing movements and ultimately collapse of a foundation"*.

Douglas considers that the reduction factor (for shaft adhesion) is also prudent on the basis of the likelihood that less than optimal construction standards will apply to the pole foundations, with some remnant sidewall smear likely to compromise the available shaft adhesion.

In addition to traditional 'piston pull-out' or sidewall slip failure mechanisms, the uplift capacity should be checked for 'cone pull-out' failure modes. This should be based on an assumed cone angle of 70° considering the submerged weight of the soil or rock and adopting a factor of safety of 1 against 'cone pull-out'.

The modulus values given in Table 7 are appropriate for the anticipated strains expected under serviceability loading. Non-linear effects should be considered depending on the operating stress levels.

6.3.2.3 **Lateral Loading**

The design of pole foundations for lateral loading (and moments) should be based on appropriate design methods such as that described by either Brinch Hansen (1961) or Broms (1964) for determination of the ultimate lateral resistance. For pole foundations in soil, the strength parameters given in Table 6 may be adopted for assessment of ultimate lateral resistance. For poles socketed into rock, however, the ultimate limiting pressures given in Table 8, below, may be adopted for design purposes.

The choice of each parameter or limiting pressure within the given ranges will depend on the actual material strength, in-situ stress levels, the nature and duration of loading and for rock, the degree of fracturing. Reference should be made to the discussion of these aspects given in the previous section.

With respect to serviceability, the deflection performance of pole foundations may be estimated using the Young's modulus values for lateral loadings (E_h) given in Table 8, together with typical values of the lateral modulus of subgrade reaction (K_h).

Table 8: Pile Design Parameters for Lateral Loading

Material	Range of Young's Modulus Eh (MPa)	Horizontal Modulus of Subgrade Reaction, Kh (kPa/mm) with diameter, d, in mm(3)	Ultimate Lateral Limiting Pressure(4) (kPa)
Sand / Gravel			
-Medium Dense	10-25	(4,000-6,000) / d	Kp = 3.2 to 3.8[4]
-Dense	20-40	(6,000-12,000) / d	Kp = 3.3 to 4.6[4]
Clay(1)			
- Soft; "Special"	1 – 3	-(5)	-(4)
- Firm "Very Poor"	2 – 10	(2,000 – 4,500) / d	-(4)
- Stiff "Poor"	4 – 20	(4,000 – 9,000) / d	-(4)
- Very stiff "Normal"	8 – 40	(10,000 – 30,000) / d	-(4)
-hard including extremely weathered rock "Normal"	16 – 80	(20,000 – 60,000) / d	-(4)
Volcanic / Sedimentary Rock(2)			
-Very low strength	50 – 150	(40,000 – 130,000) / d	2,000 – 3,000
-Low strength	100 – 300	(80,000 – 240,000) / d	4,000 – 10,000
-Medium strength	250 – 1,000	(200,000 – 450,000) / d	20,000 – 40,000
-High strength	1,000 – 2,000	(500,000 – 1,000,000) / d	40,000 – 60,000

Notes to table:

1 - For soil, the above modulus values are valid for a typical range of operating strains (i.e., ≤1% strain) and within the elastic stress range; no effect of pile interaction is taken in to account and larger modulus values may be appropriate for small strain circumstances (e.g. dynamic or earthquake loading).

2 - For the rock, modulus values only applicable over linear elastic range with maximum strain of 1% and should only be used when there is no interaction between piles.

3 - Based on published correlations for uniform – isotropic material.

4 - Ultimate lateral resistance (Pp) for soils may be estimated on the basis of the strength parameters given in Table 6. For piles in clay adopt Pp = 2.cu at the surface increasing to 9.cu at four pile diameters where the ultimate strength remains at 9.cu. For piles in sand, adopt the ultimate passive resistance (Pp) as 3Kp x overburden stress, where Kp is the passive resistance for the nominated sand unit.

5 – Ignore in calculations.

6. – Where the soil layer contains layers of loose sand, the lower bound values for medium dense sand should be adopted.

The use of modulus of subgrade reaction, ks (vertical) is not appropriate for pile design.

It should be noted that the above stiffness parameters are for a uniform, isotropic strata with no trenches or steep slopes nearby. In cohesive soils (and rock) the stiffness may be assumed as constant (i.e. uniform with depth).

6.4 Design and Construction Considerations

6.4.1 Bedrock Excavatability

Bedrock was encountered within the upper 3 m of the profile within a number of bores (Bores 7, 10, 12, 16, 23, 24, 25, 30. 32, 41, 42, 44, 48, 49 and 51. and ranged from very low strength to high strength.

It is possible that pile rig refusal could be encountered within medium strength or stronger rock with a lower rate of production in the low strength rock. Excavatability is also dependent on rock jointing (RQD). Fracture spacing within the rock, where coring was undertaken, was generally between 0.01 m to 0.5 m, which may assist in excavatability, although some bores returned higher RQD (Bores 16, 18 and 22 for instance).

If bedrock prevents the adequate penetration of auger boring equipment, then it may be necessary to use hydraulic or pneumatic rock breaking equipment (e.g. 'down the hole' piling hammers) to continue the hole to the required depth.

Contractors should be responsible for the correct selection of piling rig and equipment for production / penetration rates.

6.4.2 Groundwater and Collapsing Soils

For the majority of bores the groundwater table is expected to below the founding depth of the poles, with the possible exception of the following:

- Bore 2 where groundwater was encountered at about 3.2 m depth in residual soils;
- Bore 4. where groundwater was encountered at about 3.9 m depth in residual soils;
- Bore 8, where groundwater was encountered at about 4.0 m depth in residual soils;
- Bore 18, where groundwater was encountered at about 4.5 m depth in alluvial sand;
- Bore 21, where groundwater was encountered at about 4.1 m depth in alluvial clay;
- Bore 28, where groundwater was encountered at about 4.1 m depth in alluvial clay; and
- CPT 39, where groundwater was encountered at 7.2 m depth in alluvial sand.

In areas of shallow groundwater, and "very poor soils" such as firm clays, or "unsuitable soils", uncased bored piles are not recommended.

Particular care should be taken in respect to site drainage conditions. Where soils become inundated due to changes in site drainage, it can lead to softening of soils and a loss of strength. This could compromise the stability of the as-designed poles or lead to unacceptable deflections or tilting of the poles.

6.4.3 Construction Access

Based on the trafficability of our equipment during investigation, the ground surface is not expected to cause significant access restraints for construction vehicles. However, particular areas which could be subject to poor ground conditions following wet weather include areas where 'very poor' soils were encountered (Bores 2, 5, 15, 16, 21, 28 and 50) and in the areas mapped as alluvial soils.

Temporary access roads could be constructed from granular material such as select material (crushed rock), ballast (or similar igneous rock) and/or crushed recycled concrete.

Where excessively wet zones or poor subgrades are encountered during construction (for example near low lying swamp areas, gullies and creek crossings etc.) specific geotechnical design of temporary access pavements using rock materials in-conjunction with geofabrics and geotextiles is recommended.

Where cranes, piling rigs or similar highly loaded machinery are used during construction, specific geotechnical hardstand support design parameters and bearing capacity estimates by this office is recommended.

Contractors should be responsible for selecting equipment based on equipment capabilities, together with the anticipated conditions in terms of site access.

6.5 Soil Aggressivity

The assessment of soil aggressivity has been made with reference to the requirements for concrete and steel piles presented in AS 2159 (2009).

Based on the geo-chemical soil tests listed in Table 4 in Section 5 and with reference to the requirements for concrete and steel piles presented in AS 2159 (2009), the following exposure classifications are suggested in Table 9.

Table 9: Results of Aggressivity Laboratory Testing

Bore	Steel Elements	Concrete Elements
3	Non Aggressive	Mildly Aggressive
4	Moderately Aggressive	Non Aggressive
8	Mildly Aggressive	Non Aggressive
11	Non Aggressive	Non Aggressive
13	Non Aggressive	Non Aggressive
15	Non Aggressive	Non Aggressive
17	Mildly Aggressive	Mildly Aggressive
19	Mildly Aggressive	Moderately Aggressive
21	Non Aggressive	Non Aggressive
23	Mildly Aggressive	Mildly Aggressive
27	Mildly Aggressive	Non Aggressive
28	Mildly Aggressive	Non Aggressive
29	Non Aggressive	Mildly Aggressive
30	Non Aggressive	Non Aggressive
31A	Mildly Aggressive	Non Aggressive
33c	Mildly Aggressive	Mildly Aggressive
40	Non Aggressive	Non Aggressive
41	Mildly Aggressive	Mildly Aggressive
42	Mildly Aggressive	Mildly Aggressive
44	Non Aggressive	Non Aggressive
48	Non Aggressive	Non Aggressive
49	Non Aggressive	Non Aggressive
50	Non Aggressive	Mildly Aggressive
50	Mildly Aggressive	Moderately Aggressive
51	Moderately Aggressive	Non Aggressive
53	Non Aggressive	Mildly Aggressive

Notes to table:

- Non-aggressive
- Mildly aggressive
- Moderately aggressive
- Severely Aggressive
- Very Severe

All buried concrete structures should be suitably protected against decay or corrosion, taking into account the subsurface conditions and water table fluctuations.

7. References

AS 2159. (2009). *Piling - Design and Installation.* Standards Australia.

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DeNicola, C, R. (1993). *Installation Effects in Model Piles in Sand.* Canadian Geotechnical Journal 30(3).

Jardine, R, S. (2005). *Design of Pile Foundations in Hong Kong - New Approach: Proceedings of the Institution of Civil Engineers - Geotechnical Engineering 158(2).*

O'Neill, M. (2001). *Cyclic Load Response of Drilled Shafts in Sand.* Journal of Geotechnical and Geoenvironmental Engineering 127(8).

8. Limitations

Douglas Partners Pty Ltd (Douglas) has prepared this report (or services) for this project for the Hunter Pole Replacement Program in line with Douglas' proposal 226603.00 dated December 2023 and acceptance received from Matthew Faferko of Ausgrid in a purchase order form Ausgrid PO 4501072672. The work was carried out under Douglas' Engagement Terms. This report is provided for the exclusive use of Ausgrid for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas, does so entirely at its own risk and without recourse to Douglas for any loss or damage. In preparing this report Douglas has necessarily relied upon information provided by the client and/or their agents.

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

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

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

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. Douglas cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

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

Appendix A

About this Report

Terminology, Symbols and Abbreviations

Soil Descriptions

Rock Descriptions

Sampling, Testing and Excavation Methodology

Cone-Penetration Testing

About this Report

Introduction

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

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

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

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

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

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

continued next page

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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Terminology, Symbols and Abbreviations

November 2023

Introduction to Terminology, Symbols and Abbreviations

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

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

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

Abbreviation Codes

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

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

Data Integrity Codes

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

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

Graphic Symbols

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

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Soil Descriptions

Introduction

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

classification
name
detailed description

(SC) Clayey SAND, trace silt; grey, fine to medium grained

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

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

Particle size designation and Behaviour Model

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

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

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

[1] – refer grain size subdivision descriptions below

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

Component proportions

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

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

[1] As defined in AS1726-2017 6.1.4.4

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

Composite Materials

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

Soil Descriptions

Classification

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

Soil Name

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

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

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

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

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

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

Identification of minor components

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

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

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

Soil Composition

Plasticity

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

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

Grain Size

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

Grading

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

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

Soil Descriptions

Soil Condition

Moisture

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

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

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

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

Consistency/Density/Compaction/Cementation/Extremely Weathered Material

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

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

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

Consistency (fine grained soils)

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

Relative Density (coarse grained soils)

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

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

Soil Descriptions

Compaction (anthropogenically modified soil)

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

Cementation (natural and anthropogenic)

Cementation Term	Abbreviation Code
Moderately cemented	MOD
Weakly cemented	WEK

Extremely Weathered Material

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

Soil Origin

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

Cobbles and Boulders

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

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

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Rock Strength

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

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

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

[1] Rock strength classification is based on UCS. The UCS to $I_{s(50)}$ ratio varies significantly for different rock types and specific ratios may be required for each site. The point load Index ranges shown above are as suggested in AS1726 and should not be relied upon without supporting evidence.

The following abbreviation codes are used for soil layers or seams of material "within rock" but for which the equivalent UCS strength is less than 0.6 MPa.

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

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

Rock Descriptions

Degree of Alteration

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

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

Degree of Fracturing

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

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

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Rock Descriptions

Defect Descriptions

Defect Type

Term	Abbreviation Code
Bedding plane	B
Infilled seam	IS
Cleavage	CV
Crushed zone	CZ
Decomposed seam	DS
Fault	F
Joint	JT
Lamination	LAM
Parting	P
Shear zone	SZ
Vein	VN
Drilling/handling break	DB , HB
Fracture	FC

Rock Defect Orientation

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

Rock Defect Coating

Term	Abbreviation Code
Clean	CN
Coating	CT
Healed	HE
Infilled	INF
Stained	SN
Tight	TI
Veneer	VNR

Rock Defect Infill

Term	Abbreviation Code
Calcite	CA
Carbonaceous	CBS
Clay	CLAY
Iron oxide	FE
Manganese	MN

intentionally blank

Rock Defect Shape/Planarity

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

Rock Defect Roughness

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

Defect Orientation

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

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Sampling, Testing and Excavation Methodology

Terminology
Symbols
Abbreviations

November 2023

Sampling and Testing

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

SAMPLE				TESTING	
SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			1.0		
	SPT			SPT	4,9,11 N=20
			1.45		

Sampling

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

Sample Type	Code
Auger sample	A
Bulk sample	B
Core sample	C
Disturbed sample	D
Sample from SPT test	SPT
Environmental sample	ES
Gas sample	G
Undisturbed tube sample	U[1]
Water sample	W
Piston sample	P
Core sample for unconfined compressive strength testing	UCS
Material Sample	MT

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

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

Field and Laboratory Testing

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

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

Field and laboratory testing (continued)

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

Groundwater Observations

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

Drilling or Excavation Methods/Tools

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

Method	Abbreviation Code
Toothed bucket	TB[1]
Mud/blade bucket	MB[1]
Ripping tyne/ripper	R
Rock breaker/hydraulic hammer	RB
Hand auger	HA[1]
NMLC series coring	NMLC
HMLC series coring	HMLC
NQ coring	NQ3
HQ coring	HQ3
PQ coring	PQ3
Push tube	PT[1]
Rock roller	RR[1]
Solid flight auger. Suffixes: /T = tungsten carbide tip, /V = v-shaped tip	AD[1]
Sonic drilling	SON[1]
Vibrocore	VC[1]
Wash bore (unspecified bit type)	WB[1]
Existing exposure	X
Hand tools (unspecified)	HAND
Predrilled	PD
Diatube	DT[1]
Hollow flight auger	HSA[1]
Vacuum excavation	VE

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

Appendix B

Borehole Logs

Cone Penetration Plots

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 16.6 AHD
COORDINATE: E:359451.6, N:6369179.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH1
PROJECT No: 226603.00
DATE: 01/02/24
SHEET: 1 of 2

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
01/02/24 No free groundwater observed			FILL / Silty CLAY: brown; low plasticity.		FILL	NA	w<PL		D		0.10		
		0.20	CLAY, with silt: brown.						D		0.50		
	16	1				St	w<PL		D/SPT		1.00 – 1.45	SPT PP	2,2,4 N=6 140-170kPa
	15	2	From 2.20m: grey								2		
	14	2.50	CLAY: mottled orange grey red.			VSt to H	w<PL				2.50	PP	250-300kPa
									D/SPT		2.50 – 2.95	SPT	5,7,14 N=21
	13	3									3		
		4									4.00	PP	>600kPa
	12		4.20m: grading to extremely weathered rock						D/SPT		4.00 – 4.45	SPT	5,14,25 N=39

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

PLANT: Truck Mounted
METHOD: Solid flight auger TC Bit to 5.11m
REMARKS:

OPERATOR: Traccess Drilling

LOGGED: Lloyd
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

Generated with CORE-GS by Geroc - Soil Log

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 16.6 AHD
COORDINATE: E:359451.6, N:6369179.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH1
PROJECT No: 226603.00
DATE: 01/02/24

CONDITIONS ENCOUNTERED									SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*)	DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] CLAY: mottled orange grey red.			VSt to H		w<PL						
	11, 10, 9, 8, 7	6, 7, 8, 9	Borehole discontinued at 5.11m depth. Limit of investigation, refusal.											

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

PLANT: Truck Mounted
OPERATOR: Traccess Drilling
LOGGED: Lloyd
METHOD: Solid flight auger TC Bit to 5.11m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 14.6 AHD
COORDINATE: E:359222.9, N:6369273.4
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH2
PROJECT No: 226603.00
DATE: 30/01/24
SHEET: 1 of 2

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			FILL / Silty Sandy GRAVEL (GM): brown; medium to coarse, sub-angular to sub-rounded; fine to medium sand.		FILL	NA	D		D/ES		0.10		
	14	0.40	FILL / Sandy Gravelly CLAY (CL): grey brown mottled orange; medium plasticity; fine to medium sand; fine, sub-angular to sub-rounded gravel.		FILL	F to St	w<PL w=PL		D		0.50		
		1							SPT		1.00 – 1.45	SPT	3,4,4 N=8
			1.40m: possible change to residual in SPT									PP	250kPa
	13	1.50	Sandy GRAVEL (CI): pale grey mottled orange; medium to coarse; fine sand.		RS	VSt	w>PL w=PL						
	12	2							SPT		2.50 – 2.95	SPT	2,3,5 N=8
		3										PP	350-380kPa
Free groundwater observed at 3.2m 30/01/24	11												
		4	From 4.00m: low plasticity						SPT		4.00 – 4.45	SPT	3,9,11 N=20
			4.30m: ironstained, grading towards rock like structure									PP	400-430kPa
	10											PP	>600kPa

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger with TC Bit to 6.0m
REMARKS:

OPERATOR: Ground Test (Douglas)
LOGGED: Eadie
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

Generated with CORE-GS by Geroc - Soil Log

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 14.6 AHD
COORDINATE: E:359222.9, N:6369273.4
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH2
PROJECT No: 226603.00
DATE: 30/01/24
SHEET: 2 of 2

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	9	5.00	SILTSTONE: grey; very low strength.			NA	NA		D		5.00 – 5.20		
									SPT		5.50 – 5.95	SPT	3,4,12 N=16 300mm of cave in
									D		5.80 – 6.00		
	8, 7, 6, 5	6	Borehole discontinued at 6.00m depth. Limit of investigation.										

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger with TC Bit to 6.0m
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Eadie
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 17.5 AHD
COORDINATE: E:358181.3, N:6369733.4
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH3
PROJECT No: 226603.00
DATE: 31/01/24
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
31/01/24 No free groundwater observed			FILL / Sandy SILT (ML), trace gravel: brown; low plasticity; fine sand; fine to coarse, sub-angular to sub-rounded gravel; with rootlets.	FILL possibly TOP	NA	M		ES		0.30		
	17	0.50	Silty CLAY (CL), with sand: grey; low plasticity; fine sand.	RS	H	w<PL					SPT	7,13,20 N=33
											PP	>600kPa
					VSt	w>PL					SPT	4,4,5 N=9
											PP	250-350kPa
											SPT	3,5,7 N=12

Depth scale: 1, 2, 3, 4. RL scale: 17, 16, 15, 14, 13.

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

Generated with CORE-GS by Geroc - Soil Log

PLANT: Comacchio Geo 405
METHOD: Solid flight auger with TC Bit to 6.0m
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Eadie
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 17.5 AHD
COORDINATE: E:358181.3, N:6369733.4
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH3
PROJECT No: 226603.00
DATE: 31/01/24
SHEET: 2 of 2

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
		[CONT] Silty CLAY (CL), with sand: grey; low plasticity; fine sand.		RS	VSt	w>PL						
	5.20	SANDSTONE: grey; fine grained, very low strength.									SPT	16,25/110 Refusal
	12										PP	>600kPa
	6	Borehole discontinued at 6.00m depth. Limit of investigation.										
	11											
	7											
	10											
	8											
	9											
	9											
	8											

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

PLANT: Comacchio Geo 405
OPERATOR: Ground Test (Douglas)
LOGGED: Eadie
METHOD: Solid flight auger with TC Bit to 6.0m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 14.2 AHD
COORDINATE: E:356953.3, N:6370773.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH4
PROJECT No: 226603.00
DATE: 31/01/24
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	14	0.10	SILT (ML): pale grey; low plasticity.		COL	VSt to H	NA						
	13, 12, 11	1, 2, 3	CLAY (CH): grey mottled orange; high plasticity.		RS	VSt	w=PL				1, 2, 3		
Free groundwater observed at 3.9m 31/01/24	10	3.50, 4	CLAY (CL), with sand, trace gravel: orange mottled red; medium plasticity; fine to coarse sand; fine to medium gravel; gravels comprise of ironstone.		RS	VSt to H	w=PL w>PL				4		

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

PLANT: Truck Mounted
OPERATOR: Traccess Drilling
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 5.9m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 14.2 AHD
COORDINATE: E:356953.3, N:6370773.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH4
PROJECT No: 226603.00
DATE: 31/01/24

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	9		[CONT] CLAY (CL), with sand, trace gravel: orange mottled red; medium plasticity; fine to coarse sand; fine to medium gravel; gravels comprise of ironstone.		RS	VSt to H	w=PL w>PL						
	8	6	Borehole discontinued at 5.90m depth. Limit of investigation.										
	7	7											
	6	8											
	5	9											

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

PLANT: Truck Mounted
METHOD: Solid flight auger with TC Bit to 5.9m
REMARKS:

OPERATOR: Traccess Drilling

LOGGED: Reiher-Smith
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 31.0 AHD
COORDINATE: E:356511.1, N:6371102.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH5
PROJECT No: 226603.00
DATE: 30/01/24
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
31/01/24 No free groundwater observed			FILL / Silty GRAVEL (GM), trace sand: brown; fine to medium; fine sand.	FILL	NA	D	D/ES	0.10		
							D	0.50		
		0.60	FILL / Sandy SILT (ML), trace gravel: brown to pale grey; fine sand; fine, sub-angular to sub-rounded gravel.	FILL	NA	w<PL	D	0.80		
	30	1					D	1.00	SPT	3,5,7 N=12
		1.30	Sandy CLAY (CI): orange red pale grey; medium plasticity; fine sand; driller observed increased resistance. From 2.80m: Grading towards very low strength sandstone	RS	St to VSt	w<PL	SPT	1.30–1.45	PP	>600kPa
							D			
	29	2								
							SPT	2.50–2.95	SPT	6,11,19 N=30
	28	3.00	SANDSTONE: grey mottled red; very low strength, fine grained.		NA	NA			PP	>600kPa
	27	4					SPT	4.00–4.30	SPT	4,23,5 Refusal
	26									

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

Generated with CORE-GS by Geroc - Soil Log

PLANT: Comacchio Geo 405
OPERATOR: Ground Test (Douglas)
LOGGED: Eadie
METHOD: Solid flight auger with TC Bit to 5.63m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 31.0 AHD
COORDINATE: E:356511.1, N:6371102.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH5
PROJECT No: 226603.00
DATE: 30/01/24
SHEET: 2 of 2

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] SANDSTONE: grey mottled red; very low strength, fine grained. 5.10m: orange mottled grey			NA	NA		SPT		5.50 – 5.63	SPT	25/130 Refusal
	25, 24, 23, 22, 21	6, 7, 8, 9	Borehole discontinued at 5.63m depth. SPT refusal on fine grained sandstone.										

Generated with CORE-GS by Geroc - Soil Log

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger with TC Bit to 5.63m
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Eadie
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 16.9 AHD
COORDINATE: E:356227.9, N:6371481.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH6
PROJECT No: 226603.00
DATE: 30/01/24
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
31/01/24 No free groundwater observed			FILL / Silty GRAVEL: brown; fine to medium, sub-angular to sub-rounded. 0.90m: Increase in clay content 1.30m: Geofab	FILL	NA	M to D	D/ES	0.10		
							D	0.50		
	16	1					D	1.00	SPT	8,5,9 N=14
		1.30	Sandy CLAY (CL): pale grey brown mottled orange; low plasticity; fine sand. 2.50m-2.60m: Trace of pebbly, fine grained gravels	RS	St to VSt	w<PL	D	1.30		
	15	2						1.45	PP	>600kPa
	14								SPT	8,8,10 N=18 >600kPa
		3			St to VSt	w>PL		3	PP	>600kPa
									PP	
	13	4	5.00m: Driller observed resistance at 5.0m					4	SPT	5,6,8 N=14
	12								PP	250-300kPa

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger with TC Bit to 5.56m
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Eadie
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 16.9 AHD
COORDINATE: E:356227.9, N:6371481.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH6
PROJECT No: 226603.00
DATE: 30/01/24

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
		5.00	SANDSTONE: grey; very low strength, fine grained.			H	NA					SPT	25/60 Refusal
	11	6	Borehole discontinued at 5.56m depth. SPT refusal on fine grained sandstone.										
	10	7											
	9	8											
	8	9											
	7												

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

PLANT: Comacchio Geo 405
OPERATOR: Ground Test (Douglas)
LOGGED: Eadie
METHOD: Solid flight auger with TC Bit to 5.56m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 55.3 AHD
COORDINATE: E:355348.5, N:6372522.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH7
PROJECT No: 226603.00
DATE: 31/01/24
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
31/01/24 No free groundwater observed	55	0.00–0.50	Silty CLAY, trace sand, trace gravel: pale brown; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel. From 0.00m-0.10m: with rootlets		RS possibly XWM	H to	w<PL						
	54, 53	0.50–3.00	SANDSTONE: pale grey with orange brown ironstaining; very low to low strength, highly weathered.						SPT		1.00–1.11	SPT	25/110 Refusal
									SPT		2.50–2.61	SPT	25/110 Refusal
	52, 51	3.00	Borehole discontinued at 3.00m depth. Limit of investigation.										

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Eadie
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 32.5 AHD
COORDINATE: E:354670.1, N:6373322.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH8
PROJECT No: 226603.00
DATE: 01/02/24
SHEET: 1 of 2

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
0.00–0.40	FILL / Sandy GRAVEL (GP): grey brown; fine to coarse, sub-angular to sub-rounded; fine to coarse sand.	FILL	NA	D / M	ES	0.10		
0.40–3.00	Silty CLAY (CI), with sand: grey brown mottled orange; medium plasticity; fine sand. From 2.00m: Sandy clay	RS possibly COL	H	w=PL	SPT	1.00–1.45	SPT	2,5,9 N=14
						1.45	PP	440kPa
					SPT	2.50–2.95	SPT	7,9,16 N=16
						2.95	PP	>400kPa
3.00–4.00	Sandy CLAY (CL), trace gravel: grey orange mottled brown; low plasticity; fine to medium, rounded to sub-rounded gravel.	RS	H	w=PL				
4.00–4.40	Sandy CLAY (CL), trace gravel: brown; fine to medium, rounded to sub-rounded gravel; (extremely weathered pebbly sandstone).	XWM	H to Fr	w<PL	SPT	4.00–4.43	SPT	14,22,25/130 Refusal
						4.43	PP	>600kPa
4.40–4.81	SANDSTONE: dark grey. From 4.65m: TC refusal				SPT	4.80		25/10 Refusal

Groundwater: Free groundwater observed, possibly perched 01/02/24 (at 4.00 m)

RL (m): 32, 31, 30, 29, 28

Borehole discontinued at 4.81m depth.
Limit of Investigation.

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit
REMARKS:
OPERATOR: Ground Test (Douglas)
LOGGED: Chaplin
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 32.5 AHD
COORDINATE: E:354670.1, N:6373322.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH8
PROJECT No: 226603.00
DATE: 01/02/24

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS

Generated with CORE-GS by Geroc - Soil Log

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Chaplin
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 57.0 AHD
COORDINATE: E:353315.2, N:6374258.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH9
PROJECT No: 226603.00
DATE: 01/02/24
SHEET: 1 of 2

Groundwater: 01/02/24 No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	0.00–0.20	SILT (ML), with clay, with sand: pale brown; low plasticity; fine sand. 0.00m-0.05m: with rootlets	COL	St	w<PL				
56 (at 1 m)	0.20–2.00	CLAY (CI), with sand, trace gravel: grey mottled red orange; medium plasticity; fine to coarse sand; fine to medium, angular to sub-angular gravel; gravels comprise of ironstone.	RS	VSt	w=PL; w>PL to w=PL	SPT	1.00–1.45	SPT; PP	2,4,5 N=9; 350kPa
55 (at 2 m), 54 (at 3 m)	2.00–3.50	Sandy CLAY (CI), trace gravel: grey mottled red orange; medium plasticity; fine to coarse sand; fine to medium, angular to sub-angular gravel; gravels comprise of ironstone.	RS possibly XWM	H	w>PL to w=PL	SPT	2.50–2.95	SPT; PP	4,7,9 N=16; 520kPa
53 (at 4 m), 52	3.50–	Sandy CLAY (CI), trace gravel: pale grey mottled red orange; medium plasticity; fine to coarse sand; angular to sub-angular, gravels comprise of ironstone gravel.	RS possibly XWM	H	w<PL to w=PL	SPT	4.00–4.45	SPT; PP	6,13,18 N=31; 450->600kPa

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Chaplin
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 57.0 AHD
COORDINATE: E:353315.2, N:6374258.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH9
PROJECT No: 226603.00
DATE: 01/02/24
SHEET: 2 of 2

CONDITIONS ENCOUNTERED									SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*)	DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
		5.00	SANDSTONE: orange brown ironstaing; fine to medium grained, very low strength, highly weathered.											
			From 5.00m: driller observed increase in resistance							SPT		5.50	PP	>600kPa
												5.55	SPT	25/50 Refusal
	51	6	Borehole discontinued at 6.00m depth. Limit of investigation.											
	50	7												
	49	8												
	48	9												
	47													

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Chaplin
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 58.8 AHD
COORDINATE: E:351791.5, N:6375028.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH10
PROJECT No: 226603.00
DATE: 01/02/24
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
01/02/24 No free groundwater observed	0.00–0.20	TOPSOIL / Clayey Sandy SILT (ML): dark brown; low plasticity; fine to medium sand; abundant rootlets.	TOP	NA	w<PL				
	0.20–0.50	Sandy CLAY (CL): orange brown; low plasticity; fine to coarse sand.	RS	H	w<PL				
	0.50–1.00	Sandy CLAY (CL): orange brown; low plasticity; fine to coarse sand; (extremely weathered basalt).	XWM	H to Fr	w<PL				
	1.00–3.00	BASALT: orange brown ironstaining; very low to low strength, highly weathered (possibly extremely), excavatable with TC-Bit.				SPT	1.00–1.22	SPT	12,25/70 Refusal
						SPT	2.50–2.60	SPT	25/100 Refusal

RL (m): 58, 57, 56, 55, 54

Borehole discontinued at 3.00m depth.
Limit of investigation, TC refusal.

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit to 3.0m
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Chaplin
CASING: Uncased

Generated with CORE-GS by Geroc - Soil Log

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 103.9 AHD
COORDINATE: E:350658.6, N:6375603.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH11
PROJECT No: 226603.00
DATE: 02/02/24
SHEET: 1 of 1

Groundwater	RL (m)	Depth (m)	Description of Strata	Origin(#)	Consis.(*) / Density.(*)	Moisture	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
02/02/24 No free groundwater observed		0.00–0.20	FILL / Sandy SILT (ML): brown; low plasticity; fine to medium sand; with rootlets.	FILL	NA	w<PL				
		0.20–0.60	FILL / GRAVEL (GP): grey; fine to coarse, angular to sub-angular; basalt gravels.	FILL	NA	D	D	0.30–0.40		
	103	0.60–2.00	Clayey Gravelly SAND: orange brown; fine to coarse; fine to medium, angular to sub-angular gravel; extremely weathered basalt. From 2.00m: Increase in drilling pressure indicative of rock	XWM	D to VD	M	SPT	1.00–1.45	SPT	17,20,24 N=44
	102	2.00–2.80	BASALT: grey with orange brown ironstaining; highly weathered.				SPT	2.50–2.73	SPT	17,25/80 Refusal
	101	2.80	Borehole discontinued at 2.80m depth. Limit of investigation, TC refusal on possibly high strength basalt.							

RL scale: 103, 102, 101, 100, 99. Depth scale: 1, 2, 3, 4.

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit to 2.8m
REMARKS:

OPERATOR: Ground Test (Douglas)
LOGGED: Chaplin
CASING: Uncased

Generated with CORE-GS by Geroc - Soil Log

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 91.7 AHD
COORDINATE: E:349937.7, N:6376179.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH12
PROJECT No: 226603.00
DATE: 02/02/24
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
02/02/24 No free groundwater observed			TOPSOIL / Clayey SILT (ML): red brown; low plasticity; abundant rootlets.		TOP	NA	w<PL						
	91	0.20	Silty CLAY (CI), with gravel: brown; medium plasticity; fine to coarse, angular to sub-angular gravel.		RS	VSt	w=PL		SPT		1.00 – 1.45	SPT	7,7,9 N=16
	90	1									1.45	PP	350kPa
		2.00	Silty CLAY (CI), with gravel: pale grey white; medium plasticity; fine to coarse, angular to sub-angular gravel; gravels comprise of unweathered calcite.		RS possibly XWM	VSt	w=PL to w<PL		D		2.20 – 2.30		
	89	2.50	SILTSTONE: dark grey with orange brown ironstaining; very low to low strength, highly weathered.						SPT		2.50 – 2.60	SPT	25/100 (HB)
											2.60	PP	>600kPa
	88, 87	3, 4	Borehole discontinued at 2.80m depth. Limit of investigation, TC refusal at 2.8m.										

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit to 2.8m
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Chaplin
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 131.3 AHD
COORDINATE: E:349314.0, N:6377696.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH13
PROJECT No: 226603.00
DATE: 06/02/24
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
06/02/24 No free groundwater observed		0.20	FILL / Silty CLAY (CL), with gravel: brown; low plasticity; fine to medium, sub-angular to sub-rounded gravel; some organics.		FILL	NA	w<PL		D		0.20		
	131	1.80	Silty CLAY, trace sand: brown mottled red; medium plasticity; fine sand.		RS	VSt to H	w<PL w=PL		D		0.50		
	130								D		1.00	PP	>600kPa
									SPT/D		1.45	SPT	5,6,18 N=24
	129		Silty SAND, with clay: brown; fine to coarse; extremely weathered sandstone.		XWM		D		D		2.00		
									SPT		2.50		
			Borehole discontinued at 2.55m depth. Limit of investigation.						D		2.55	SPT	20/150

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

PLANT: Truck Mounted
METHOD: Solid flight auger TC Bit to 2.55m
REMARKS:

OPERATOR: Traccess Drilling

LOGGED: Lloyd
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 76.8 AHD
COORDINATE: E:348261.0, N:6380727.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH14
PROJECT No: 226603.00
DATE: 07/02/24
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
07/02/24 No free groundwater observed		0.00	Sandy CLAY (CL-CI), with silt: brown; low to medium plasticity; fine to medium sand.	RS	VSt	w<PL	D	0.10		
		0.20	Silty CLAY (CH): brown mottled orange grey; high plasticity.	RS	VSt to H		D	0.30–0.50		
	76						D	0.80–0.90		
		1.00	Silty CLAY (CH), trace sand, trace gravel: pale grey mottled red; medium to high plasticity; fine to medium sand; fine to medium, sub-angular to sub-rounded gravel; gravel is sandstone fragment.	RS	H	w<PL w=PL	SPT	1.00–1.45	SPT	3,5,10 N=15
		1.45							PP	400-500kPa
	75	2.00	Silty CLAY (CI), trace sand: pale grey mottled red; medium plasticity; fine sand.	RS	H		SPT	2.50	SPT	21/50
									PP	>400kPa
	74	3				w<PL				
	73	3.80	Silty CLAY (CH), trace sand: mottled pale grey brown orange; high plasticity; fine sand.	RS possibly XWM	H		SPT	4.00–4.30	SPT	12,27/150
		4.30							PP	500->600kPa
	72									

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

PLANT: Truck Mounted
METHOD: Solid flight auger TC Bit to 6.0m
REMARKS:

OPERATOR: Traccess Drilling

LOGGED: Lloyd
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 76.8 AHD
COORDINATE: E:348261.0, N:6380727.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH14
PROJECT No: 226603.00
DATE: 07/02/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	71	5.00	Sandy CLAY (CI): brown mottled orange; medium plasticity; fine sand.		RS possibly XWM	H	w<PL		SPT		5.50 – 5.65	SPT	22/150
	70, 69, 68, 67	6	Borehole discontinued at 6.00m depth. Limit of investigation.										

Depth scale: 5.00, 6, 7, 8, 9

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

PLANT: Truck Mounted
OPERATOR: Traccess Drilling
LOGGED: Lloyd
METHOD: Solid flight auger TC Bit to 6.0m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 58.4 AHD
COORDINATE: E:347589.0, N:6382208.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH15
PROJECT No: 226603.00
DATE: 02/02/24
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL / DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
02/02/24 No free groundwater observed	58.4	0.00	Silty SAND (SM): pale brown to pale orange; fine. From 0.00m-0.10m: with rootlets		ALV	L (to 1.50), MD (1.50–3.50)	D (to 0.10), M		D	0.40–0.50		
									SPT	1.00–1.45	SPT	3,3,4 N=7
									SPT	2.50–2.95	SPT	6,8,10 N=18
		3.50	Silty Sandy CLAY (CL): pale grey; low plasticity.		RS possibly XWM	VSt to H	w=PL		D	3.60–3.70		
		3.80	SANDSTONE: pale grey; fine, possibly very low to low strength.						SPT	4.00–4.10	SPT	(HB)
		4.10									PP	>600kPa

Borehole discontinued at 4.10m depth.
Limit of investigation, SPT refusal on sandstone.

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger TC Bit to 4.1m
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Chaplin
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 48.1 AHD
COORDINATE: E:346921.1, N:6383862.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH16
PROJECT No: 226603.00
DATE: 15/02/24
SHEET: 1 of 2

CONDITIONS ENCOUNTERED

Groundwater: 15/02/24 No free groundwater observed whilst augering

Depth (m)	Description of Strata	Origin(#)	Consis./Density (*)	Moisture	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
0.10	TOPSOIL / SAND (SP), with clay: pale brown to brown; fine to coarse; abundant organics.	TOP	NA	D									
0.80	SAND, with clay, trace gravel: pale brown to brown; fine to coarse; sub-angular to sub-rounded gravel; gravel content appears to be natural.	RS	L to MD	D						D D	0.20 0.50		
1.70	Clayey SAND (SC), trace gravel: brown mottled orange; fine to coarse; sub-angular to sub-rounded gravel; gravel content appears to be natural.	RS	MD	M						D SPT/D	1.00 1.00–1.45	SPT	10,9,7 N=16
2.10	Silty SAND (SM), with gravel: orange brown; fine to coarse; sub-angular to sub-rounded gravel; (extremely weathered sandstone).	XWM	ND	D									
2.50	SANDSTONE: brown; inferred very low to low strength, highly to moderately weathered		ND	ND									
	SANDSTONE: dark grey, fine to coarse grained 2.60m-3.10m: with occasional coarse size pebbles 2.75m: calcite vein (white)				SW to FR	M	100	98	2.55m: DB 2.79m: P, SH, PR, RF 3.10m: P, SH, PR, RF 3.33m: JT, SH/20°, PR, RF 4.02m: DB				
	4.08m-4.22m: fragmented zone						100	86	4.08-4.22m: FG, with river gravels / pebbles 4.53m: P, SH, IR, RF				

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 2.5m, NMLC coring to 6.4m
CASING: HQ to 2.5m
REMARKS: Test location approx 20m off nearby creek

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 48.1 AHD
COORDINATE: E:346921.1, N:6383862.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH16
PROJECT No: 226603.00
DATE: 15/02/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	43		[CONT] SANDSTONE: dark grey, fine to coarse grained					SW to FR		M	100	86		5.30m: DB 5.48m: DB						
	42	6	6.00m-6.20m: with occasional coarse size pebbles								100	96		5.70m: DB 6.15-6.19m: FG 6.40m: DB				6		
		7	Borehole discontinued at 6.40m depth. Auger TC refusal / Change to NMLC coring.																	
		8																		
		9																		

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 2.5m, NMLC coring to 6.4m
CASING: HQ to 2.5m
REMARKS: Test location approx 20m off nearby creek

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	48.1 AHD	**LOCATION ID:**	BH16
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:346921.1, N:6383862.2	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	15/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.50-6.40 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 35.1 AHD
COORDINATE: E:345839.8, N:6384574.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH17
PROJECT No: 226603.00
DATE: 06/02/24
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
06/02/24 No free groundwater observed	35		FILL / Clayey SILT (ML), with sand: brown; low plasticity; fine sand.		FILL	NA	w<PL		D			
		0.30	Sandy CLAY (CH), with silt: brown; high plasticity; fine sand.		RS possibly ALV	VSt to H	w<PL w=PL		D	0.50		
	34	1							D	1.00		
									SPT/D		SPT	8,10,11 N=21
										1.45	PP	450-500kPa
	33	2										
		2.20	Sandy CLAY, with silt: mottled pale grey orange; low to medium plasticity; fine sand; grading to extremely weathered material.		RS	H	NA		D	2.30		
										2.50		
									D/SPT		SPT	8,12,21 N=33
	32	3								2.95	PP	500-600kPa
	31	4	Borehole discontinued at 3.60m depth. Limit of investigation.									

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

PLANT: Truck Mounted
METHOD: Solid flight auger TC Bit to 3.6m
REMARKS:

OPERATOR: Traccess Drilling

LOGGED: Lloyd
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 28.5 AHD
COORDINATE: E:343308.5, N:6385172.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH18
PROJECT No: 226603.00
DATE: 06/03/24
SHEET: 1 of 2

Groundwater	RL (m)	Depth (m)	Description of Strata	Origin(#)	Consis.(*) / Density (*)	Moisture	Sample Type	Sample Interval / Depth (m)	Test Type	Results and Remarks
	28.5	0.00	Silty CLAY (CI): brown mottled orange; medium plasticity.	ALV	H	w<PL	D	0.40–0.50		
							SPT	1.00–1.45	SPT	9,11,16 N=27
									PP	>600kPa
		1.90	Silty CLAY (CL), with sand: dark brown; low plasticity; fine sand.	ALV	St	w>PL	SPT	2.50–2.95	SPT	3,4,5 N=9
									PP	160-200kPa
		3.30	SAND (SC), with clay: grey mottled orange brown; fine to medium.	ALV	MD	M				
Free groundwater observed at 4.5m 06/03/24						W	SPT	4.00–4.45	SPT	7,13,15 N=28
		4.70	SANDSTONE: grey; fine.							

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

PLANT: Comacchio GEO 405
OPERATOR: Ground Test
LOGGED: Chaplin
METHOD: SFA to 5.0m, NMLC to 7.16m
CASING: HWT to 5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 28.5 AHD
COORDINATE: E:343308.5, N:6385172.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH18
PROJECT No: 226603.00
DATE: 06/03/24
SHEET: 2 of 2

Depth (m)	Description of Strata	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks	Test Type	Results and Remarks
5.00	PEBBLY SANDSTONE: grey, fine grained	FR	5.00	H	100	100			
6								PLT PLT	PL(D)=2.2MPa PL(A)=2.4MPa
							6.90m: DB		
7								PLT PLT	PL(D)=2.3MPa PL(A)=2.4MPa
	Borehole discontinued at 7.16m depth. Limit of investigation.								

RL (m): 23, 22

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

PLANT: Comacchio GEO 405
METHOD: SFA to 5.0m, NMLC to 7.16m
REMARKS:

OPERATOR: Ground Test

LOGGED: Chaplin
CASING: HWT to 5m

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	28.5 AHD	**LOCATION ID:**	BH18
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:343308.5, N:6385172.0	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	06/03/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 5.00-7.16 m depth

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 52.5 AHD
COORDINATE: E:341331.3, N:6385056.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH19
PROJECT No: 226603.00
DATE: 16/02/24
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
16/02/24 No free groundwater observed		0.10	TOPSOIL / Silty SAND (SM), trace clay: dark brown to dark grey; fine to coarse; abundant organics.	TOP	NA	D				
		0.30	Sandy CLAY (CI), with silt: dark grey; medium plasticity; fine to medium sand.	COL	H	w<PL	D	0.20	PP	>400kPa
	52	2.00	Silty CLAY (CH): dark grey mottled orange; high plasticity. 1.30m: with mottled red and orange colouring	RS	St to VSt	w=PL	D	0.50	PP	100-150kPa
	51						D	1.00	PP	100-110kPa
							SPT/D	1.00–1.45	SPT	3,4,4
	50	3.70	Silty CLAY (CH), trace sand: grey orange mottled red; high plasticity; fine to medium sand; grading towards extremely weathered sandstone / siltstone.	RS	VSt to H	ND		2.50	PP	>400kPa
	49						D/SPT	2.50–2.95	SPT	7,9,14
	48		Silty CLAY (CL), with sand, with gravel: brown grey; low plasticity; fine to medium sand; sub-angular to sub-rounded gravel; gravel comprised of sandstone / siltstone fragments, extremely weathered sandstone / siltstone.	XWM	ND	w<PL	D/SPT	4.00–4.14	SPT	25/140

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

PLANT: Multidril 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 5.5m, SPT refusal 5.5m to 5.53m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 52.5 AHD
COORDINATE: E:341331.3, N:6385056.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH19
PROJECT No: 226603.00
DATE: 16/02/24

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] Silty CLAY (CL), with sand, with gravel: brown grey; low plasticity; fine to medium sand; sub-angular to sub-rounded gravel; gravel comprised of sandstone / siltstone fragments, extremely weathered sandstone / siltstone.		XWM	ND	w<PL						
	47	5.20	SANDSTONE: grey mottled brown; fine to medium grained, inferred very low to low strength, highly to moderately weathered.			ND	ND		D/SPT		5.50	SPT	20/30
			Borehole discontinued at 5.53m depth. SPT refusal (hammer bouncing) on inferred very low to low strength sandstone .										
	46	6											
	45	7											
	44	8											
	43	9											

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

Generated with CORE-GS by Geroc - Soil Log

PLANT: Multidril 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 5.5m, SPT refusal 5.5m to 5.53m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook
SURFACE LEVEL: 82.7 AHD
COORDINATE: E:340013.7, N:6385240.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: BH20
PROJECT No: 226603.00
DATE: 06/02/24
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
06/02/24 No free groundwater observed	0.00–0.20	FILL / Silty CLAY (CL), trace sand, trace gravel: brown; low plasticity; fine to medium sand; sub-angular to sub-rounded gravel; road embankment fill.	FILL	NA	w<PL	D	0.10		
	0.20–2.10	Silty CLAY (CH), trace sand: orange brown pale grey; high plasticity; fine sand; grading towards extremely weathered sandstone.	RS	H	w<PL	D	0.50		
						D	1.00		
						D		SPT	8,12,25/70
						SPT	1.00–1.37		
							1.45	PP	>600kPa
	2.10–2.52	Silty SAND (SM), trace clay: brown; fine to coarse; extremely weathered sandstone.	XWM	NA	D	D	2.20		
						D/SPT	2.50	SPT	25/20

Borehole discontinued at 2.52m depth.
SPT refusal on inferred sandstone bedrock.

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess Drilling
LOGGED: Lloyd
METHOD: Solid flight auger with TC Bit to 2.5m, SPT refusal 2.5m to 2.52m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 45.3 AHD
COORDINATE: E:338082.4, N:6385777.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH21
PROJECT No: 226603.00
DATE: 07/02/24
SHEET: 1 of 1

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
0.00–0.20	Sandy SILT (ML): brown; low plasticity; fine sand.	ALV	St	w<PL	D	0.00–0.20		
0.20–2.50	Sandy CLAY (CL-CI), with silt: pale brown; low to medium plasticity; fine sand.	ALV	St to VSt	w<PL	D	0.40–0.60		
					D	0.80–1.00		
					SPT	1.00–1.45	SPT	5,5,5 N=10
						1.45	PP	150-300kPa
2.50–4.00	Clayey SAND (SC), trace gravel: brown mottled pale orange; fine to coarse; fine, sub-angular to sub-rounded gravel. 3.50m-4.00m: Possible bands of gravel / cobbles	ALV	MD	M (to ~3.6m); W	SPT	2.50–2.95	SPT	4,5,6 N=11
						2.95	PP	50kPa
4.00–4.90	Sandy CLAY (CI), trace gravel: grey mottled pale brown orange; medium plasticity; fine to medium sand; fine, sub-angular to sub-rounded gravel.	RS	VSt to H	w<PL	SPT	4.00–4.45	SPT	16,8,14 N=22
						4.45	PP	>600kPa
4.90	Borehole discontinued at 4.90m depth. Refusal on possible sandstone.							

GROUNDWATER: ▼ Free groundwater observed at 4.1m 07/02/24

RL (m): 45, 44, 43, 42, 41

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

PLANT: Truck Mounted
OPERATOR: Traccess Driling
LOGGED: Lloyd
METHOD: Solid flight auger TC Bit to 4.9m
CASING: Uncased
REMARKS: Bore hole drilled to 3.5m, refused on cobble, moved 1.7m

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid	**SURFACE LEVEL:** 97.2 AHD	**LOCATION ID:** BH22
PROJECT: Hunter Pole Replacement Program	**COORDINATE:** E:336057.6, N:6386010.9	**PROJECT No:** 226603.00
LOCATION: Kurri Kurri to Muswellbrook	**DATUM/GRID:** MGA2020 Zone 56	**DATE:** 08/02/24
	DIP/AZIMUTH: 90°/---°	**SHEET:** 1 of 2

Groundwater: 08/02/24 No free groundwater observed

Depth (m)	RL (m)	Description of Strata	Origin	Consis./Density	Moisture
0.00–0.10		TOPSOIL / Clayey SAND (SC), with gravel: dark brown; fine to coarse; fine to coarse, sub-angular to sub-rounded gravel; abundant organics.	TOP	NA	M
0.10–0.30	97	Clayey SAND (SC), with gravel: dark brown; fine to coarse; fine to coarse, sub-angular to sub-rounded gravel; gravel appears to be natural.	COL	MD	M
0.30–0.50		Sandy CLAY (CI): brown mottled red; medium plasticity; fine to medium sand.	RS possibly COL	H	w<PL
0.50–1.80	96	Silty SAND, with gravel: pale brown; fine to coarse; fine to medium, sub-angular to sub-rounded gravel; gravels are rock fragments, extremely weathered sandstone.	XWM	ND	D
1.80–1.86		CORE LOSS			
1.86–	95, 94, 93	PEBBLY SANDSTONE: brown to dark brown; with subrounded to subangular fragments and pebbles up to 20mm, possible conglomerate 2.50m: colour change to grey to dark grey with subrounded to subangular fragments up to 20mm			

Rock

Depth (m)	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks
1.80–1.86	Core loss				
1.86–2.00					
2.00–2.50	MW	M			1.86-2.50m: FG
2.50–	SW	M	96	54	2.65m: P, SH, PR, RF
					3.30m: DB
			100	99	4.17m: JT, 10°, UN, RF
			100	100	4.87m: DB

Sampling & Testing

Type	Depth (m)	Test Type	Results and Remarks
D	0.20		
D	0.40	PP	>400kPa
D	0.70		
D/SPT	1.00–1.14	SPT	20/140 Refusal

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

PLANT: Multidrill 4.0T **OPERATOR:** Traccess **LOGGED:** Reiher-Smith

METHOD: Solid flight auger TC Bit to 1.8m, NLMC to 6.45m **CASING:** HQ to 1.8m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 97.2 AHD
COORDINATE: E:336057.6, N:6386010.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH22
PROJECT No: 226603.00
DATE: 08/02/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	92		[CONT] PEBBLY SANDSTONE: brown to dark brown; with subrounded to subangular fragments and pebbles up to 20mm, possible conglomerate					SW		M to H	100	100		6.20m: DB						
	91	6												6.45m: DB				6		
		7	Borehole discontinued at 6.45m depth. Auger TC refusal / change to NMLC coring.																	
		8																		
		9																		

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 1.8m, NLMC to 6.45m
CASING: HQ to 1.8m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	97.2 AHD	**LOCATION ID:**	BH22
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:336057.6, N:6386010.9	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	08/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 2: 1.80-6.00 m depth

Box 2 of 2: 6.00-6.45 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 66.2 AHD
COORDINATE: E:335311.3, N:6386365.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH23
PROJECT No: 226603.00
DATE: 09/02/24
SHEET: 1 of 2

CONDITIONS ENCOUNTERED | SAMPLE | TESTING

Groundwater: 09/02/24 No free groundwater observed whilst augering

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE
66	0.10	TOPSOIL / Silty SAND (SM), with clay: dark brown; fine to coarse; abundant organics.	TOP	NA	M
	0.30	Silty CLAY (CH), trace sand: dark brown mottled red; high plasticity; fine to medium sand.	RS	St to VSt	w=PL
	0.80	Silty CLAY (CH), trace sand, trace gravel: red; high plasticity; sub-angular to sub-rounded gravel; gravel content appears natural.	RS	H	w<PL
65	2.20	Sandy CLAY (CI), trace gravel: red pale grey mottled orange; medium plasticity; fine to medium sand; sub-angular to sub-rounded gravel; gravel content appears natural, composed of sandstone fragments, grading towards extremely weathered sandstone.	RS possibly XWM	VSt to H	w<PL
64	2.70	SANDSTONE: grey brown; inferred very low to low strength, highly weathered, possibly pebbly sandstone		ND	ND
63, 62		SANDSTONE: dark grey, fine to medium grained; with ironstain laminations dipping 10°-20° 3.84m-3.85m: interbedded clay seam 4.07m-4.13m: interbedded claystone band 4.10m-4.50m: red staining 4.28m-4.34m: interbedded claystone band 4.50m-4.60m: interbedded claystone band			

ROCK

WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS
MW	2.70–4.10	L	100	90	2.70-2.74m: FG 2.90m: JT, 10°, PR, SN Fe, RF 3.06-3.08m: FG 3.50m: DB
			100	86	3.50-3.52m: FG 3.74-3.78m: FG 3.89m: JT, 10°, PR, RF 3.92-4.02m: FG
HW to MW	4.10–4.60				
MW	4.60–				4.88m: DB

SAMPLE / TESTING

TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
D	0.20	PP	150-250kPa
D	0.50	PP	>400kPa
D	1.00	PP	>400kPa
SPT/D	1.00–1.45	SPT	14,11,13 N=24
D/SPT	2.50–2.61	SPT	20/110 Refusal

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

Generated with CORE-GS by Geroc - Combined Log

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 2.7m NLMC to 6.5m
CASING: HQ to 2.7m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 66.2 AHD
COORDINATE: E:335311.3, N:6386365.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH23
PROJECT No: 226603.00
DATE: 09/02/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	61 60	6	[CONT] SANDSTONE: dark grey, fine to medium grained; with ironstain laminations dipping 10°-20° 5.20m-6.50m: occasional coarse grained fragments / pebbles					MW SW SW to FR	5.02 5.80	L M	100 100	86 51		5.02m: DB 5.12m: P, SH, PR, RF 5.25m: P, SH, PR, RF 5.35m: DB 5.42m: P, SH, IR, RF 5.49-5.54m: FG 5.60m: JT, 20°, PR, RF 5.67-5.69m: FG 5.74m: JT, 30°, PR, RF 5.82m: P, SH, PR, RF 5.90m: JT, 30-40°, PR, SN Fe, RF 6.02m: JT, 10°, UN, RF 6.47m: DB 6.50m: DB				6		
		7 8 9	Borehole discontinued at 6.50m depth. Auger TC refusal / change to NMLC coring.																	

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 2.7m NLMC to 6.5m
CASING: HQ to 2.7m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	66.2 AHD	**LOCATION ID:**	BH23
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:335311.3, N:6386365.8	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	09/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.70-6.50 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 62.6 AHD
COORDINATE: E:334579.7, N:6386714.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH24
PROJECT No: 226603.00
DATE: 09/02/24
SHEET: 1 of 2

Groundwater: 09/02/24 No free groundwater observed whilst augering

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
0.10	TOPSOIL / Sandy SILT (ML), with clay: dark brown; low plasticity; fine to medium sand; abundant organics.	TOP	NA	w<PL										
0.30		COL	F	w<PL							D	0.20		
	Sandy SILT (ML), with clay: dark brown to brown; low plasticity; fine to medium sand.										D	0.50		
	Silty CLAY (CH), with sand: orange brown; high plasticity; fine to medium sand.	RS	St to VSt	w<PL w=PL							D	1.00	PP	350-400kPa
											SPT/D	1.00–1.45	SPT	5,4,9 N=13
2.20	SANDSTONE: grey brown; inferred very low to low strength, highly weathered		ND	ND							D/SPT	2.50–2.63	SPT	20/130 Refusal
2.65	SANDSTONE: grey brown orange; occasional ironstaining				MW	2.65–3.30	L	100	76	2.65-2.83m: FG; 3.05-3.08m: FG; 3.22m: DB; 3.28m: DB				
					MW to SW	3.30–	L to M	100	20	3.38m: DB; 3.47m: DB; 3.52m: DB; 3.52-3.74m: FG; 3.80m: P, SH, PR, TI, RF; 3.81-3.89m: JT, SV, PR, RF; 3.91m: P, SH, PR, RF; 4.00-4.04m: FG; 4.11m: P, SH, PR, RF; 4.19-4.30m: FG; 4.47-4.53m: FG; 4.68m: JT, 10°, UN, RF; 4.73-4.95m: FG				

RL (m): 62 at ~0.6 m; 61 at ~1.6 m; 60 at 2.6 m; 59 at 3.6 m; 58 at 4.6 m.

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 2.65m, NMLC to 6.5m
CASING: HQ to 2.65m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Generated with CORE-GS by Geroc - Combined Log

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 62.6 AHD
COORDINATE: E:334579.7, N:6386714.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH24
PROJECT No: 226603.00
DATE: 09/02/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	57	6	[CONT] SANDSTONE: grey brown orange; occasional ironstaining					MW to SW	5.30	L to M	100	88		5.00m: DB 5.09-5.11m: FG 5.24-5.28m: FG				6		
								FR		M to H				6.18m: DB 6.50m: DB						
		7 8 9	Borehole discontinued at 6.50m depth. Auger TC refusal / change to NMLC coring.																	

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 2.65m, NMLC to 6.5m
CASING: HQ to 2.65m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	62.6 AHD	**LOCATION ID:**	BH24
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:334579.7, N:6386714.5	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	09/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.65-6.50 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 81.5 AHD
COORDINATE: E:334038.5, N:6386979.4
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH25
PROJECT No: 226603.00
DATE: 07/02/24
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
07/02/24 No free groundwater observed		0.20	FILL / Sandy CLAY (CI), with gravel: dark brown; medium plasticity; fine to coarse sand; fine to coarse gravel.		FILL	NA	w=PL		D/ES	0.20		
	81	0.60	FILL / Clayey Sandy GRAVEL (GC): pale brown; fine to coarse, sub-angular to sub-rounded; fine to coarse sand.		FILL	NA	D		ES D	0.40–0.50 0.50–0.60		
		1.00	Silty CLAY (CI), trace sand, trace gravel: pale brown; medium plasticity; fine to medium sand; fine, sub-angular to sub-rounded gravel; gravels are rock fragments.		RS and XWM	H	w<PL		D	0.80–1.00		
			SILTSTONE; grey brown, possible very low strength, extremely to highly weathered.			NA	NA		SPT	1.00–1.05	SPT	10/50

Borehole discontinued at 1.40m depth.
Refusal on possible siltstone.

RL scale: 80, 79, 78, 77. Depth scale: 2, 3, 4.

Generated with CORE-GS by Geroc - Soil Log

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

PLANT: Truck Mounted
OPERATOR: Traccess Drilling
LOGGED: Lloyd
METHOD: Solid flight auger TC Bit to 1.4m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 39.1 AHD
COORDINATE: E:332021.5, N:6387273.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH26
PROJECT No: 226603.00
DATE: 05/03/24
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
05/03/24 No free groundwater observed	39, 38	1	Silty Sandy CLAY (CI): brown; medium plasticity; fine to medium sand. 0.00m-0.20m: abundant rootlets		ALV	VSt to H	w<PL		D		0.80 – 1.00		
		1.40	Silty Sandy CLAY (CI): yellow brown; medium plasticity; fine to medium sand.		ALV	VSt to H	w<PL		D		1.50 – 1.60		
	37	2	Borehole discontinued at 1.80m depth. Refusal on hard object.										

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

PLANT: Hand Auger
METHOD: Hand tools to 1.8m
REMARKS:

OPERATOR: Douglas Partners

LOGGED: Chaplin
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 106.5 AHD
COORDINATE: E:329598.3, N:6387882.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH27
PROJECT No: 226603.00
DATE: 08/02/24
SHEET: 1 of 2

Groundwater: 08/02/24 No free groundwater observed

RL (m)	Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
	0.10	TOPSOIL / Clayey SAND (SC), with silt: dark brown; fine to medium; abundant organics and rootlets.	TOP	NA	M									
	0.30	Silty CLAY (CL), with sand: dark brown; low plasticity.	RS possibly COL	H	w<PL						D	0.20	PP	>400kPa
106	0.90	Silty SAND (SM), with clay: pale brown; fine to coarse; grading towards extremely weathered material.	RS possibly XWM	MD to D	D						D; D	0.50; 0.80		
105	2.50	Sandy CLAY (CI): pale brown mottled grey; medium plasticity; fine sand; extremely weathered sandstone.	XWM	NA	w<PL						D/SPT	1.00–1.45	PP; SPT	400-500kPa; 15,17,17 N=34
104–102	2.50–4.80	SANDSTONE: brown orange, fine to medium grained; with ironstaining. 2.60m: occasional pale grey bands				MW to SW	L to M	100 (2.50–4.02); 97 (4.02–)	97; 47	2.60-2.61m: FG; 2.71m: JT, 10°, PR, RF; 2.98m: JT, 20°, PR, RF; 3.90m: JT, 20°, PR, RF; 4.02m: DB; 4.02-4.14m: FG; 4.17-4.28m: JT, SV-80, PR, TI, RF; 4.35m: P, SH, PR, RF; 4.41m: JT, 10°, PR, TI, RF				
	4.80					HW	VL			4.80-5.02m: FG				

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 2.5m, NMLC to 6.8m
CASING: HQ to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 106.5 AHD
COORDINATE: E:329598.3, N:6387882.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH27
PROJECT No: 226603.00
DATE: 08/02/24

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS
		[CONT] SANDSTONE: brown orange, fine to medium grained; with ironstaining	HW		VL	97	47	5.08-5.14m: FG
	5.14	CORE LOSS		5.14				
	5.19	SANDSTONE: grey, fine to medium grained 5.40m-6.10m: with ironstaining 6.52m-6.57m: with ironstaining	SW to FR	5.19	M to H	100	100	5.52m: DB 5.98m: DB 6.55m: DB 6.70m: DB 6.80m: DB

RL markers: 101, 100. Depth markers: 6, 7, 8, 9.

Borehole discontinued at 6.80m depth.
Auger TC refusal / change to NMLC coring.

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger TC Bit to 2.5m, NMLC to 6.8m
CASING: HQ to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	106.5 AHD	**LOCATION ID:**	BH27
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:329598.3, N:6387882.6	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	08/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.50-6.80 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 70.7 AHD
COORDINATE: E:327951.7, N:6387898.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH28
PROJECT No: 226603.00
DATE: 12/04/24
SHEET: 1 of 2

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	0.00–0.60	FILL / Silty CLAY (CH): dark brown; high plasticity; with rootlets.	FILL	NA	w>PL				
	0.60–3.50	Silty CLAY (CH), trace gravel: mottled dark brown, brown; high plasticity; fine to medium, rounded to sub-rounded gravel.	ALV	F to St	w=PL	SPT	1.00–1.45	SPT	2,4,5 N=9
								PP	210kPa
						SPT	2.50–2.95	SPT	2,4,4 N=8
								PP	350kPa
Free groundwater observed at 4.7 (12/04/24)	3.50–	Silty CLAY (CI), with sand: orange brown; medium plasticity; fine sand.	RS	VSt	w<PL	SPT	4.00–4.45	SPT	6,8,10 N=18
								PP	390kPa

RL (m): 70 at ~0.7 m, 69 at ~1.7 m, 68 at ~2.7 m, 67 at ~3.7 m, 66 at ~4.7 m.

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

PLANT: Ute Rig
OPERATOR: Hydro Drilling
LOGGED: Duffy
METHOD: Solid flight auger to 6.0m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 70.7 AHD
COORDINATE: E:327951.7, N:6387898.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH28
PROJECT No: 226603.00
DATE: 12/04/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] Silty CLAY (CI), with sand: orange brown; medium plasticity; fine sand.		RS	VSt	w<PL		SPT		5.50–5.60	SPT	25/125
	65	5.60	SANDSTONE: grey; fine.		XWM							PP	>600kPa
		6	Borehole discontinued at 6.00m depth. Limit of investigation.										

RL scale: 65, 64, 63, 62, 61. Depth scale: 6, 7, 8, 9.

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

PLANT: Ute Rig
OPERATOR: Hydro Drilling
LOGGED: Duffy
METHOD: Solid flight auger to 6.0m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 99.7 AHD
COORDINATE: E:327190.0, N:6387844.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH29
PROJECT No: 226603.00
DATE: 14/02/24
SHEET: 1 of 2

GROUNDWATER: 14/02/24 No free groundwater observed whilst augering

Depth (m)	Description of Strata	Origin(#)	Consis./Density (*)	Moisture	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks
0.00–0.10	TOPSOIL / Silty SAND (SM), with clay: dark brown brown; fine to coarse; abundant organics.	TOP	NA	D					
0.10–0.30		COL possibly RS	MD	D					
0.30	Silty SAND (SM), with clay: brown; fine to coarse.								
–0.80	Silty CLAY (CI), trace sand: brown; medium plasticity; fine sand.	RS	H	w<PL					
0.80–1.80	Silty CLAY (CH), with sand: orange brown; high plasticity; fine to medium sand.	RS	VSt to H	w<PL					
1.80–2.50	Silty SAND (SM), with clay, with gravel: brown; fine to coarse; sub-angular to sub-rounded gravel; gravel composed of sandstone fragments, extremely weathered.	XWM		D					
2.50–	SANDSTONE: brown, fine to medium grained 4.20m-4.90m: with dark grey bands 4.40m: occasional iron staining				SW	2.50–3.60: M; 3.60–: M-H	100 (2.50–3.90); 100 (3.90–)	64; 96	2.50-2.56m: FG 2.60m: DB 2.78m: DB 2.90m: DB 2.95-3.00m: FG 3.08m: DB 3.13m: DB 3.16m: DB 3.27-3.57m: FG 3.60m: JT, 30°-40°, PR, RF 3.79m: DB 3.90m: DB 4.00-4.04m: FG 4.18m: DB 4.42m: DB 4.70m: DB 4.88m: P, SH, PR, RF 5.00m: DB, quartz

RL (m): 99, 98, 97, 96, 95

Samples and Testing

Type	Depth (m)	Test Type	Results and Remarks
D	0.20		
D	0.50		
D	1.00		
D	1.00–1.45	SPT	4,5,6 N=11
	1.45	PP	400-500kPa
D	2.00		

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

PLANT: Multidrill 4.0T
OPERATOR: Tracess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 2.5m, NMLC coring to 6.4m
CASING: HQ to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 99.7 AHD
COORDINATE: E:327190.0, N:6387844.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH29
PROJECT No: 226603.00
DATE: 14/02/24

CONDITIONS ENCOUNTERED														SAMPLE				TESTING	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL: ORIGIN(#)	SOIL: CONSIS.(*) DENSITY.(*)	SOIL: MOISTURE	ROCK: WEATH.	ROCK: DEPTH (m)	ROCK: STRENGTH (VL L M H VH EH)	ROCK: RECOVERY (%)	ROCK: RQD	ROCK: FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE / RESULTS AND REMARKS
	94	6	[CONT] SANDSTONE: brown, fine to medium grained 4.88m: crystalline inclusions / possible quartz band From 5.12m: dark grey					SW FR	5.12	M to H	100 100	96 100		lam / inf 5.08m: DB 5.47m: DB 5.83m: DB 6.40m: DB				6	
		7 8 9	Borehole discontinued at 6.40m depth. Auger TC refusal / change to NMLC coring.																

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

Generated with CORE-GS by Geroc - Combined Log

PLANT: Multidrill 4.0T
OPERATOR: Tracess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 2.5m, NMLC coring to 6.4m
CASING: HQ to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	99.7 AHD	**LOCATION ID:**	BH29
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:327190.0, N:6387844.5	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	14/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.50-6.40 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 114.3 AHD
COORDINATE: E:325150.5, N:6388029.4
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH30
PROJECT No: 226603.00
DATE: 14/02/24
SHEET: 1 of 2

Groundwater: 14/02/24 No free groundwater observed whilst augering

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture
0.00–0.30	FILL / Sandy GRAVEL (GP), trace clay: brown grey; sub-angular to sub-rounded; fine to coarse sand; gravel composed of crushed quarried rock, access track material.	FILL	NA	D
0.30–0.80	Silty CLAY (CH): brown orange; high plasticity.	RS	VSt	w<PL or w=PL
0.80–2.70	Silty CLAY (CH), trace sand, trace gravel: brown mottled orange; high plasticity; fine sand; sub-angular to sub-rounded gravel; trace carbonaceous inclusions, gravel content appears to be natural.	RS	VSt to H	w<PL or w=PL
2.70–2.90	SANDSTONE: brown, fine to coarse grained; inferred very low strength, highly weathered			ND
2.90–	SANDSTONE: brown orange pale grey, fine to coarse grained; trace interbedded pebbles / fragments (pebbles / fragments are sub-rounded to sub-angular up to 8mm in size, with iron staining. 3.00m-4.25m: with interbedded clay infill bands			

RL (m): 114, 113, 112, 111, 110

Rock

Weath.	Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks
HW	2.90–4.25	VL	100	13	2.90-4.25m: FG
HW to MW	4.25–4.48	L			4.48m: DB
MW	4.48–	L to M	100	25	4.48-4.85m: FG; 4.89m: JT, 10°, PR, RF

Sample / Testing

Sample Type	Depth (m)	Test Type	Results and Remarks
ES/D	0.10		
D	0.50	PP	200->400kPa
D, D	1.00–1.45	SPT	5,7,7 N=14
	1.45	PP	>400kPa
D, D	2.50–2.89	SPT	5,15,20/90
	2.89	PP	>400kPa

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

PLANT: Multidrill 4.0T
OPERATOR: Tracess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 2.9m, NMLC coring to 6.1m
CASING: HQ to 2.9m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 114.3 AHD
COORDINATE: E:325150.5, N:6388029.4
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH30
PROJECT No: 226603.00
DATE: 14/02/24

CONDITIONS ENCOUNTERED															SAMPLE				TESTING	
					SOIL			ROCK												
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)	RECOVERY (%)	RQD	FRACTURE SPACING (m) (0.005 0.01 0.05 0.10 0.50 1.00 5.00)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	109	6	[CONT] SANDSTONE: brown orange pale grey, fine to coarse grained; trace interbedded pebbles / fragments (pebbles / fragments are sub-rounded to sub-angular up to 8mm in size, with iron staining 5.70m-6.10m: trace quartz fragments 5.75m-5.77m: quartz infill					MW	5.14	L to M	100	25		4.93-5.00m: FG 5.10-5.14m: FG				6		
									5.17 5.18	SEAM			SEAM	5.14-5.17m: CS, SH, PR, INF Clay, SM						
								MW	5.62	M				5.20m: JT, 10°-50°, UN, RF 5.29m: JT, 20°, PR, RF 5.32-5.34m: FG 5.41m: P, SH, PR, RF 5.50-5.53m: FG						
									5.63					5.62-5.63m: CS, SH, PR, INF Clay, SM						
								MW		M				5.63-5.66m: FG 5.76m: P, SH, PR, RF, quartz infill 5.86-5.88m: FG 5.92m: DB 6.00m: DB 6.10m: DB						
		7 8 9	Borehole discontinued at 6.10m depth. Auger TC refusal / change to NMLC coring.																	

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

PLANT: Multidrill 4.0T
OPERATOR: Tracess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 2.9m, NMLC coring to 6.1m
CASING: HQ to 2.9m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	114.3 AHD	**LOCATION ID:**	BH30
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:325150.5, N:6388029.4	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	14/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.90-6.10 m depth

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 45.2 AHD
COORDINATE: E:323733.9, N:6389235.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH31A
PROJECT No: 226603.00
DATE: 17/07/24
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
17/07/24 No free groundwater observed	0.00–0.30	FILL / Sandy CLAY: orange brown; high plasticity; fine to medium sand.	FILL	ND	M	A	0.20		
	0.30–4.10	CLAY, trace sand: orange brown; high plasticity. From 2.80m: with sand. From 3.70m: trace gravel (sandstone), possibly trace cobbles	RS	H	w=PL	A	0.40	PP	250-300kPa
						SPT	1.00–1.45	SPT / PP	5,11,17 N=28 / 350-450kPa
						SPT	2.50–2.95	SPT	5,10,8 N=18
	4.10–5.70	Sandy CLAY, trace gravel: grey mottled orange; high plasticity; fine to medium sand; fine, sub-angular gravel; extremely weathered sandstone.	XWM	H	w<PL	SPT	4.00–4.45	SPT	10,18,18 N=36
						SPT	5.50–5.70	SPT	25,25/50

Borehole discontinued at 5.70m depth.
Limit of investigation.

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

PLANT: DT100
METHOD: Solid fight auger
REMARKS:

OPERATOR: (Hickman)

LOGGED: Gawn / Huynh
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 75.5 AHD
COORDINATE: E:322012.6, N:6389688.7
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH32
PROJECT No: 226603.00
DATE: 05/03/24
SHEET: 1 of 2

CONDITIONS ENCOUNTERED

GROUNDWATER: 05/03/24 No free groundwater observed

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE
0.00	Silty CLAY (CH): brown; high plasticity. 0.00m-0.20m: abundant rootlets	RS	H	w<PL
0.40	Silty CLAY (CL-CI), with gravel: pale brown mottled orange; low to medium plasticity; angular to sub-angular gravel.	XWM	H	w<PL
1.80	SANDSTONE: yellow brown; interbedded extremely and highly weathered.			
2.50	CORE LOSS: 0.1m			
2.60	SANDSTONE: yellow brown, fine grained. 4.69m-4.86m: carbonate cemented			

RL (m): 75, 74, 73, 72, 71

ROCK

WEATH.	DEPTH (m)	STRENGTH
(core loss)	2.50–2.60	(core loss)
HW	2.60–2.94	L
HW	2.94–3.05	VL
HW	3.05–3.20	L
XW	3.20–3.25	SEAM
HW	3.25–4.29	M
XW	4.29–4.33	SEAM
HW	4.33–4.62	M
XW	4.62–4.69	SEAM
MW	4.69–4.86	VH
HW	4.86–4.96	L

RECOVERY (%): 97
RQD: 55

DEFECTS & REMARKS

- 2.66-2.76m: FC
- 2.82m: JT, SV, PR, Fe, RF
- 2.89-2.94m: P x3, 10°, PR, Clay, SM
- 2.94-3.05m: FC
- 3.20-3.25m: DS
- 3.45m: JT, 15-20°, PR, Fe, RF
- 3.60m: JT, 15-20°, PR, Clay, RF
- 3.65m: JT, 30°, PR, TI, RF
- 3.71m: JT, 30°, PR, TI, RF
- 3.79m: JT, 15-20°, PR, TI, RF
- 3.94m: JT, 60°, PR, TI Fe, RF
- 4.10m: JT, 15°, IR, Fe, RF
- 4.16m: JT, 35°, PR, TI, RF
- 4.29-4.33m: DS
- 4.37m: JT, 40°, PR, TI, RF
- 4.44m: JT, 20°, PR, Fe, RF
- 4.60m: P, 15°, PR, TI Clay, RF
- 4.62-4.69m: DS
- 4.84m: P, 15°, Fe
- 4.86m: P, 20°
- 4.86-4.96m: P x5,

SAMPLE

TYPE	INTERVAL DEPTH (m)
D	0.10 – 0.30
SPT	1.00 – 1.27

TESTING

TEST TYPE	RESULTS AND REMARKS
PP	>400kPa
SPT	20,25/150
PP	>600kPa
PLT	PL(A)=0.08MPa
PLT	PL(D)=0.54MPa
PLT	PL(A)=0.53MPa
PLT	PL(D)=0.50MPa
PLT	PL(A)=0.76MPa
PLT	PL(A)=0.65MPa
PLT	PL(D)=0.34MPa
PLT	PL(D)=3.2MPa
PLT	PL(A)=5.4MPa

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

PLANT: Comacchio Geo 405
OPERATOR: Ground Test (Douglas)
LOGGED: Chaplin
METHOD: SFA to 2.50m, NMLC to 6.0m
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 75.5 AHD
COORDINATE: E:322012.6, N:6389688.7
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH32
PROJECT No: 226603.00
DATE: 05/03/24
SHEET: 2 of 2

CONDITIONS ENCOUNTERED														SAMPLE				TESTING	
					SOIL			ROCK											
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)	RECOVERY (%)	RQD	FRACTURE SPACING (m) (0.005 0.05 0.50 1.00 5.00)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	70		[CONT] SANDSTONE: yellow brown, fine grained					HW		M	97 100	55 20		15°, PR, TI Clay, RF 5.14m: JT, 15°, PR, TI Fe, RF 5.40m: JT, 5°, PR, TI Fe, RF 5.53m: P, 15°, PR, Fe, RF 5.59m: P, 15°, PR, Fe, RF 5.64m: P, 15°, PR, Fe, RF 5.68m: P, 15°, PR, Clay, RF 5.78m: P, 15°, PR, Fe, RF 5.79m: P, 15°, PR, Fe, RF 5.85m: JT, 10°, IR, Fe, RF 5.93m: JT, 20°, PR, Fe, RF					PLT PLT PLT PLT	PL(A)=0.79MPa PL(D)=0.60MPa PL(D)=0.57MPa PL(A)=0.70MPa
		6	Borehole discontinued at 6.00m depth. Limit of investigation.																	
		7																		
		8																		
		9																		

Generated with CORE-GS by Geroc - Combined Log

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

PLANT: Comacchio Geo 405
OPERATOR: Ground Test (Douglas)
LOGGED: Chaplin
METHOD: SFA to 2.50m, NMLC to 6.0m
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	75.5 AHD	**LOCATION ID:**	BH32
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:322012.6, N:6389688.7	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	05/03/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.50-6.00 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 50.8 AHD
COORDINATE: E:321062.1, N:6392182.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH33C
PROJECT No: 226603.00
DATE: 12/04/24
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
12/04/24 No free groundwater observed			TOPSOIL / Silty CLAY (CH): dark brown; high plasticity; with rootlets.		TOP	NA	w=PL						
		0.20	Silty CLAY (CH), with sand, trace gravel: red brown; high plasticity; fine sand; sub-angular gravel.		RS	VSt	w<PL						
	50	1							SPT		1.00 – 1.45	SPT	4,4,4 N=8
												PP	>600kPa
	49	2									2		
						VSt			SPT		2.50 – 2.95	SPT	6,10,13 N=23
	48	3										PP	>600kPa
	47	4							SPT		4.00 – 4.45	SPT	8,12,16 N=28
	46											PP	>600kPa

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

PLANT: Ure Rig
OPERATOR: Hydro Drilling
LOGGED: Duffy
METHOD: Solid flight auger to 6.0m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 50.8 AHD
COORDINATE: E:321062.1, N:6392182.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH33C
PROJECT No: 226603.00
DATE: 12/04/24
SHEET: 2 of 2

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
		5.00	Sandy SILT (ML), with clay, trace gravel: red brown; fine sand; fine gravel.		RS possibly XWM	VSt	w<PL						
						H			SPT		5.50 – 5.95	SPT	10,15,18 N=33
	45										5.95	PP	>600kPa
		6	Borehole discontinued at 6.00m depth. Limit of investigation.										
	44	7											
	43	8											
	42	9											
	41												

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

PLANT: Ure Rig
OPERATOR: Hydro Drilling
LOGGED: Duffy
METHOD: Solid flight auger to 6.0m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 52.3 AHD
COORDINATE: E:318524.7, N:6396773.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH40
PROJECT No: 226603.00
DATE: 13/02/24
SHEET: 1 of 2

Groundwater: 13/02/24 No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	0.10	TOPSOIL / Silty SAND (SM), with clay: dark brown; fine to coarse; abundant organics.	TOP	NA	D				
	0.30	Silty SAND (SM), with clay: dark brown; fine to coarse.	ALV	MD	D	D	0.20		
52		Sandy CLAY (CH), with silt, trace gravel: dark grey; high plasticity; fine to medium sand; sub-angular to sub-rounded gravel; gravel content appears to be natural.	ALV	VSt to H	w<PL or w=PL	D	0.50		
51	1					D	1.00–1.45	SPT	6,8,9 N=17
							1.45	PP	>400kPa
50	2								
						D	2.50–2.95	SPT	6,7,7 N=14
49	3						2.95	PP	>400-kPa
	3.50	Silty CLAY (CH), with gravel, trace sand: brown; high plasticity; sub-rounded gravel; fine sand; gravel content appears to be natural, with interbedded river gravels / pebbles, with iron staining.	ALV	St to VSt	w=PL				
48	4					D	4.00–4.45	SPT	5,4,5 N=9
							4.45	PP	230-270kPa

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

PLANT: Multidrill 4.0T
METHOD: Solid flight auger with TC Bit to 6.0m
REMARKS:

OPERATOR: Tracess

LOGGED: Reiher-Smith
CASING: to 0m

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 52.3 AHD
COORDINATE: E:318524.7, N:6396773.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH40
PROJECT No: 226603.00
DATE: 13/02/24

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	47	5.00	Silty CLAY (CH): pale grey dark grey black; high plasticity; with carbonaceous inclusions, with iron staining.		RS	VSt	w<PL or w=PL		D		5.50 – 5.70		
		5.70	Sandy CLAY (CH), with silt, with gravel: orange brown; high plasticity; fine to coarse sand; sub-angular to sub-rounded gravel; gravel content appears to be natural.		RS	VSt	w<PL or w=PL		D		5.70 – 5.95	SPT	5,5,7 N=12
												PP	320-380kPa
		6										PP	250-300kPa
	46 – 43	6 – 9	Borehole discontinued at 6.00m depth. Limit of investigation.										

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

PLANT: Multidrill 4.0T
OPERATOR: Tracess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 6.0m
CASING: to 0m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 92.4 AHD
COORDINATE: E:319054.2, N:6399251.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH41
PROJECT No: 226603.00
DATE: 13/02/24
SHEET: 1 of 2

Groundwater: 13/02/24 No free groundwater observed whilst augering

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks
0.00–0.10	TOPSOIL / Silty SAND (SM): grey; fine to coarse; abundant organics.	TOP	NA	D						
0.10–0.80	Silty CLAY (CI), with sand: grey brown; medium plasticity; fine to medium sand.	RS possibly COL	H	w<PL						
0.80–2.30	Silty SAND (SM), with clay: pale grey orange; fine to coarse; continuous rock-like structure, extremely weathered sandstone.	XWM		D						
2.30–4.00	SANDSTONE: pale grey orange, fine to coarse grained; inferred very low strength, extremely to highly weathered 3.90m: Increased drilling resistance (hard)		ND	NDF						
4.00–4.38	SANDSTONE: orange grey, fine to coarse grained; with interbedded pebbles (lithic)				SW	4.00–4.38	M–H			4.05m: DB 4.29m: DB 4.38m: DB
4.38–4.46	CORE LOSS					4.38–4.46		91	42	
4.46–4.95	SANDSTONE: orange grey, fine to coarse grained; with interbedded pebbles (llithic)				HW MW	4.46–4.85 4.85–4.95	VL L	100	0	4.46-4.85m: FG, INF Clay 4.90m: DB

Sample Type	Interval / Depth (m)	Test Type	Results and Remarks
D	0.20		
D	0.50		
D	1.00–1.26	SPT	8,10/110 N=10
D	1.00–1.26		
	1.26	PP	>400kPa
D	2.50–2.63	SPT	20/130
	4.00		10/0

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

PLANT: Multidrill 4.0T
OPERATOR: Tracess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 4.0m, NMLC coring to 6.0m
CASING: HQ to 4m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 92.4 AHD
COORDINATE: E:319054.2, N:6399251.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH41
PROJECT No: 226603.00
DATE: 13/02/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] SANDSTONE: orange grey, fine to coarse grained; with interbedded pebbles (lithic)																	
	87	5.27	CLAYSTONE: pale grey orange; with iron staining 5.48m: Occasional dark grey laminations / bands					HW		VL	100	0		4.95-5.75m: FG						
											100	0		5.75-6.00m: FG						
		6	Borehole discontinued at 6.00m depth. Auger TC refusal / change to NMLC coring.																	

Depth scale: 7, 8, 9

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

PLANT: Multidrill 4.0T
OPERATOR: Tracess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 4.0m, NMLC coring to 6.0m
CASING: HQ to 4m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	92.4 AHD	**LOCATION ID:**	BH41
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:319054.2, N:6399251.8	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	13/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 4.00-6.00 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 65.4 AHD
COORDINATE: E:319753.7, N:6402230.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH42
PROJECT No: 226603.00
DATE: 16/02/24
SHEET: 1 of 2

Groundwater: 16/02/24 No free groundwater observed whilst augering

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks
0.00–0.10	TOPSOIL / Silty SAND (SM), trace clay: dark brown; fine to coarse; abundant organics.	TOP	NA	D						
0.10–2.20	Silty CLAY (CH), with sand: brown; high plasticity; fine to medium sand; trace carbonaceous inclusions .	ALV possibly RS	St to VSt	w=PL						
2.20–2.70	Silty SAND (SM), trace clay: pale grey pale brown; fine to coarse; extremely weathered sandstone.	XWM	NA	D						
2.70–	SANDSTONE: orange grey; with ironstaining, with fragments / pebbles, subrounded to subangular up to 5mm, possible pebbly sandstone				HW	2.70–2.79	VL	100	45	2.70-2.79m: FG
					HW	2.79–3.03	L			2.89m: HB
					HW	3.03–3.32	VL			3.03-3.29m: FG
					HW	3.32–3.44	L			3.30m: JT, 20°, IR, RF; 3.44-3.50m: FG
					HW	3.44–3.80	VL	100	77	3.50-3.80m: FG
	4.75m-4.90m: trace carbonaceous inclusions				MW	3.80–4.92	L			4.75m: P, SH, PR, RF
					HW	4.92–	VL			4.92-5.00m: FG

RL (m): 65, 64, 63, 62, 61

Sample Type	Depth (m)	Test Type	Results and Remarks
D	0.05		
D	0.50		
D	1.00	PP	350-390kPa
SPT/D	1.00–1.45	SPT	4,4,5 N=9
D/SPT	2.50–2.59	SPT	20/90 Refusal

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 2.7m, NMLC coring to 6.5m
CASING: HQ to 2.7m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Generated with CORE-GS by Geroc - Combined Log

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 65.4 AHD
COORDINATE: E:319753.7, N:6402230.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH42
PROJECT No: 226603.00
DATE: 16/02/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	60 59	6	[CONT] SANDSTONE: orange grey; with ironstaining, with fragments / pebbles, subrounded to subangular up to 5mm, possible pebbly sandstone 5.65m-5.75m: conglomerate band					MW to SW	5.00 6.00	L to M M	100	87		5.81m: P, SH, PR, RF 5.85-5.95m: JT, 60-70°, IR, RF 6.50m: DB				6		
		7 8 9	Borehole discontinued at 6.50m depth. Auger TC refusal / change to NMLC coring.																	

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 2.7m, NMLC coring to 6.5m
CASING: HQ to 2.7m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 65.4 AHD
COORDINATE: E:319753.7, N:6402230.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH42
PROJECT No: 226603.00
DATE: 16/02/24
SHEET: 1 of 1

Box 1 of 1: 2.70-6.50 m depth

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BOREHOLE LOG

CLIENT: Ausgrid	**SURFACE LEVEL:** 103.3 AHD	**LOCATION ID:** BH44	
PROJECT: Hunter Pole Replacement Program	**COORDINATE:** E:319277.9, N:6405749.7	**PROJECT No:** 226603.00	
LOCATION: Kurri Kurri to Muswellbrook	**DATUM/GRID:** MGA2020 Zone 56	**DATE:** 16/02/24	
	DIP/AZIMUTH: 90°/---°	**SHEET:** 1 of 2	

CONDITIONS ENCOUNTERED — SOIL / ROCK; **SAMPLE**; **TESTING**

Groundwater: 16/02/24 No free groundwater observed whilst augering

Depth (m)	Description of Strata	Origin(#)	Consis.(*) / Density(*)	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks
0.00–0.10	TOPSOIL / Clayey SAND (SC), with gravel: dark brown; fine to coarse; sub-angular to sub-rounded gravel; abundant organics.	TOP	NA	M						
0.10–0.30		COL	MD	M						
0.30–0.80	Clayey SAND (SC), with gravel: brown; fine to medium; sub-angular to sub-rounded gravel; with buried cobbles / boulders, boulders composed of ferruginised siltstone.	COL	MD to D	D						
0.80	Silty SAND (SM), with clay: red brown; fine to coarse.	XWM	ND	D						
~1.0–2.60	Silty SAND (SM), with gravel, trace clay: pale brown; fine to coarse; sub-angular to sub-rounded gravel; gravel content appears to be natural, extremely weathered sandstone. 2.60m-2.65m: interbedded sandstone band	XWM	ND	D						
2.60–2.87	SILTSTONE: orange brown				HW to MW	2.60–2.87	VL	100	0	2.60-3.32m: FG
2.87–3.73	SILTSTONE: orange grey; with ironstain laminations, with ironstaining / ironstain fill, possible claystone. 3.50m-3.70m: tuffaceous inclusions interbedded				HW (2.87–3.00); HW to MW (3.00–3.73)	2.87, 3.00, 3.73	VL	100	31	3.32-4.00m: FG
3.73–4.63	SILTSTONE: brown mottled grey orange; with ironstain laminations, possible claystone				HW (3.73–4.00); MW (4.00–4.50); HW to MW (4.50–)	4.00, 4.50	L (4.00–4.50); VL			4.50-4.92m: FG
4.63–4.85	SANDSTONE: orange brown; with ironstain laminations				HW to MW	4.85	VL			
4.85–					HW (4.85–4.92); SW (4.92–)	4.92	M	100	92	

Sample Type	Depth (m)	Test Type	Results and Remarks
D	0.20		
D	0.50		
D	1.00		
SPT/D	1.00–1.09	SPT	20/90 Refusal

RL (m): 103, 102, 101, 100, 99

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

PLANT: Multidrill 4.0T **OPERATOR:** Traccess **LOGGED:** Reiher-Smith

METHOD: Solid flight auger with TC Bit to 2.6m, NMLC coring to 6.37m **CASING:** HQ to 2.6m

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 103.3 AHD
COORDINATE: E:319277.9, N:6405749.7
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH44
PROJECT No: 226603.00
DATE: 16/02/24
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	98		SANDSTONE: grey orange; with ironstaining / ironstain infill					SW		M	100	92		5.02m: DB 5.47m: DB 5.55m: DB 5.58m: DB 5.78m: P, SH, PR, RF 5.85m: P, SH, PR, RF						
	97	6.00	SILTSTONE: grey red; with ironstaining / ironstain infill											5.93-6.37m: DB				6		
		7 8 9	Borehole discontinued at 6.37m depth. Auger TC refusal / change to NMLC coring.																	

Generated with CORE-GS by Geroc - Combined Log

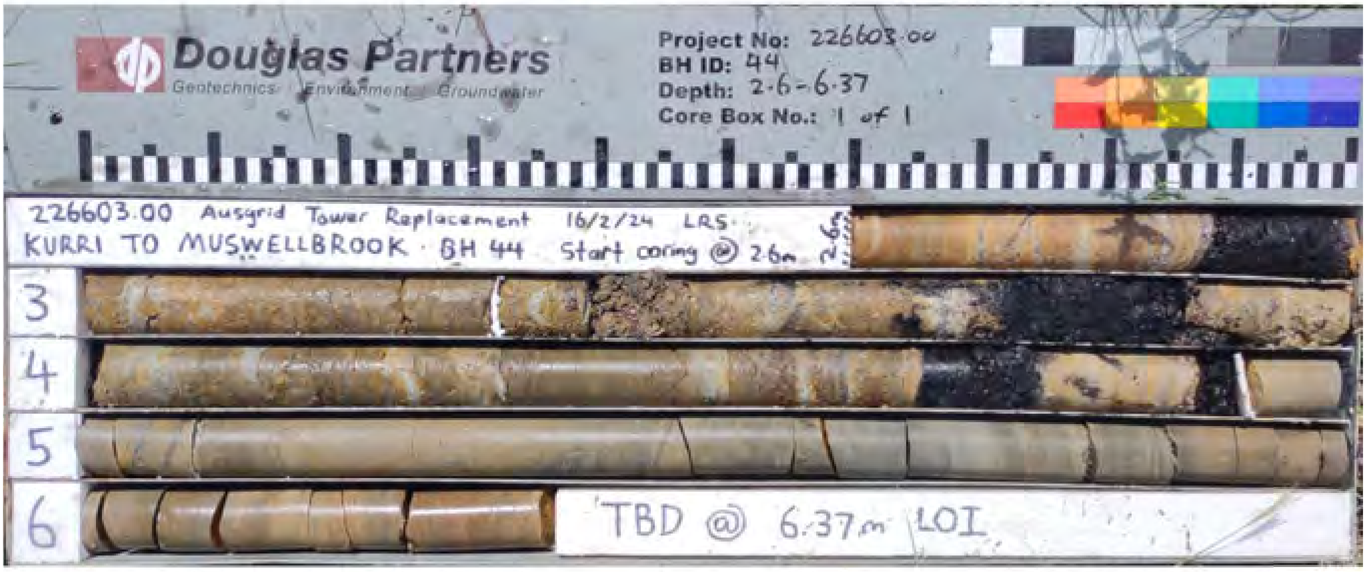
NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 2.6m, NMLC coring to 6.37m
CASING: HQ to 2.6m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	103.3 AHD	**LOCATION ID:**	BH44
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:319277.9, N:6405749.7	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	16/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1



Box 1 of 1: 2.60-6.37 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 104.1 AHD
COORDINATE: E:315621.6, N:6412380.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH48
PROJECT No: 226603.00
DATE: 17/07/24
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER: 17/07/24 No free groundwater observed

Description of strata

Depth (m)	Description of strata	Origin(#)	Consis.(*) / Density.(*)	Moisture
0.05	TOPSOIL / Silty Sandy CLAY (CL): dark brown; low plasticity; with rootlets.	TOP	NA	w<PL
0.30	Clayey SAND (SC): brown; fine to coarse; with rootlets.	RS	UK	M
0.75	Sandy CLAY (CL-CI), trace gravel: brown; low to medium plasticity; fine to coarse sand; fine to medium, sub-angular to sub-rounded gravel; iron staining.	RS	UK	w<PL
1.42	SANDSTONE: pale grey, fine to coarse grained; iron staining			
2.30	CONGLOMERATE: pale grey 2.23m-2.29m: possibly siderite, still part of conglomerate matrix			
2.75	TUFF: pale grey			
2.97	SILTSTONE: dark grey			
3.80	SANDSTONE: grey, fine to coarse grained; iron staining			
	Borehole discontinued at 3.80m depth. Limit of investigation.			

RL (m): 104, 103, 102, 101

Rock

Weath.	Depth (m)	Strength	Recovery (%)	RQD
HW	0.75–0.84	L	100	91
HW	0.84–1.29	M	100	91
	1.29–1.31	SEAM		
HW	1.31–1.42	M	89	46
HW	1.42–1.50	VL	89	46
HW	1.50–1.69	M	89	46
HW	1.69–1.86	VL	100	0
HW	1.86–2.33	M	100	0
	2.33–2.40	SEAM		
HW	2.40–2.53	M	100	0
HW	2.53–2.75	VL	100	0
HW	2.75–2.97	M	100	0
	2.97–3.23	SEAM	100	0
HW	3.23–3.72	M		
	3.72–3.75	SEAM		
HW	3.75–3.80	M		

Defects & Remarks

- 0.82m: JT, 30°, IR, Fe, RF
- 1.12m: P, SH, PR, RF
- 1.29-1.31m: CS
- 1.41m: P, SH, PR, Fe, RF
- 1.60m: P, SH, PR, RF
- 1.81m: P, 70°, PR, RF
- 1.94m: JT x2, 70°, PR, RF
- 2.00-2.13m: F
- 2.20m: JT, 60°, PR, RF
- 2.30m: JT x2, 20°, PR, RF
- 2.33-2.40m: CS
- 2.40-2.44m: F
- 2.66m: P, SH, PR, RF
- 2.80m: JT, 10°, IR, RF
- 2.87m: JT x2, SV, PR, RF
- 2.97-3.23m: CS
- 3.25m: P, SH, IR, RF
- 3.38m: P, SH, PR, RF
- 3.44m: P, SH, PR, TI Fe
- 3.50m: P, SH, PR, RF
- 3.58m: P, SH, PR, RF
- 3.63m: JT, 10°, PR, Fe, RF
- 3.72-3.75m: CS

SAMPLE

Type	Depth (m)
D	0.10
D	0.50
D	0.70

TESTING

Test Type	Results and Remarks
SPT	5/150 (HB) SPT refusal (double bounce)
PLT	PL(D)=0.51MPa PL(A)=0.73MPa
PLT	PL(D)=0.85MPa PL(A)=0.67MPa
PLT	PL(D)=0.27MPa PL(A)=0.47MPa

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

PLANT: DT100
OPERATOR: Ground Test (Douglas)
LOGGED: Huynh
METHOD: Solid flight auger with TC Bit to 0.75 m, NMLC coring to 3.8 m
CASING: HWT to 0.75m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	104.1 AHD	**LOCATION ID:**	BH48
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:315621.6, N:6412380.0	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	17/07/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

0.75-3.80 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 120.0 AHD
COORDINATE: E:314661.0, N:6415043.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH49
PROJECT No: 226603.00
DATE: 10/04/24
SHEET: 1 of 2

GROUNDWATER: 10/04/24 No free groundwater observed

Depth (m)	RL (m)	Description of Strata	Origin(#)	Consis./Density(*)	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks
0.00–0.40	120	TOPSOIL / CLAY (CH): brown red; high plasticity.	TOP	St	w<PL						
0.40–2.40	119.6	Silty CLAY (CH), with sand, trace gravel: grey; high plasticity; fine sand; fine to medium, sub-angular to sub-rounded gravel.	RS	H	w<PL						
2.40–2.57		CORE LOSS: 0.17m					2.40				
2.57–3.77		LAMINITE: grey; interbedded pale grey fine grained sandstone, 80% and 20%, dark grey siltstone				MW	2.57	M	70	38	2.58-2.65m: CS; 2.71-2.73m: IS, 2°, PR, Clay, SM; 2.79m: HB; 2.94m: JT, 40°, UN, SL; 3.04m: HB; 3.17m: HB, 50°, UN, Clay, SM; 3.27m: JT, 80°, IR, SN Fe, RF; 3.34-3.36m: IS, Clay; 3.41m: JT, 70°, IR, CN, RF; 3.51m: HB; 3.71m: JT, 70°, PR, SM; 3.73-3.80m: HB
3.77–4.00		CLAYSTONE: grey				HW	3.77	L			
4.00–4.16	116	CORE LOSS: 0.16m					4.00				
4.16–4.84		CLAYSTONE: grey				HW	4.16	L	82	40	4.16m: JT, 50°, IR, SN Fe, RF
4.84–		COAL: black									

SAMPLE / TESTING

Depth (m)	Type	Test Type	Results and Remarks
1.00–1.45	SPT	SPT	14,15,17 N=32

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

PLANT: Comacchio Geo 405
OPERATOR: Ground Test (Douglas)
LOGGED: Duffy
METHOD: Solid flight auger to 2.4m, NMLC coring to 7m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	120.0 AHD	**LOCATION ID:**	BH49
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:314661.0, N:6415043.1	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	10/04/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	2 of 2

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD
115	5.00	CORE LOSS: 0.1m		5.00		82	40
	5.10	COAL: black	HW	5.10	L	85	42
	5.70	CORE LOSS: 0.1m		5.70			
114	5.80	CLAYSTONE: mottled grey and orange	HW	5.80	L	100	50
	6.30	SILTSTONE: grey	MW	6.30	M		
	7	Borehole discontinued at 7.00m depth. Limit of investigation.					

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

PLANT: Comacchio Geo 405 **OPERATOR:** Ground Test (Douglas) **LOGGED:** Duffy

METHOD: Solid flight auger to 2.4m, NMLC coring to 7m **CASING:** Uncased

REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	120.0 AHD	**LOCATION ID:**	BH49
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:314661.0, N:6415043.1	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	10/04/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.40-7.00 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 142.2 AHD
COORDINATE: E:314100.2, N:6416551.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH50
PROJECT No: 226603.00
DATE: 10/04/24

GROUNDWATER: 10/04/24 No free groundwater observed

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE
0.00–0.70	FILL / Silty CLAY (CH): red brown; high plasticity.	FILL	NA	w<PL
0.70–1.90	FILL / Silty CLAY (CH): grey; high plasticity; (apparently moderately to well compacted).	FILL	NA	w<PL
1.90–4.40	FILL / COAL WASH: black; (apparently poorly to moderately compacted).	possibly FILL	NA	M
4.40–	FILL / COAL WASH (CI): grey; with clay, medium plasticity, with silt, (apparently poorly to moderately compacted).	FILL	NA	M

RL (m): 142, 141, 140, 139, 138

SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
D	0.50–0.70		
SPT	1.00–1.45	SPT	13,19,24 N=43
D	2.00–2.50		
SPT	2.50–2.95	SPT	4,6,7 N=13
D	3.50–4.00		
SPT	4.00–4.45	SPT	8,10,11 N=21

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger to 7.6m
REMARKS:

OPERATOR: Ground Test (Douglas)
LOGGED: Duffy
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 142.2 AHD
COORDINATE: E:314100.2, N:6416551.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH50
PROJECT No: 226603.00
DATE: 10/04/24
SHEET: 2 of 2

CONDITIONS ENCOUNTERED									SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	137		[CONT] FILL / COAL WASH (CI): grey; with clay, medium plasticity, with silt, (apparently poorly to moderately compacted).		FILL	NA	M						
									SPT		5.50 – 5.95	SPT	8,18,24/100
	136	5.70	Silty CLAY (CH): grey; high plasticity.		XWM	H	ND						
	135	7										SPT	20/50
	134	8	Borehole discontinued at 7.60m depth. Limit of investigation.										
	133	9											

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

PLANT: Comacchio Geo 405
METHOD: Solid flight auger to 7.6m
REMARKS:

OPERATOR: Ground Test (Douglas)

LOGGED: Duffy
CASING: Uncased

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 129.5 AHD
COORDINATE: E:312213.0, N:6418412.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH51
PROJECT No: 226603.00
DATE: 13/02/24
SHEET: 1 of 2

Groundwater: 13/02/24 No free groundwater observed whilst augering

RL (m)	Depth (m)	Description of Strata	Origin	Consis./Density	Moisture
	0.10	TOPSOIL / Silty CLAY (CH), trace sand: dark brown; high plasticity; fine sand; abundant organics.	TOP	NA	w>PL or w=PL
129 – 127.3	0.10 – 2.20	Silty CLAY (CH): grey brown; high plasticity. 0.80m: trace sand and gravel content	ALV	St to VSt; VSt; F to St	w>PL or w=PL; w<PL or w=PL; w=PL
127	2.20 – 2.70	Sandy CLAY (CI), with silt: orange brown mottled pale grey; medium plasticity; fine to coarse sand; extremely weathered sandstone.	XWM		w<PL
126.8 – 125	2.70 –	SANDSTONE: orange brown grey, fine to medium grained; with iron staining. 3.50m-5.67m: possible occasional interbedded siltstone bands. 3.64m-3.65m: interbedded clay band. 3.70m: with subhorizontal laminations. 4.30m: with iron stain laminations dipping 0°-10°			

Rock

Run depth (m)	Weathering	Strength	Recovery (%)	RQD
2.70 – 3.00	MW	EL	100	50
3.00 –	MW	EL to M	100	60
			100	75
			100	78

Defects & Remarks

- 2.70-2.80m: FG
- 2.90-2.94m: HB
- 2.94-3.00m: FG
- 3.13m: DB
- 3.22m: P, SH, PR, RF
- 3.25m: DB
- 3.25-3.33m: FG
- 3.37m: P, SH, UN, RF
- 3.60m: DB
- 3.67-3.72m: FG
- 3.77m: P, SH, PR, RF
- 3.91m: DB
- 4.05-4.15m: DB
- 4.27m: DB
- 4.40m: JT, 20°-30°, PR, RF
- 4.50m: DB
- 4.53m: DB
- 4.64m: DB

Sample / Testing

Type	Depth (m)	Test Type	Results and Remarks
D	0.20		
D	0.50	PP	250-350kPa
D	1.00	PP	90-100kPa
D	1.00 – 1.45	SPT	2,1,2 N=3
	1.45	PP	90-120kPa
D	2.50 – 2.64	SPT	20/140
	2.64	PP	>400kPa

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

PLANT: Multidrill 4.0T **OPERATOR:** Tracess **LOGGED:** Reiher-Smith
METHOD: Solid flight auger with TC Bit to 2.7m, NMLC coring to 5.7m **CASING:** HQ to 2.7m
REMARKS: Relocated bore approx 250m due to boggy access

Refer to explanatory notes for symbol and abbreviation definitions

Generated with CORE-GS by Geroc - Combined Log

Douglas Partners

BOREHOLE LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	129.5 AHD	**LOCATION ID:**	BH51
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:312213.0, N:6418412.0	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	13/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	2 of 2

CONDITIONS ENCOUNTERED					SOIL			ROCK							SAMPLE				TESTING	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)	RECOVERY (%)	RQD	FRACTURE SPACING (m) (0.005 0.01 0.05 0.10 0.50 1.00 5.00)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	124		[CONT] SANDSTONE: orange brown grey, fine to medium grained; with iron staining 4.96m-4.98m: interbedded clay band					MW		L to M	100	78		5.15-5.20m: FG 5.27m: JT, 10°, PR, TI, RF 5.38-5.42m: DB 5.43-5.57m: JT, 60° -70°, PR, RF 5.57-5.67m: FG						
		6 7 8 9	Borehole discontinued at 5.67m depth. Auger TC refusal / change to NMLC coring.																	

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

PLANT: Multidrill 4.0T **OPERATOR:** Tracess **LOGGED:** Reiher-Smith

METHOD: Solid flight auger with TC Bit to 2.7m, NMLC coring to 5.7m **CASING:** HQ to 2.7m

REMARKS: Relocated bore approx 250m due to boggy access

Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	129.5 AHD	**LOCATION ID:**	BH51
PROJECT:	Hunter Pole Replacement Program	**COORDINATE:**	E:312213.0, N:6418412.0	**PROJECT No:**	226603.00
LOCATION:	Kurri Kurri to Muswellbrook	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	13/02/24
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

Box 1 of 1: 2.70-5.67 m depth

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 210.4 AHD
COORDINATE: E:305846.5, N:6432371.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH52
PROJECT No: 226603.00
DATE: 12/02/24
SHEET: 1 of 2

Groundwater: 12/02/24 No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE
210.4	0.10	TOPSOIL / Silty SAND (SM), with clay, with gravel: dark brown; fine to coarse; abundant organics, gravel content appears to be natural clay; sub-angular to sub-rounded gravel.	TOP / COL	NA / MD	D / D
	0.30	Silty SAND (SM), with clay, with gravel: dark brown to dark grey; fine to coarse; sub-angular to sub-rounded gravel; gravel content appears to be natural.	COL	H	w<PL
	0.70	Sandy CLAY (CH), with silt, with gravel: dark brown to brown; high plasticity; fine to coarse sand; sub-angular to sub-rounded gravel; gravel content appears to be natural.			
	2.00	Silty CLAY (CH), with sand, with gravel: dark grey; high plasticity; fine to medium sand; sub-angular to sub-rounded gravel; gravel content appears to be natural.	COL possibly RS	VSt to H	w<PL
		Sandy Gravelly CLAY (CI), with silt: grey brown; medium plasticity; fine to coarse sand; sub-angular to sub-rounded gravel; gravel content appears to be natural.	RS	H	w<PL

RL scale: 210, 209, 208, 207, 206. Depth scale: 1, 2, 3, 4.

SAMPLE / TESTING AND REMARKS

TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
D	0.20		
D	0.50	PP	>400kPa
D	1.00	PP	>400kPa
SPT/D	1.00–1.45	SPT	4,8,9 N=17
	2.50	PP	>400kPa
D/SPT	2.50–2.95	SPT	14,15,18 N=33
	4.00	PP	>400kPa
D/SPT	4.00–4.45	SPT	7,9,12 N=21

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

PLANT: Multidrill 4.0T **OPERATOR:** Traccess **LOGGED:** Reiher-Smith
METHOD: Solid flight auger with TC Bit to 6.0m **CASING:** Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 210.4 AHD
COORDINATE: E:305846.5, N:6432371.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH52
PROJECT No: 226603.00
DATE: 12/02/24

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	205		[CONT] Sandy Gravelly CLAY (CI), with silt: grey brown; medium plasticity; fine to coarse sand; sub-angular to sub-rounded gravel; gravel content appears to be natural.		RS	H	w<PL		D/SPT		5.50 – 5.63	SPT	20/130 Refusal
		6	Borehole discontinued at 6.00m depth. Limit of investigation.										
	204												
		7											
	203												
		8											
	202												
		9											
	201												

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

Generated with CORE-GS by Geroc - Soil Log

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 6.0m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 231.4 AHD
COORDINATE: E:305021.1, N:6431723.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH53
PROJECT No: 226603.00
DATE: 12/02/24
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
12/02/24 No free groundwater observed		0.10	TOPSOIL / Silty SAND (SM), with clay: dark brown; fine to coarse; abundant organics.		TOP	NA	ND						
		0.30	Silty SAND (SM), with clay: dark brown to brown; fine to coarse.		COL	L to MD	D		D		0.20		
	231	0.90	Silty SAND (SM), with clay, with gravel: grey brown; fine to coarse; sub-angular to sub-rounded gravel; gravel content appears to be natural. From 0.80m: increased clay content		COL	D to VD	D		D D		0.50 0.80		
	230 229	3.20	Sandy CLAY (CL), trace gravel: grey; low plasticity; fine to coarse sand; sub-angular to sub-rounded gravel; gravel content appears to be natural.		COL possibly RS	H	w<PL		D/SPT D/SPT		1.00–1.14 2.50–2.77	PP SPT PP SPT	>400kPa 25/140 Refusal >400kPa 6,20/120 Refusal
	228 227		Silty SAND (SM), with gravel, trace clay: brown; fine to coarse; sub-angular to sub-rounded gravel; gravel content appears to be natural, grading towards extremely weathered sandstone / conglomerate.		RS	D to VD	D		D D/SPT		3.50 4.00–4.09	SPT	20/90 Refusal

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 5.5m, SPT refusal 5.5m to 5.6m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 231.4 AHD
COORDINATE: E:305021.1, N:6431723.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH53
PROJECT No: 226603.00
DATE: 12/02/24

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	226	5.00	Silty SAND (SM), with clay, with gravel: brown; fine to coarse; sub-angular to sub-rounded gravel; gravel content appears to be natural, extremely weathered sandstone / conglomerate.		XWM		D		D/SPT		5.50–5.60	SPT	20/100 Refusal
	225, 224, 223, 222	6, 7, 8, 9	Borehole discontinued at 5.60m depth. SPT Refusal (hammer bouncing) on inferred sandstone / conglomerate bedrock.										

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 5.5m, SPT refusal 5.5m to 5.6m
CASING: Uncased
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 176.0 AHD
COORDINATE: E:304184.2, N:6430929.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH54
PROJECT No: 226603.00
DATE: 12/02/24
SHEET: 1 of 2

Groundwater: 12/02/24 No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE
	0.10	TOPSOIL / Silty SAND (SM), with clay: grey brown; fine to coarse; abundant organics.	TOP	NA	D
	0.30	Silty SAND (SM), with clay: grey brown; fine to coarse.	COL	L to MD	D
	0.80	Sandy CLAY (CI), with silt: orange grey brown; medium plasticity; fine to coarse sand.	COL	VSt to H	w<PL
175	2.00	Sandy Gravelly CLAY (CH): brown orange; high plasticity; fine to coarse sand; sub-angular to sub-rounded gravel; gravel content appears to be natural, with buried cobbles of varying size.	COL possibly RS	VSt to H	w<PL
174, 173, 172	4.60	Silty CLAY (CH), with gravel, trace sand: red brown; high plasticity; sub-angular to sub-rounded gravel; fine to medium sand; trace carbonaceous inclusions.	RS	VSt to H	w<PL w=PL
171		Silty CLAY (CH), with sand, trace gravel: orange brown pale grey; high plasticity; fine sand; sub-angular to sub-rounded gravel; gravel content appears to be natural, trace carbonaceous inclusions.	RS	St to VSt	w=PL

SAMPLE / TESTING AND REMARKS

TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
D	0.20		
D	0.50		
D	0.70		
	1.00	PP	>400kPa
D/SPT	1.00–1.45	SPT	7,18,10 N=28
	2.50	PP	>400kPa
D/SPT	2.50–2.95	SPT	5,9,11 N=20
	4.00	PP	250-450kPa
D/SPT	4.00–4.45	SPT	6,7,9 N=16

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 6.0m
CASING: Uncased
REMARKS: Test location offset approx 170m due to no access for vehicles / drill rig

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Hunter Pole Replacement Program
LOCATION: Kurri Kurri to Muswellbrook

SURFACE LEVEL: 176.0 AHD
COORDINATE: E:304184.2, N:6430929.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH54
PROJECT No: 226603.00
DATE: 12/02/24
SHEET: 2 of 2

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] Silty CLAY (CH), with sand, trace gravel: orange brown pale grey; high plasticity; fine sand; sub-angular to sub-rounded gravel; gravel content appears to be natural, trace carbonaceous inclusions.		RS	St to VSt	w=PL				5.50	PP	150-350kPa
									D/SPT			SPT	6,6,6 N=12
	170	6									5.95		
			Borehole discontinued at 6.00m depth. Limit of investigation.										
	169	7											
	168	8											
	167	9											
	166												

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

PLANT: Multidrill 4.0T
OPERATOR: Traccess
LOGGED: Reiher-Smith
METHOD: Solid flight auger with TC Bit to 6.0m
CASING: Uncased
REMARKS: Test location offset approx 170m due to no access for vehicles / drill rig

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

CONE PENETRATION TEST

CLIENT: AUSGRID

PROJECT: HUNTER POLE REPLACEMENT PROGRAM

LOCATION: Kurri Kurri to Muswellbrook

REDUCED LEVEL: 53.4 m AHD

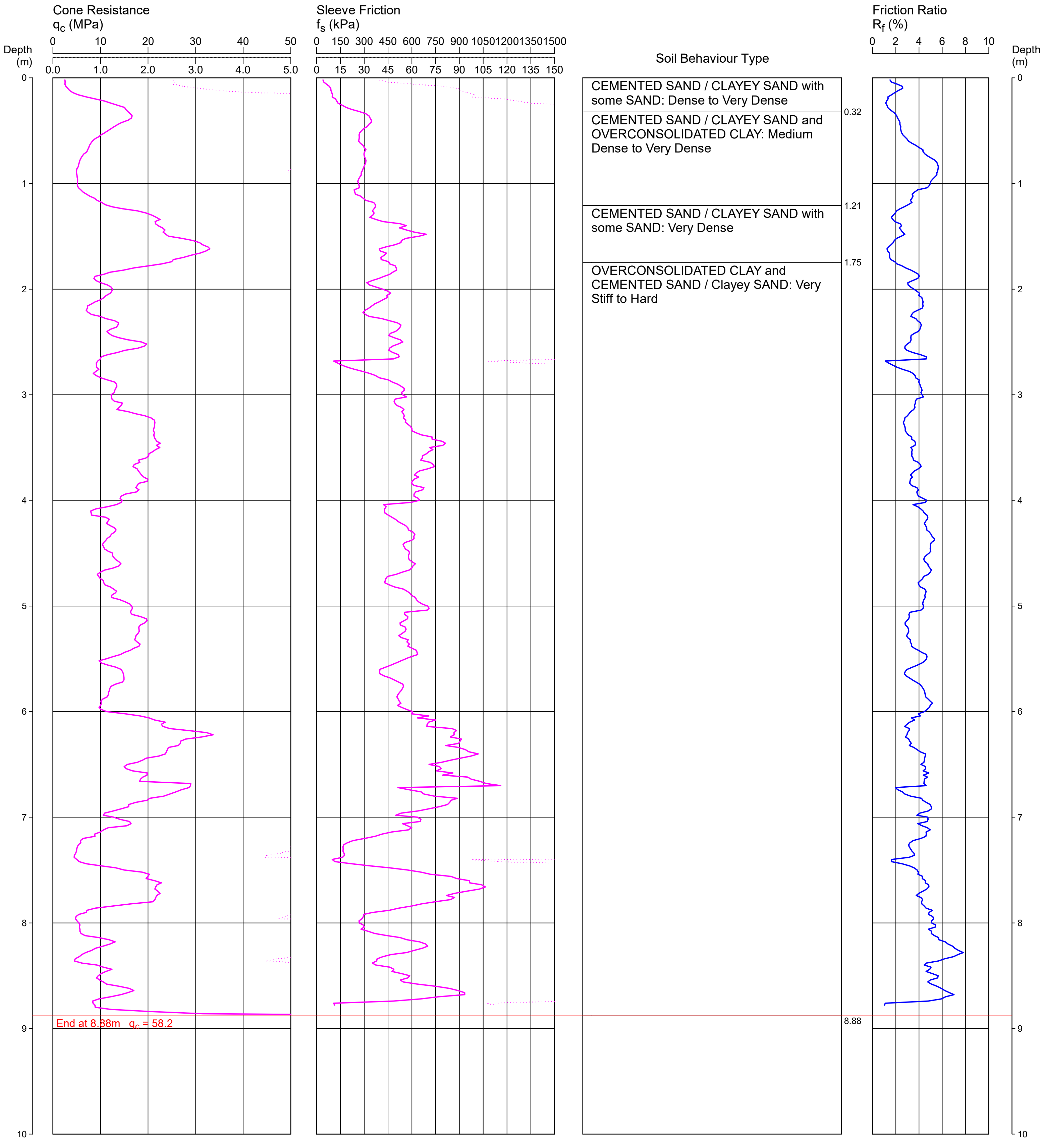
COORDINATES: 319090E 6394481N GDA2020 Zone 56

CPT38

Page 1 of 1

DATE 21/12/2023

PROJECT No: 226603



REMARKS: TEST DISCONTINUED DUE TO REFUSAL ON INFERRED WEATHERED ROCK
NO GROUNDWATER OBSERVED AFTER WITHDRAWAL OF RODS

File: \\dpnclnas01\Projects\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\4.0 Field Work\4.2 Testing\CPT\CPT38.CP5
Cone ID: 200313 **Type:** I-CFXY-10

ConePlot Version 5.9.2

Douglas Partners
Geotechnics | Environment | Groundwater

CONE PENETRATION TEST

CLIENT: AUSGRID

PROJECT: HUNTER POLE REPLACEMENT PROGRAM

LOCATION: Kurri Kurri to Muswellbrook

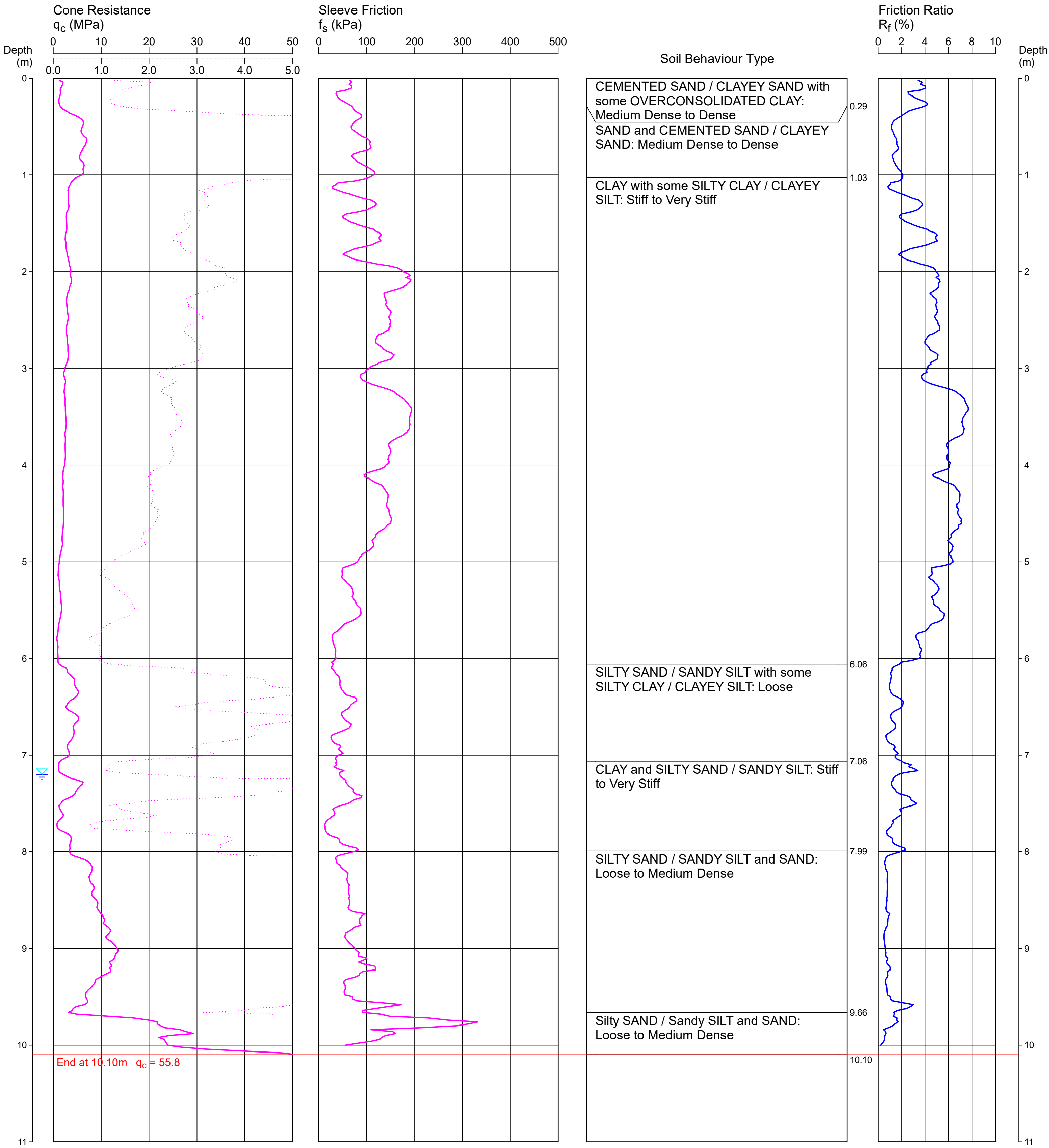
REDUCED LEVEL: 51.2 m AHD

COORDINATES: 318560E 6396366N GDA2020 Zone 56

CPT39

DATE 21/12/2023

PROJECT No: 226603



REMARKS: TEST DISCONTINUED DUE TO REFUSAL ON INFERRED WEATHERED ROCK
GROUNDWATER OBSERVED AT 7.2M AFTER WITHDRAWAL OF RODS

Water depth after test: 7.20m depth (measured)

File: \\dpnclnas01\Projects\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\4.0 Field Work\4.2 Testing\CPT\CPT39.CP5

Cone ID: 200313 **Type:** I-CFXY-10

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: AUSGRID

PROJECT: HUNTER POLE REPLACEMENT PROGRAM

LOCATION: Kurri Kurri to Muswellbrook

REDUCED LEVEL: 57.5 m AHD

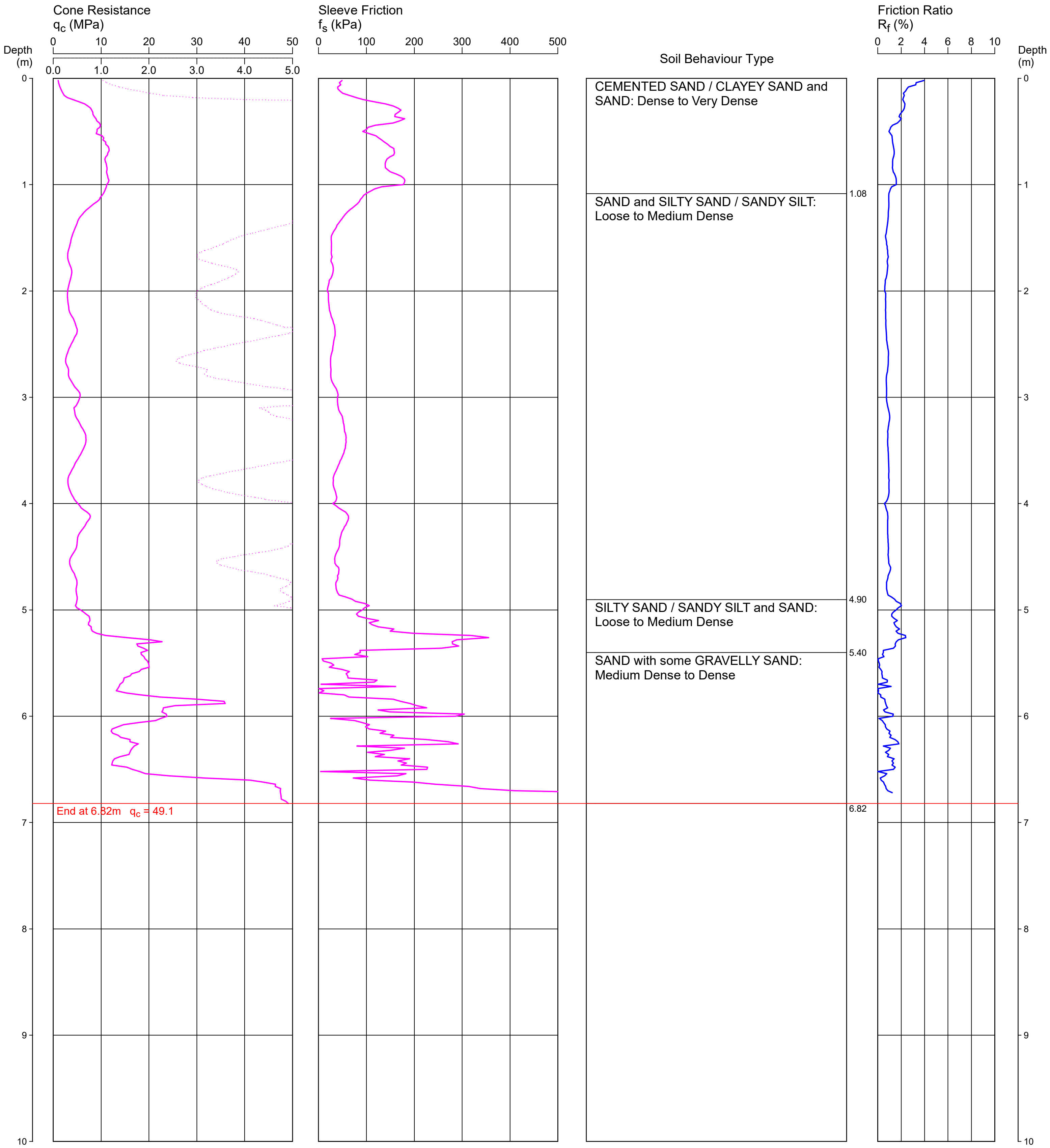
COORDINATES: 319647E 6404879N GDA2020 Zone 56

CPT43

Page 1 of 1

DATE 21/12/2023

PROJECT No: 226603



REMARKS: TEST DISCONTINUED DUE TO REFUSAL ON INFERRED WEATHERED ROCK
NO GROUNDWATER OBSERVED AFTER WITHDRAWAL OF RODS

File: \\dpnclnas01\Projects\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\4.0 Field Work\4.2 Testing\CPT\CPT43.CP5
Cone ID: 200313 **Type:** I-CFXY-10

ConePlot Version 5.9.2

Douglas Partners
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CONE PENETRATION TEST

CLIENT: AUSGRID

PROJECT: HUNTER POLE REPLACEMENT PROGRAM

LOCATION: Kurri Kurri to Muswellbrook

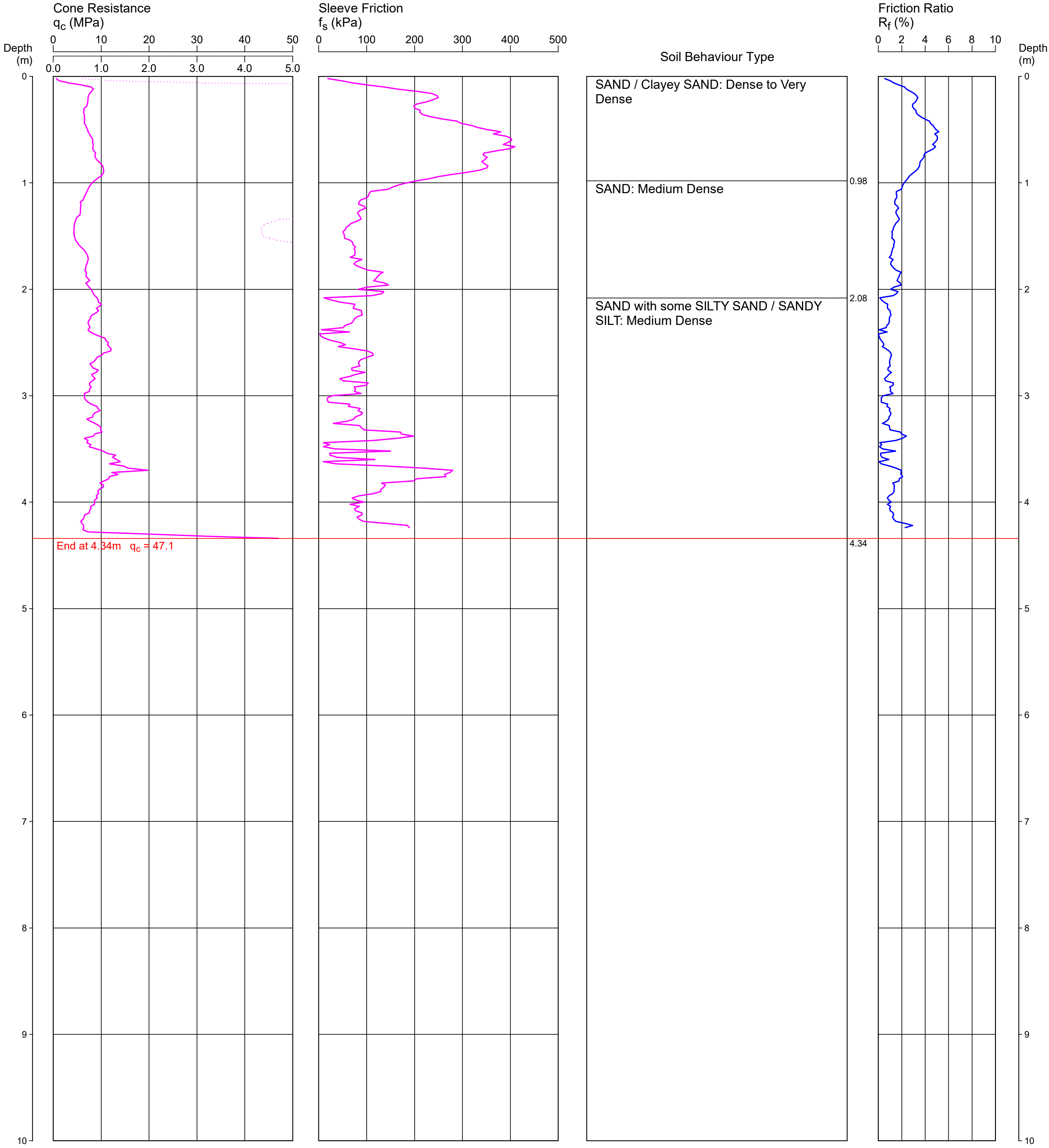
REDUCED LEVEL: 67.2 m AHD

COORDINATES: 318199E 6407571N MGA2020 Zone 56

CPT45

DATE 20/12/2023

PROJECT No: 226603



REMARKS: TEST DISCONTINUED DUE TO BENDING REFUSAL
NO GROUNDWATER OBSERVED AFTER WITHDRAWAL OF RODS

File: \\dpnclnas01\Projects\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\4.0 Field Work\4.2 Testing\CPT\CPT45.CP5
Cone ID: 200313 **Type:** I-CFXY-10

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: AUSGRID

PROJECT: HUNTER POLE REPLACEMENT PROGRAM

LOCATION: Kurri Kurri to Muswellbrook

REDUCED LEVEL: 72.4 m AHD

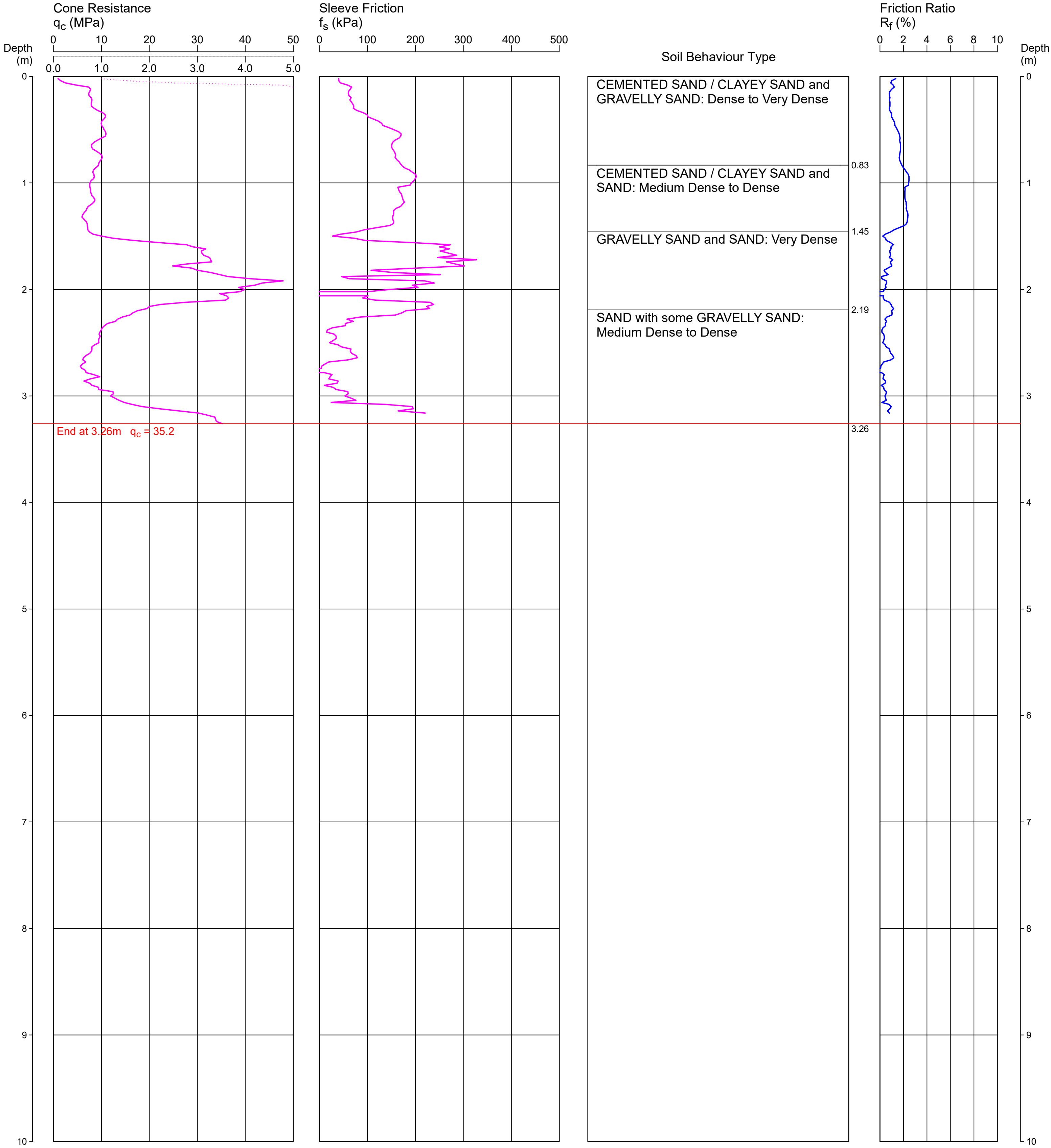
COORDINATES: 317856E 6408781N MGA2020 Zone 56

CPT46

Page 1 of 1

DATE 20/12/2023

PROJECT No: 226603



REMARKS: TEST DISCONTINUED DUE TO BENDING REFUSAL
NO GROUNDWATER OBSERVED AFTER WITHDRAWAL OF RODS

File: \\dpnclnas01\Projects\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\4.0 Field Work\4.2 Testing\CPT\CPT46.CP5

Cone ID: 200313 **Type:** I-CFXY-10

ConePlot Version 5.9.2

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CONE PENETRATION TEST

CLIENT: AUSGRID

PROJECT: HUNTER POLE REPLACEMENT PROGRAM

LOCATION: Kurri Kurri to Muswellbrook

REDUCED LEVEL: 79.2 m AHD

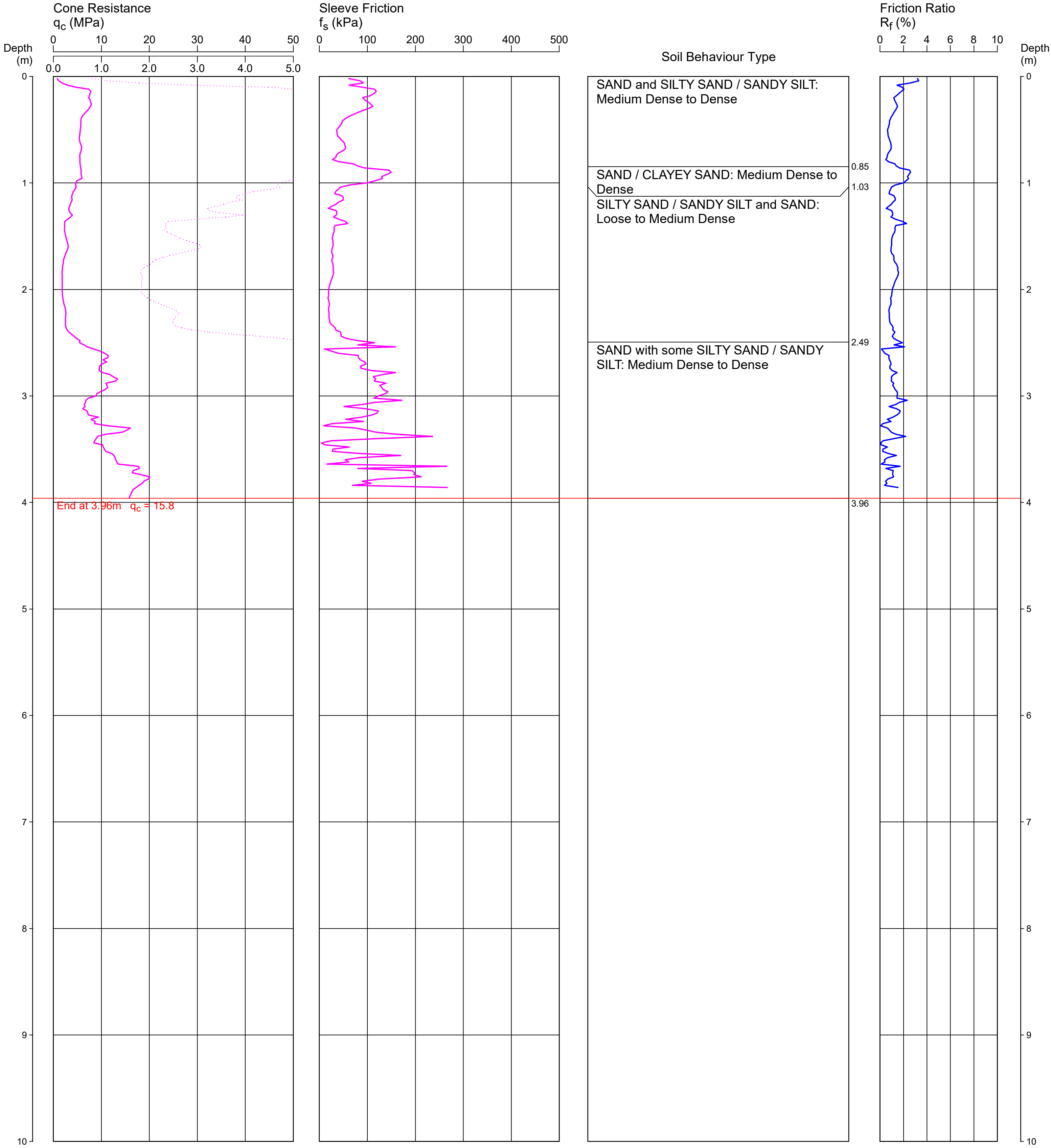
COORDINATES: 317472E 6410222N MGA2020 Zone 56

CPT47

Page 1 of 1

DATE 20/12/2023

PROJECT No: 226603



REMARKS: TEST DISCONTINUED DUE TO BENDING REFUSAL
NO GROUNDWATER OBSERVED AFTER WITHDRAWAL OF RODS

File: \\dpnclnas01\Projects\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\4.0 Field Work\4.2 Testing\CPT\CPT47.CP5
Cone ID: 200313 **Type:** I-CFXY-10

ConePlot Version 5.9.2

Douglas Partners
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Appendix C

Results of Laboratory Testing

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 349150

Client Details

Client	Douglas Partners Newcastle
Attention	Michael Gawn
Address	Box 324 Hunter Region Mail Centre, Newcastle, NSW, 2310

Sample Details

Your Reference	**226603.00 Muswellbrook**
Number of Samples	5 Soil
Date samples received	18/04/2024
Date completed instructions received	18/04/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	26/04/2024
Date of Issue	26/04/2024

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		349150-1	349150-2	349150-3	349150-4	349150-5
Your Reference	UNITS	BH28	BH33c	BH50	BH50	BH49
Depth		1-1.45	2.5-2.95	1-1.45	3.5-3.95	1-1.45
Date Sampled		12/04/2024	12/04/2024	10/04/2024	10/04/2024	10/04/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	18/04/2024	18/04/2024	18/04/2024	18/04/2024	22/04/2024
Date analysed	-	23/04/2024	23/04/2024	23/04/2024	23/04/2024	23/04/2024
pH 1:5 soil:water	pH Units	8.0	8.6	9.4	7.5	9.0
Electrical Conductivity 1:5 soil:water	µS/cm	770	830	170	660	150
Chloride, Cl 1:5 soil:water	mg/kg	590	1,000	50	720	110
Sulphate, SO4 1:5 soil:water	mg/kg	660	33	84	67	55

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			18/04/2024	1	18/04/2024	18/04/2024		18/04/2024	[NT]
Date analysed	-			23/04/2024	1	23/04/2024	23/04/2024		23/04/2024	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	8.0	8.0	0	100	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	1	770	810	5	102	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	590	650	10	109	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	660	710	7	114	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Envirolab Services Pty Ltd
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CERTIFICATE OF ANALYSIS 357436

Client Details

Client	Douglas Partners Newcastle
Attention	Michael Gawn
Address	Box 324 Hunter Region Mail Centre, Newcastle, NSW, 2310

Sample Details

Your Reference	**226603.00 Muswellbrook**
Number of Samples	2 Soil
Date samples received	25/07/2024
Date completed instructions received	25/07/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	01/08/2024
Date of Issue	01/08/2024

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Soil Aggressivity			
Our Reference		357436-1	357436-2
Your Reference	UNITS	31A	48
Depth		2.5-2.95	0.5
Date Sampled		17/07/2024	17/07/2024
Type of sample		Soil	Soil
Date prepared	-	25/07/2024	25/07/2024
Date analysed	-	26/07/2024	26/07/2024
pH 1:5 soil:water	pH Units	7.6	6.4
Electrical Conductivity 1:5 soil:water	µS/cm	840	86
Chloride, Cl 1:5 soil:water	mg/kg	1,100	24
Sulphate, SO4 1:5 soil:water	mg/kg	240	79

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Soil Aggressivity					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			25/07/2024	[NT]	[NT]	[NT]	[NT]	25/07/2024	[NT]
Date analysed	-			26/07/2024	[NT]	[NT]	[NT]	[NT]	26/07/2024	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	101	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	103	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	108	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	108	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Samples received out the holding time.

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CERTIFICATE OF ANALYSIS 347446

Client Details

Client	Douglas Partners Newcastle
Attention	Michael Gawn
Address	Box 324 Hunter Region Mail Centre, Newcastle, NSW, 2310

Sample Details

Your Reference	**226603.00, Muswellbrook**
Number of Samples	19 Soil
Date samples received	26/03/2024
Date completed instructions received	26/03/2024

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	04/04/2024
Date of Issue	03/04/2024

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Results Approved By
Diego Bigolin, Inorganics Supervisor

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		347446-1	347446-2	347446-3	347446-4	347446-5
Your Reference	UNITS	4	3	8	11	13
Depth		1-1.45	1-1.45	2.5-2.95	1-1.45	1-1.45
Date Sampled		30/01/2024	31/01/2024	01/02/2024	02/02/2024	06/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	28/03/2024	28/03/2024	28/03/2024	28/03/2024	28/03/2024
Date analysed	-	28/03/2024	28/03/2024	28/03/2024	28/03/2024	28/03/2024
pH 1:5 soil:water	pH Units	7.4	5.4	8.1	8.9	5.8
Electrical Conductivity 1:5 soil:water	µS/cm	1,500	70	640	150	190
Chloride, Cl 1:5 soil:water	mg/kg	2,200	10	690	92	54
Sulphate, SO4 1:5 soil:water	mg/kg	730	100	270	46	170

Misc Inorg - Soil						
Our Reference		347446-6	347446-7	347446-8	347446-9	347446-10
Your Reference	UNITS	15	17	19	21	23
Depth		0.4-0.5	0.5-0.8	0.5-0.8	0.4-0.6	0.5-0.8
Date Sampled		02/02/2024	06/02/2024	16/02/2024	07/02/2024	09/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	28/03/2024	28/03/2024	28/03/2024	28/03/2024	28/03/2024
Date analysed	-	28/03/2024	28/03/2024	28/03/2024	28/03/2024	28/03/2024
pH 1:5 soil:water	pH Units	7.3	5.2	4.5	6.6	4.8
Electrical Conductivity 1:5 soil:water	µS/cm	15	820	760	21	540
Chloride, Cl 1:5 soil:water	mg/kg	<10	990	750	<10	500
Sulphate, SO4 1:5 soil:water	mg/kg	<10	650	540	<10	450

Misc Inorg - Soil						
Our Reference		347446-11	347446-12	347446-13	347446-14	347446-15
Your Reference	UNITS	27	29	30	40	41
Depth		0.5-0.8	0.5-0.8	1-1.3	0.5-0.8	1-1.26
Date Sampled		08/02/2024	14/02/2024	14/02/2024	13/02/2024	13/02/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	28/03/2024	28/03/2024	28/03/2024	28/03/2024	28/03/2024
Date analysed	-	28/03/2024	28/03/2024	28/03/2024	28/03/2024	28/03/2024
pH 1:5 soil:water	pH Units	6.6	5.3	8.9	7.6	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	590	360	330	120	530
Chloride, Cl 1:5 soil:water	mg/kg	640	290	190	92	690
Sulphate, SO4 1:5 soil:water	mg/kg	240	240	130	20	130

Misc Inorg - Soil					
Our Reference		347446-16	347446-17	347446-18	347446-19
Your Reference	UNITS	42	44	51	53
Depth		0.5-0.8	1-1.3	0.5-0.8	0.5-0.8
Date Sampled		16/02/2024	16/02/2024	13/02/2024	12/02/2024
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	28/03/2024	28/03/2024	28/03/2024	28/03/2024
Date analysed	-	28/03/2024	28/03/2024	28/03/2024	28/03/2024
pH 1:5 soil:water	pH Units	8.6	9.1	6.9	5.3
Electrical Conductivity 1:5 soil:water	µS/cm	630	130	1,600	56
Chloride, Cl 1:5 soil:water	mg/kg	660	20	2,100	29
Sulphate, SO4 1:5 soil:water	mg/kg	100	21	370	50

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	347446-2
Date prepared	-			28/03/2024	1	28/03/2024	28/03/2024		28/03/2024	28/03/2024
Date analysed	-			28/03/2024	1	28/03/2024	28/03/2024		28/03/2024	28/03/2024
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	7.4	7.5	1	100	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	1	1500	1500	0	99	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	2200	2100	5	96	94
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	730	740	1	96	#

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	28/03/2024	28/03/2024		[NT]	[NT]
Date analysed	-			[NT]	11	28/03/2024	28/03/2024		[NT]	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	11	6.6	6.4	3	[NT]	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	[NT]	11	590	540	9	[NT]	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	11	640	590	8	[NT]	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	[NT]	11	240	230	4	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
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Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
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The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

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Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

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Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Where matrix spike recoveries fall below the lower limit of the acceptance criteria (e.g. for non-labile or standard Organics <60%), positive result(s) in the parent sample will subsequently have a higher than typical estimated uncertainty (MU estimates supplied on request) and in these circumstances the sample result is likely biased significantly low.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

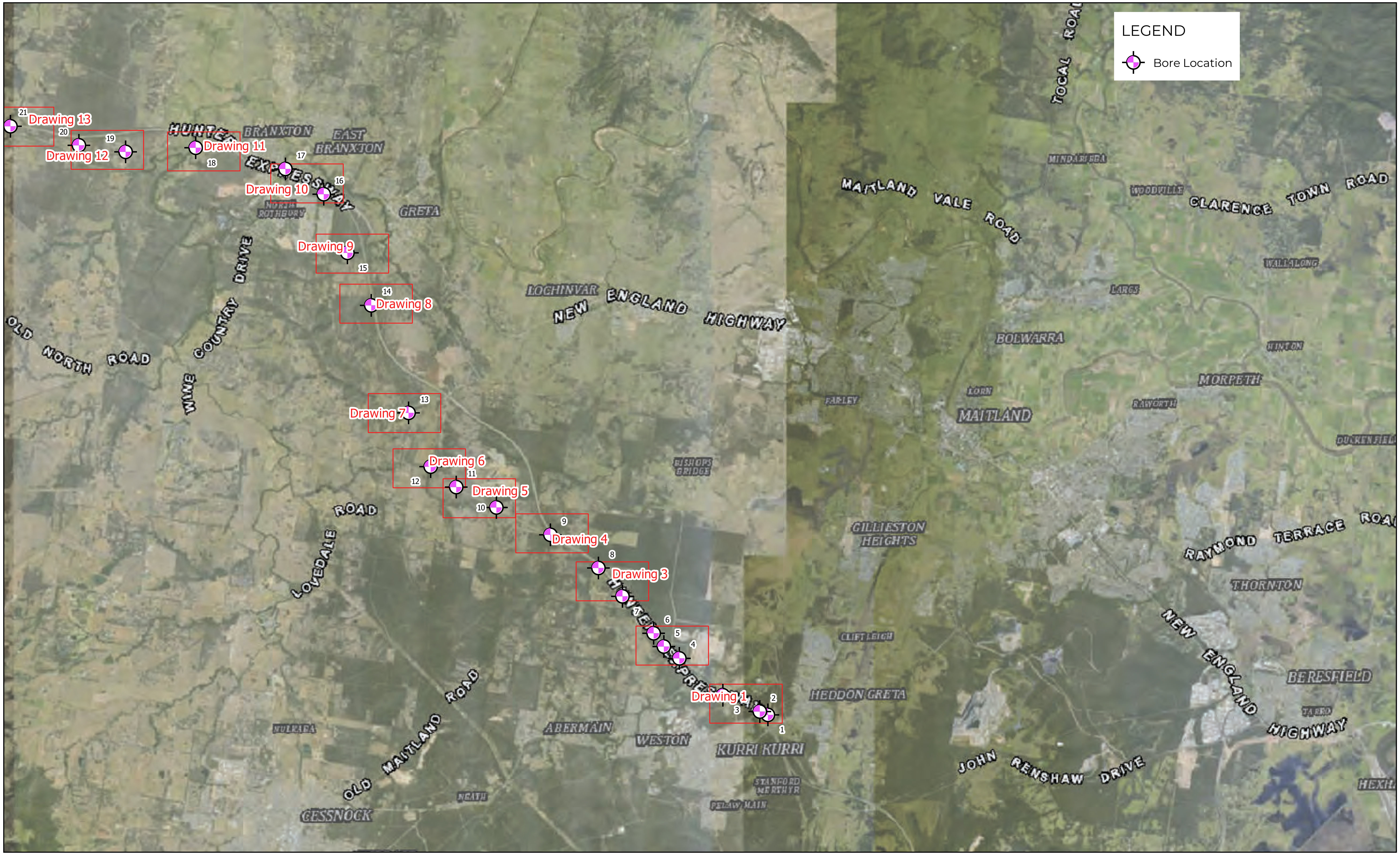
Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

MISC_INORG_DRY:
Percent recovery is not applicable due to the high concentration of the analyte/s in the sample/s. However an acceptable recovery was obtained for the LCS.

Appendix D

Test Location Plans



NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Key Drawing for Test Location Plans**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: MPG	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: K1
SCALE: 1:100000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 2,000 4,000 6,000 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: Key Drawing for Test Location Plans Geotechnical Investigation for Pole Replacement Program Kurri Kurri to Muswellbrook, NSW	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: MPG		DRAWING No: K2
SCALE: 1:100000 @A3	DATE: 21.August.2024		REVISION: 0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Key Drawing for Test Location Plans**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: MPG	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: K3
SCALE: 1:100000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS	CLIENT: AUSGRID		TITLE: **Key Drawing for Test Location Plans**
	OFFICE: Newcastle	DRAWN BY: MPG	**Geotechnical Investigation for Pole Replacement Program**
	SCALE: 1:100000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

PROJECT:	226603.00
DRAWING No:	K4
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 1
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 2
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 3
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 4
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY:CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	5
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS	CLIENT: AUSGRID		TITLE: **Test Location Plan** **Geotechnical Investigation for Pole Replacement Program** **Kurri Kurri to Muswellbrook, NSW**
	OFFICE: Newcastle	DRAWN BY: CTB	
	SCALE: 1:5000 @A3	DATE: 21.August.2024	

PROJECT:	226603.00
DRAWING No:	6
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

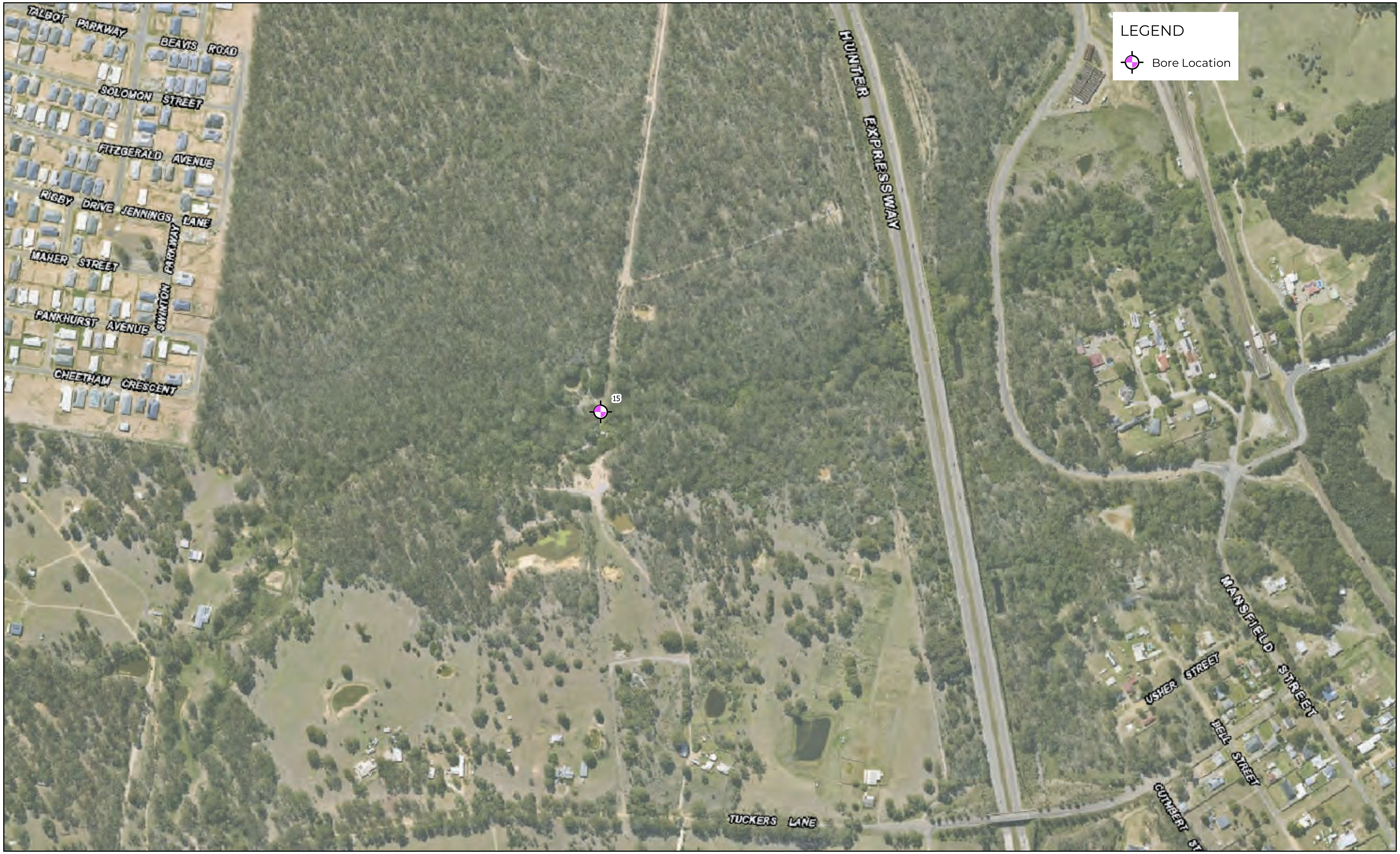
PROJECT:	226603.00
DRAWING No:	7
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS	CLIENT: AUSGRID		TITLE: **Test Location Plan**
	OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**
	SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

PROJECT:	226603.00
DRAWING No:	8
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz



NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

PROJECT:	226603.00
DRAWING No:	9
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 10
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	11
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		
OFFICE: Newcastle	DRAWN BY:CTB	
SCALE: 1:5000 @A3	DATE: 21.August.2024	

TITLE: **Test Location Plan**
Geotechnical Investigation for Pole Replacement Program
Kurri Kurri to Muswellbrook, NSW

N

PROJECT:	226603.00
DRAWING No:	12
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
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Douglas PARTNERS

CLIENT: AUSGRID		
OFFICE: Newcastle	DRAWN BY: CTB	
SCALE: 1:5000 @A3	DATE: 21.August.2024	

TITLE: **Test Location Plan**
Geotechnical Investigation for Pole Replacement Program
Kurri Kurri to Muswellbrook, NSW

N

PROJECT:	226603.00
DRAWING No:	13
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
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2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY:CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 14
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

PROJECT:	226603.00
DRAWING No:	15
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

CLIENT: AUSGRID		TITLE: **Test Location Plan**
OFFICE: Newcastle	DRAWN BY:CTB	**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

PROJECT:	226603.00
DRAWING No:	16
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	17
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan** **Geotechnical Investigation for Pole Replacement Program** **Kurri Kurri to Muswellbrook, NSW**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB		DRAWING No: 18
SCALE: 1:5000 @A3	DATE: 21.August.2024		REVISION: 0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY:CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	19
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 20
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS	CLIENT: AUSGRID	TITLE: **Test Location Plan**	PROJECT: 226603.00
	OFFICE: Newcastle / DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 21
	SCALE: 1:5000 @A3 / DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY:CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 22
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	23
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS	CLIENT: AUSGRID		TITLE: **Test Location Plan**
	OFFICE: Newcastle	DRAWN BY:CTB	**Geotechnical Investigation for Pole Replacement Program**
	SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

PROJECT:	226603.00
DRAWING No:	24
REVISION:	0

N

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: Test Location Plan
OFFICE: Newcastle	DRAWN BY: CTB	Geotechnical Investigation for Pole Replacement Program
SCALE: 1:5000 @A3	DATE: 21.August.2024	Kurri Kurri to Muswellbrook, NSW

N

PROJECT:	226603.00
DRAWING No:	25
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
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0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY:CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 26
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	27
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB	**Test Location Plan** **Geotechnical Investigation for Pole Replacement Program** **Kurri Kurri to Muswellbrook, NSW**	DRAWING No: 28
SCALE: 1:5000 @A3	DATE: 21.August.2024		REVISION: 0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY:CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 29
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
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0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 31
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
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Douglas PARTNERS	CLIENT: AUSGRID		TITLE: **Test Location Plan**
	OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**
	SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

PROJECT:	226603.00
DRAWING No:	32
REVISION:	0

N

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
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2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	33
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB	**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	34
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY:CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	35
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.Rev3 - P:\226603.00 - KURRI MUSWELLBROOK, Pole Replacement\7.0 Drawings\7.2 Out\226603.00.D.qgz

NOTE:
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0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	36
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE:	**Test Location Plan**
OFFICE: Newcastle	DRAWN BY: CTB		**Geotechnical Investigation for Pole Replacement Program**
SCALE: 1:5000 @A3	DATE: 21.August.2024		**Kurri Kurri to Muswellbrook, NSW**

N

PROJECT:	226603.00
DRAWING No:	37
REVISION:	0

NOTE:
1. Drawing projection in GDA2020 / MGA zone 56, adapted from aerial imagery from Metromap.com
2. Test locations are approximate only and were located using differential GPS typically accurate to ± 1 m depending on satellite coverage

0 200 400 m

Douglas PARTNERS

CLIENT: AUSGRID		TITLE: **Test Location Plan**	PROJECT: 226603.00
OFFICE: Newcastle	DRAWN BY:CTB	**Geotechnical Investigation for Pole Replacement Program**	DRAWING No: 30
SCALE: 1:5000 @A3	DATE: 21.August.2024	**Kurri Kurri to Muswellbrook, NSW**	REVISION: 0

N

Douglas Partners
Geotechnics | Environment | Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

New Eastern Hub Sub-Transmission Substation
Lot 9 DP250890 Hebden Road, Muswellbrook

Prepared for
Ausgrid

Project 224764.00
November 2023

Document History

Document details

Project No.	224764.00	Document No.	R.002.Rev0
Document title	Report on Geotechnical Investigation New Eastern Hub Sub-Transmission Substation		
Site address	Lot 9 DP250890 Hebden Road, Muswellbrook		
Report prepared for	Ausgrid		
File name	224764.00.R.002.Rev0		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Draft A	Adrian Chaplin / Michael Harris	Michael Gawn	3 November 2023
Revision 0	Jeremy Hill / Michael Harris	Michael Gawn	22 November 2023

Distribution of copies

Status	Electronic	Paper	Issued to
Draft A	1	0	Paul Hurst, Ausgrid
Revision 0	1	0	Paul Hurst, Ausgrid

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

	Signature	Date
Author		22 November 2023
Reviewer		22 November 2023

Douglas Partners acknowledges Australia's First Peoples as the Traditional Owners of the Land and Sea on which we operate. We pay our respects to Elders past and present and to all Aboriginal and Torres Strait Islander peoples across the many communities in which we live, visit and work. We recognise and respect their ongoing cultural and spiritual connection to Country.

FS 604853

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Report on Geotechnical Investigation
New Eastern Hub Sub-Transmission Substation
Lot 9 DP250890 Hebden Road, Muswellbrook

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed new substation adjacent to the existing Muswellbrook Substation at Lot 9 DP250890 Hebden Road, Muswellbrook. The investigation was commissioned in an email dated 20 September 2023 by Paul Hurst and Sulev Kalamae of Ausgrid and was undertaken in accordance with Douglas Partners Pty Ltd (DP) proposal dated 18 September 2023.

It is understood that the proposed development of the site includes a new 132 kV Sub-Transmission Substation. The proposed development is outlined in Section 2 of this report.

The purpose of the investigation was to provide information and comments on the following:

- A summary of investigation methods;
- Borehole logs and core photos (if required) as well as test location plan;
- Summarised subsurface conditions, noting rock and groundwater depths, if encountered;
- Vertical Seismic Profiling (VSP) and interpretated dynamic parameters;
- Thermal resistivity test results;
- Soil aggressivity of buried structural elements with reference to AS 2159 (2009);
- Soil erosion and dispersion characteristics, as well as methods to deal with problem soils and suitable construction methods;
- Excavation conditions (to the depth of investigation);
- Safe batter slopes and temporary support for excavations;
- Geotechnical suitability of excavated material for re-use as filling;
- Site classification with reference to AS 2870 (2011) and characteristic surface movement (y_s);
- Shallow (pads / strips) and reinforced slab foundation options if suitable, including founding depths and design parameters (e.g. allowable bearing pressures);
- Bored pile founding depths and end bearing capacity design parameters;
- Retaining wall design parameters (Bulk density, Ka, Ko and Kp values);
- Design subgrade California Bearing ratio (CBR);
- Flexible and rigid pavement thickness design in accordance with relevant Austroads guidelines for the proposed transformer driveway; and
- Earthworks preparation measures (fill layer thickness and compaction requirements).

The investigation included the drilling of 30 boreholes and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the items listed above.

DP has undertaken a preliminary contamination and waste classification assessment (DP 2023) in conjunction with the geotechnical report, which is reported separately. DP (2023) indicates that limited soil contamination is present, and the report should be read in conjunction with this report.

2. Site Description

The site is located at Lot 9 DP250890 Hebden Road, Muswellbrook (refer Table 1). The site generally consists of vacant grassed land and at the time of the investigation was being used for cattle grazing.

Hebden Road and the North West Rail Line is located immediately north of the northern site boundary and Lake Lidell is located on the southern boundary of the site.

The site falls from the northern boundary, generally to the south, south-east and south-west at relatively uniform and low grades from a maximum of RL 138 (AHD) adjacent to Hebden Road, to approximately RL 128 adjacent to Lake Lidell.

Site vegetation comprised mature trees in the north-western portion, juvenile to semi-mature trees along all site boundaries and grass cover across the entirety of the site.

A narrow gully is situated along the eastern boundary and falls from north to south, from Hebden Road and outflows in to Lake Lidell.

Table 1: Site Identification

Item	Details
Allotment Identification	Lot 9 DP250890 Hebden Road, Muswellbrook
Street Address	Lot 9 Deposited Plan 250890
Locality	8.9 ha
Site Area	Zone RE1 Public Recreation
Local Government Area	Muswellbrook Shire Council
Current Land Use	Vacant – grazing land

A part of the site is shown in Figure 1 below.

Figure 1: Site Facing South-West toward Lake Lidell.

3. Published Data

Reference to the NSW Hunter Coalfield Regional geology sheet (1:100,000) indicates that the western portion of the site is underlain by Permian aged Mulbring Siltstone, part of the Maitland Group, which comprises siltstone, claystone and minor fine-grained sandstone. The far eastern portion of the site is underlain by late Permian Saltwater Creek formation of the Whittingham Coal Measures which forms part of the Singleton Supergroup and is characterised by sandstone, siltstone and minor coaly bands.

The bores encountered residual clay soils overlying rocks of the Mulbring Siltstone.

Reference to published mapping indicates that the site is not within an area of known acid sulfate soils (ASS).

The site is not located within a proclaimed mine subsidence district.

4. Proposed Development

The proposed development is understood to comprise:

- An outdoor switch yard;
- Prefabricated single storey metal clad and steel framed building;
- Mobile Equipment Room or 'MER' to be installed on top of foundations;
- Associated electrical infrastructure works may include either a new or a modified concrete slab, some steelwork, framed cable support structures and a number of in-ground conduit banks and possibly concrete cable jointing pits;
- Two synchronous condensers and associated foundations and buildings;
- Retaining walls up to 2 m in height;
- Buried pipes and electrical services;
- Earthworks to comprise cut and fill to create a platform for overlying construction; and
- Associated exit/entry pavement.

The client provided a typical design drawing of a substation switchgear replacement, which is proposed at the site, and which is titled "ZN 228 Stockton – 33/11kV Substation 11 kV Switchgear Replacement Civil & Structural Works Transportable 11 kV Switch Building Support Structure Details – Sheet 1", and the drawing has been attached for information within Appendix C.

No structural loads were provided to DP at the time of this report.

The approximate layout of the proposed development is shown on Drawing 1, Appendix A

5. Field Work

5.1 Field Work Methods

Field work for the investigation was generally undertaken in the period of the 25 September 2023 to 20 October 2023 and comprised the following:

- A site walkover by an environmental engineer to set out test locations in areas accessible and free from buried services. The test locations were nominated by the client and DP;
- Drilling of 30 bores (Bores 1 to 29, and 27A) using a purpose-built geotechnical drilling rig. The bores were drilled to depths ranging from 1.0 m to 20.74 m depth, using solid flight auger, rotary and NMLC coring methods;
    - o Installation of three piezometers in Bores 5, 23 and 29 for the purpose of enabling groundwater level measurement. Screens were installed at depths from 1.0 m to 4.0 m (Bores 5 and 23) and 1.0 m to 7.0 m (Bore 29);
- The piezometers were purged after installation and groundwater readings conducted on 20 October 2023;

- Installation of two grouted in 85 mm diameter PVC (Bores 21 and 27A) to 20 m depth for the purpose of seismic testing;
- Thermal resistivity in-situ testing and laboratory testing was undertaken at selected depths and test locations. Further methods on field testing and laboratory testing is outlined in Section 7.11 of this report;
- The test locations were set out by an engineer from DP who also logged the subsurface profile at each test location and collected samples for identification and laboratory testing purposes. In-situ testing in the soil profile comprised of standard penetration testing and pocket penetrometer testing at selected depths / locations;
- The test locations were recorded in GDA2020 using a differential GPS and are considered accurate to ±0.1 m, depending on satellite coverage, and the results are documented on the attached Borehole Logs. The locations of the tests are shown on Drawing 1 in Appendix C.

5.2 Field Work Results

The subsurface conditions encountered at the test locations are presented in detail in the Borehole logs included in Appendix A. These should be read in conjunction with the general notes preceding them, which explain the descriptive terms and classification methods used in the reports.

The subsurface conditions encountered within the test locations have been categorised into broad geotechnical units according to their inferred geological origin, as follows:

- Unit 1 - Topsoil (organics and silts):
  - Unit 1A – (Clayey Silt with Organics) Topsoil;
  - Unit 1B – (Clayey Silt): Typically very stiff to hard in consistency; and
- Unit 2 - Residual soils; Silty Clay or Sandy Clay. Typically very stiff to hard in consistency;
- Unit 3: Rock: Siltstone:
  - Unit 3A - Extremely weathered material (soil like properties);
  - Unit 3B - Very low to low strength;
  - Unit 3C – Low to medium strength; and
  - Unit 3D – Medium to high strength.

The predominant subsurface conditions encountered within the bores are summarised in Table 2 below.

Table 2: Summary of Boreholes (1 of 2)

Borehole		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RL (AHD)		137.9	136.8	135.7	134.8	137.0	138.5	138.5	137.9	136.1	135.8	137.4	134.9	138.8	136.3	137.5
Material Description	Unit	Depth Range (m)														
Topsoil (organics and silt)	1A	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05
Clayey Silt (Typically VST to H)	1B	NE	0.05 - 0.20	NE	NE	0.05 - 0.60	0.05 - 0.20	NE	0.05 - 0.20	0.05 - 0.30	NE	0.05 - 0.20	NE	NE	NE	NE
Silty Clay / Sandy Clay (Typically VST to H)	2	0.05 - 1.04	0.20 - 4.00	0.05 - 3.25	0.05 - 1.10	0.60 - 2.70	0.20 - 2.50	0.05 - 1.00	0.20 - 2.6	0.30 - 2.55	0.05 - 2.65	0.20 - 2. 55	0.05 - 1.00	0.05 - 1.00	0.05 - 2.20	0.05 - 2. 65
Siltstone (Extremely Weathered Material)	3A	NE	(2.5-4.0)	3.25 - 6.20	NE	(1.0-2.7)	(1.5-2.55)	(0.7-1.0)	(1.10 - 2.60)	(1.5-2.55)	NE	NE	NE	NE	NE	NE
Siltstone (Typically VL to L)	3B	NE	NE	6.20 - 10.30	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Siltstone (Typically L to M)	3C	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Siltstone (Typically M to H)	3D	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Free Groundwater Observations (m)		NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO

Notes to Table:
NE – Not encountered
NFGWO – No free groundwater observed
VL – very low strength, L – Low Strength, M – Medium Strength, H – High Strength
(1.5-2.3) grading to weathered material
It should be noted that layers of extremely weathered material and clay lined discontinuities where present within layers of the rock Units listed above, and that some limited layers of weaker/stronger rock was encountered in the Units summarised above.

Table 2: Summary of Boreholes (2 of 2)

Borehole		16	17	18	19	20	21	22	23	24	25	26	27	27A	28	29
RL (AHD)		138.0	137.0	135.1	136.5	135.4	136.4	134.0	136.5	135.5	134.7	133.6	134.8	134.9	135.6	132.4
Material Description	Unit	Depth Range (m)														
Topsoil (organics and silt)	1A	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	0.0-0.05	NE	0.0-0.05	0.0-0.05
Clayey Silt (Typically VST to H)	1B	NE	NE	NE	NE	NE	NE	NE	0.05 - 0.40	NE	0.05 - 0.60	NE	NE	NE	0.05 - 0.60	NE
Silty Clay / Sandy Clay (Typically VST to H)	2A	0.05 - 2.80	0.05 - 2.70	0.05 - 1.14	0.05 - 1.10	0.05 - 2.00	0.05 - 3.0	0.05 - 1.00	0.40 - 2.70	0.05 - 2.60	0.60 - 2.85	0.05 - 2.05	0.05 - 2.50	NE	0.60 - 2.70	0.05 - 2.50
Siltstone (Extremely Weathered Material)	3A	NE	NE	NE	NE	2.00 - 3.04	-	1.00 - 3.50	NE	2.60 - 3.86	NE	NE	2.50 - 4.00	NE	NE	2.50 - 3.2
Siltstone (Typically VL to L)	3B	NE	NE	NE	NE	3.04 - 9.04	3.00 - 8.96	NE	NE	3.86 - 8.00	NE	NE	4.00 - 8.68	NE	NE	3.2 - 10.30
Siltstone (Typically L to M)	3C	NE	NE	NE	NE	9.04 - 10.30	NE	NE	NE	NE	NE	NE	8.68-11.17	NE	NE	NE
Siltstone (Typically M to H)	3D	NE	NE	NE	NE	NE	8.96 - 20.74	NE	NE	8.00 - 11.53	NE	NE	11.17 - 16.40	15.80 - 20.55	NE	NE
Free Groundwater Observations (m)		NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO	NFGWO

Notes to Table:

NE – Not encountered

NFGWO – No free groundwater observed

VL – very low strength, L – Low Strength, M – Medium Strength, H – High Strength

It should be noted that layers of extremely weathered material and clay lined discontinuities where present within layers of the rock Units listed above, and that some limited layers of weaker/stronger rock was encountered in the Units summarised above.

5.3 Groundwater

No free groundwater was observed during the auger drilling of the bores. Piezometers installed in Bores 5 and 23 did not contain groundwater upon initial groundwater measurement on 20 October 2023.

It should be noted that groundwater levels are affected by factors such as climatic conditions and soil permeability and will therefore vary with time.

5.4 Vertical Seismic Profiling (VSP)

DP engaged GBG Australia as a subconsultant to undertake Vertical Seismic Profiling (VSP) within Bores 21 and 27A, for the purpose of estimating dynamic parameters. DP drilled these bores to 20 m depth each to allow 85 mm PVC casing to be installed. The bore annulus between the casing and outer bore walls was grouted with a cement water grout. It should be noted that Bore 27 was terminated at approximately 17 m depth due to the core barrel becoming stuck within the rock and was not able to be retrieved. It is understood that a mechanical failure of the drill string is the reason for the malfunction. Bore 27A was redrilled to 20 m depth to allow Seismic testing to occur.

The results of the VSP investigation undertaken by GBG along with dynamic parameters calculated by GBG are presented within the Geophysical Report in Appendix D. It is noted that the seismic velocities and resulting dynamic parameters provided in the GBG Australia report were calculated using two distinct approaches:

1. Using the average p and s-wave velocities calculated based on travel times between the surface and measurement depth; and

2. Interval velocities calculated based on the difference between the observed travel times of pairs of successively deeper measurements (1 m depth intervals).

It is noted that the interval velocities and calculated dynamic parameters provided by GBG Australia show significant variation with depth and are considered to be unreliable.

Further interpretation was undertaken by a Senior Geophysicist of DP to determine the approximate average seismic velocities and dynamic parameters of each of the main seismic layers, based on picked first arrival data provided by GBG Australia and comparison with the borelogs. The results, which we believe are more reliable, are shown in Appendix E.

The following procedure was used by DP to convert the field data to the estimated dynamic ('small strain') shear modulus (G_{dyn}), dynamic elastic or 'Young's' modulus (E_{dyn}) and dynamic bulk modulus (K_{dyn}):

(i) Calculate the vertical arrival times (T_{vp} and T_{vs}) from the measured times allowing for the source-hole offsets (X_p and X_s);

(ii) Plot scattergrams of depth (Z) versus T_{vp} and T_{vs};

(iii) Interpret linear segments of the Z-T_{vp} and Z-T_{vs} plots corresponding to constant seismic velocities with reference to lithological and geotechnical boundaries described in the bore logs;

(iv) Calculate the interval velocities V_p and V_s (in m/sec for the formulae and units in (vi) below), by estimating the slopes of linear segments of the Z-T_{VP} and Z-T_{VS} data;

(v) Assign bulk densities (ρ) in t/m^3 for each interval based on available estimates from previous investigations in similar geological conditions; and

(vi) Calculate the following dynamic insitu parameters:

Poisson's Ratio	σ	$= ((V_p/V_s)^2-2)/(2((V_p/V_s)^2-1))$	
Shear Modulus	G_{dyn}	$= \rho V_s^2 \times 10^{-3}$	(MPa)
Elastic Modulus	E_{dyn}	$= 2G_{dyn}(1+\sigma)$	(MPa)
Bulk Modulus	K_{dyn}	$= E_{dyn} / (3(1-2\sigma))$	(MPa)

The graphical p- and s-wave logs used for interpretation are scattergrams, with scatter likely resulting from seismic arrival time measurement error (visual picking error) and from the subjective identification of primary p- and s-wave arrivals (random or interpretational error). In applying this method, it is inherently difficult to generate shear waves with high amplitude. Identification of s-waves (by reversal of hammer impact direction and hence inversion of recorded waveform) is therefore difficult, particularly in view of interference from p-waves (at shallow depths) and from later cycles of converted p-wave arrivals at all depths. Such interference, from unavoidably generated p-waves and converted p-waves, in some cases increases the scatter and hence decreases the reliability of the line of best fit which defines the s-wave velocity estimate and subsequent dynamic shear modulus estimate.

It should be noted that the dynamic moduli within Appendix E are relevant to small strains (in the order of 10^{-6}) only. Large strain moduli are valid for strains of the order of 10^{-4} or greater. In the intermediate range the modulus will decrease as strain increases. If strains larger than 10^{-6} are expected, the above dynamic moduli will be too high and should be revised.

It is noted that the poisson's ratio values estimated for rock materials from the VSP presented within Appendix E are nearly double that of typical published values for similar materials. Therefore it is suggested that the dynamic parameters presented within Appendix E should be used with caution, and that any analysis for design using such values should include a sensitivity analysis which adopts parameters to ± 50% of those presented in this report, to assess the impacts these parameters provided on design.

6. Laboratory Testing

6.1 Geotechnical Laboratory Testing

The detailed geotechnical laboratory testing results are attached within Appendix B, and a summary of tests undertaken are summarised in Table 3, 4 and 5 below.

Table 3: Shrink Swell and Atterberg Limits

Bore	Depth (m)	Description	FMC (%)	LL (%)	PL (%)	PI (%)	Shrink (%)	Swell (%)	ISS (% per ΔpF)	PP before soaking (kPa)	PP after soaking (kPa)
3	0.5 - 0.8	Silty Clay	-	42	14	28	-	-	-	-	-
3	1.0 - 1.45	Silty Clay	-	72	21	51	-	-	-	-	-
10	0.5 - 0.79	Silty Clay	17.6	-	-	-	4.8	2.9	3.4	>600	100
11	0.5 - 0.82	Silty Clay	-	53	15	38	-	-	-	-	-
21	1.0 - 1.45	Silty Clay		51	24	27	-	-	-	-	-
22	0.5 - 0.75	Silty Clay	-	44	16	28	-	-	-	-	-

Notes to Table:
FMC – Field Moisture Content
LL – Liquid Limit
PL – Plastic Limit
I_{SS} – Shrink Swell Index
PP – Pocket Penetrometer Reading

Table 4: Moisture Content Determination and California Bearing Ratio

Bore	Depth (m)	Description	FMC (%)	MDD (t/m^3)	OMC (%)	CBR (%)	Swell (%)
1	0.1 - 0.6	Silty CLAY	17.6	1.54	22.5	1.5	4.0
4	0.1 - 0.6	Silty CLAY	17.5	1.58	21.0	2.5	3.0
5	0.0 - 0.6	Clayey SILT	16.3	1.54	24.0	2.5	3.0
7	0.1 - 0.6	Silty CLAY	21.2	1.45	28.0	2.5	3.0
12	0.5 - 0.9	Silty CLAY	19.0	1.49	26.0	3.0	1.5
13	0.5 - 0.9	Silty CLAY	19.8	1.59	23.0	1.5	4.5
18	0.1 - 0.6	Silty CLAY	19.6	1.47	26.0	3.0	2.5
19	0.1 - 0.6	Silty CLAY	19.2	1.49	25.5	4.0	1.5

Notes to Table:
FMC – Field Moisture Content
MDD – Maximum Dry Density
OMC – Optimum Moisture Content
CBR – California Bearing Ratio

Table 5: Emerson Classes

Bore	Depth (m)	Description	Water Temperature (°C)	Emerson Class
16	2.5 - 2.8	Silty CLAY	19.3	2
22	0.0 - 0.1	Silty CLAY	19.3	6
27	1.0 - 1.45	Silty CLAY	19.3	2

Notes to Table:
Emerson Class No. (AS 1289.3.2.1)
No 1 to 6 being most susceptible dispersive to least susceptible dispersive

The Emerson Class No. test results ranged from 2 to 6 within the Units 1 and 2 soils, indicating a variable (high to low-moderate) risk of dispersion.

6.2 Geo-chemical Laboratory Testing

Six samples were submitted to Envirolab Services Pty Ltd for analysis of pH, electrical conductivity (EC), soluble sulphate (SO_4) and soluble chloride (Cl), to assess soil aggressiveness. Detailed laboratory report sheets are provided in Appendix B, along with other chemical tests which have been reported within, and are summarised in Table 10 within Section 7.8.

6.3 Thermal Resistivity Testing

Thermal resistivity laboratory testing was performed on undisturbed samples (U70 tube samples) in accordance with ASTM D5534, and was undertaken on selected samples from the test locations (i.e. Bore). The results were plotted in the form of a dry-out curve to determine the relationship between moisture content and thermal resistivity.

The field testing was undertaken by Geotherm Australia and comprised using a probe in accordance with ASTM D5334, within bores, and the field testing was undertaken at similar depths to the above mentioned laboratory test sample.

The results of the field and laboratory testing with dry out curve interpretations are contained within Appendix B.

7. Comments

7.1 Appreciation of Subsurface Conditions

The pertinent characteristics of the subsurface conditions are further summarised as follows:

- Unit 1A topsoil typically 50 mm in thickness;
- Unit 1B clayey silt topsoil ranging up to 0.6 m depth in parts but not within all test locations;

- Unit 2 residual clay soils, underlying topsoil and ranging from 0.05 m to 2.85 m depth, but more typically up to 1.0 m depth. The silty clay was moderate to high plasticity and typically very stiff or stronger;
- Unit 3: Siltstone underlying soil, typically comprising:
  - Unit 3A Extremely weathered material (soil like properties) ranging from about 1.0 m to 6.2 m depth, and more typically between 1.0 m and 3.0 m depth;
  - Unit 3B Very low to low strength, and Unit 3C (low to medium strength) typically ranging from 3.0 m to 10.0 m depth, further underlain by;
  - Unit 3D - Medium to high strength, typically below 10 m depth (in Bores 21, 27 and 27A only).

The Unit 2 very stiff to hard residual clay, where encountered, is suitable to support lightly loaded shallow footings, and heavily loaded structural loads should be supported on piles founded within rock (Unit 3).

The Unit 2 silty clay is of moderate to high plasticity and moderately to highly reactive, and the upper clay soils near the site surface are prone to softening, particularly during extended periods of wet weather. Suitable site preparation measures will be required to facilitate construction of the pavements and the site platform.

Given the conditions encountered in the investigation and the topography of the site it is anticipated that cut and fill in the order of 2 m to 3 m depth is likely to be required to terrace the site for substation platform construction. It is suggested that the site won materials be used to construct the platform and that imported select and pavement materials be used to cap the platform.

7.2 Site Classification

Site classification of foundation soil reactivity provides an indication of the propensity of the ground surface to move with seasonal variation in moisture. Based on procedures presented in AS 2870 (2011) and on results from this investigation the recommended site classification for the proposed development is presented below.

It should be noted that standard designs within AS 2870 (2011) for site classifications which are based on characteristic surface movements only apply to structures of similar size and flexibility to residential buildings and do not apply to industrial structures or buildings larger than two storeys. Similar principles in design for reactivity / movement, however, should be incorporated into design, construction and maintenance.

Due to the presence of highly reactive clays to greater than 3.0 m depth in parts of the site, the site is technically Class E-D, as defined in AS 2870 (2011). AS 2870 (2011) does not provide standard footing options for such conditions. Accordingly, all footings should be designed in accordance with engineering principles.

As a preliminary guide to reactive soil movements in the natural site soils, the soil profiles and the laboratory tests were used to estimate the characteristic surface movement (ys) value for normal seasonal moisture variations. Based on this local information it is anticipated that characteristic surface movements are likely to be in the order of 90 mm, i.e. commensurate with a 'Class E-D' (extremely reactive) classification, where founded within the Unit 2 very stiff to hard clays, for the site in its present state, without the placement of additional filling. When cut or fill occurs on the site for platform construction, the anticipated that characteristic surface movements are likely to be in the order of 110 mm, i.e. commensurate with a 'Class E-D' (extremely reactive) classification, provided at least 0.5 m thick low to non-reactive layer is placed over the entire site. The site classification should be re-assessed after any cut fill operations.

Design, construction and maintenance should take into account the need to achieve and preserve an equilibrium soil moisture regime beneath and around buildings. Such measures include paved areas around structures to fall away from the building, flexible plumbing connections and service trenches to be backfilled with compacted clay. These and other measures are described in AS 2870 (2011) and the attached (CSIRO, 2021).

Footings should not be founded in existing or proposed filling unless it has been placed and compacted under Level 1 earthworks inspection and testing requirements in accordance with the procedures outlined in AS 3798 (2007) or specifically assessed and designed for founding within uncontrolled filling.

Engineered filling requirements are outlined below in Section 7.12 of this report.

7.3 Footings

Shallow strip and pad footings for the proposed structures could be founded in Unit 3 clay of very stiff to hard consistency and/or engineered filling may be proportioned for an allowable bearing pressure and designed for the preliminary settlement estimates listed in Table 6 below.

Table 6: Preliminary Settlement Estimates

Foundation Material	Founding Depth (m)	Footing Type and Dimension	Maximum Allowable Bearing Pressure (kPa)	Estimated Settlement (mm)
Unit 2, 3A or Engineered Fill	1.0	Pad - 1.0 m x 1.0 m	100	10 - 15
		Pad – 2.0 m x 2.0 m		10 - 20

Notes to Table:

It should be noted that the estimated settlements in the above table assume surcharge is applied uniformly across the footing, and do not include allowances for fluctuations due to seasonal ground movements.

Footings should be preferably founded within similar materials for individual buildings / structures to reduce the risk of differential settlement.

The estimated settlements outlined above are independent of, and may be additive to, reactive movements.

Footing inspections should be undertaken by a geotechnical engineer to confirm foundation conditions, if the parameters in this report are adopted for design.

All footing excavations should be prepared by installing a 100 mm of concrete blinding layer immediately after excavation and inspection, to protect the clay from softening when exposed to water ingress and or from shrinkage cracking when exposed to dry conditions.

7.4 Piles

Suitable pile footing types will need to consider several factors, including depth to rock, structural capacity of the pile and potential for hole collapse.

Bored piles are considered an appropriate pile type within the Unit 3 rock.

It is recommended that bored piles should be founded at least one pile diameter into Unit 3B rock, and should be designed based on the parameters outlined below, where required to support heavy structural loads (especially under columns).

Geotechnical Strength Reduction Factor (AS 2159)

The design geotechnical strength of a pile ($R_{d,g}$) is the ultimate geotechnical strength ($R_{d,ug}$) multiplied by the geotechnical strength reduction factor (ϕ_g), such that:

$$R_{d,g} = \phi_g \cdot R_{d,ug}$$

The calculated value $R_{d,g}$ must equal or exceed the structural design action effect E_d. Selection of the geotechnical strength reduction factor (ϕ_g) is based on a series of individual risk ratings (IRR) which are weighted and lead to an average risk rating (ARR). The individual risk ratings and final value of ϕ_g depend on the following factors:

- Site: the type, quantity and quality of testing;
- Design: design methods and parameter selection;
- Installation: construction control and monitoring;
- Pile testing regime: testing benefit factor based on percentage of piles tested and the type of testing; and
- Redundancy: whether other piles can take up load if a given pile settles or fails.

It is anticipated that the pile configuration for the structure would be a low redundancy situation, and hence the appropriate basic geotechnical strength reduction factor is likely to be 0.52. The redundancy category should be confirmed by the designer.

Table 8.2.4(B) of AS 2159 (2009) requires that 5% to 15% of piles should be subject to integrity testing if the adopted ϕ_g exceeds 0.4. Higher values of ϕ_g can be justified by more comprehensive static or dynamic load testing. Similarly, where the basic geotechnical strength reduction factor of greater than 0.4 is to be used, serviceability (load) testing must be performed for all foundations with an average risk rating of 2.5 or greater.

Bored Pile Design Parameters

The design of bored concrete piles may be based either on limit state design methods or a 'working stress' approach. The vertical Young's modulus (E_v) values and the ultimate limiting (end bearing and shaft adhesion) pressures given in Table 7 may be used to assess the limiting states for pile design purposes in accordance with AS 2159 (2009).

Alternatively the piles may be proportioned on the basis of the 'allowable pressures or serviceability' given in Table 7. The settlement of piles subjected to vertical loads will vary depending on the ('serviceability' or working) loads applied and the foundation conditions below the pile toe.

Table 7: Geotechnical Parameters for Pile Design in Rock

Rock Class / Rock Unit	Strata Depth (m) of Foundation Material						Vertical Young's Modulus, E_v (6) (MPa)	Ultimate Strength		Serviceability / Maximum Allowable End Bearing Pressure (3),(5)
	Bore 3	Bore 20	Bore 21	Bore 24	Bore 27	Bore 29		End Bearing (3),(4) (kPa)	Shaft Adhesion (1),(2) (kPa)	(kPa)
Class V - Siltstone Predominantly Unit 3B	3.3-10.3	3.1 – 8.3	3.0 – 8.9	3.9 – 8.0	4.0 – 8.7	3.2 – 10.3	75	3,000	50	700
Class IV-Siltstone Predominantly Unit 3C	-	8.3 – 10.0	-	-	8.7-11.2	-	300	4,000	150	1000
Class II-Siltstone Predominantly Unit 3D	-	-	8.9 - 20.7	8.0 – 11.5	11.2 – 16.4	-	2,000	60,000	1000	6,000

Notes to Table:
All pile end bearing parameters are based on pile penetration of at least four pile diameters below the ground surface;
1 Shaft adhesion parameters are only applicable where adequate socket roughness (roughness category "R2" or greater) is achieved. Roughness categories are defined in (Pells, Mostyn, & Walker, 1998)
2 For calculation of tension or uplift capacity the shaft adhesion should be taken as 70% of the above shaft adhesion parameters also assessed using the inverted cone method.
3 Bearing pressure values assume a minimum embedment of one pile diameter into the relevant bearing stratum.
4 Ultimate end bearing parameters mobilised at large settlements (i.e. > 5% of pile diameter).
5 Allowable end bearing parameters could experience settlements of less than 1% of the pile diameter.
6 A range of values has been given for vertical Young's Modulus (E_v) based on typical published correlations.
7 Lower end values have been given for ultimate end bearing owing to the presence of weaker seams within the rock mass. Care should be taken to ensure that the piles are not founded within these lower strength seams.

It is suggested that (Pells P. J., 1999) is used for the evaluation of the geotechnical strength and serviceability of piles designed to the parameters listed above.

The design of piles required to resist uplift or tension loads should be checked against the 'cone-pullout' failure mode as well as the shaft (i.e. 'piston pull-out') capacity of the pile. It is suggested that an inverted 60° cone from the base of the pile be used for calculation of uplift capacity.

Bored piles should have bases and sockets cleaned and free of debris and water at the time of concrete placement. Cleaning buckets should be used during pile installation to provide a suitably clean base which is at least 90% clean of drill cuttings. A roughening tool should be used to roughen sidewalls and remove clay smear during pile installation.

It is also recommended that geotechnical inspections and monitoring be undertaken during the installation of piles to confirm socket roughness and design parameters.

Notwithstanding the above, piling contractors should be responsible for selecting an appropriate piling method with reference to the ground conditions, and the pile capacities required for design.

7.5 Excavatability

The proposed depth of excavation is unknown at this stage. However for preliminary purposes, it is anticipated that excavations will be less than 3 m below current levels.

It is anticipated that bulk excavation will generally be achievable using conventional hydraulic equipment for the Unit 1 and Unit 2 soils and also Unit 3A extremely weathered rock, which were generally encountered within the upper 3 m of the profile.

It is important to note that excavatability of rock is dependent not only on rock strength, but also on the presence, orientation and extent of discontinuities such as jointing and fracturing and other factors. For example, low strength rock with few discontinuities can be more difficult to excavate than highly fractured high strength rock.

Confined and detailed excavations in medium strength and high strength rock, will likely require the use of excavators fitted with rippers, rock hammers and/or rock sawing.

7.5.1 Geotechnical Re-use of Excavated Materials

The majority of Unit 2 soils and/or Unit 3 rock encountered on site within excavations will likely be suitable for use as engineered fill as platform filling beneath pavement, hardstand and structural areas, however the suitability of the Unit 3 material will be dependent on the ability to create a suitable particle size distribution, and may require additional processing such as crushing and blending.

The reactivity of the clay should be considered and the use of site won clay soils will negatively impact characteristic surface movements (possibly commensurate with Class E-D classification). Laboratory test results also indicated that some of the clays are of high plasticity and hence consideration could be given to blending the clay with the weathered bedrock material, which was encountered at greater depth, to reduce the plasticity and improve the shrink-swell characteristics and strength of the clay soils, or capping of clay fill with at least 0.5 m of non-reactive filling will reduce overall characteristic surface movements.

The Unit 3 rock would be a suitable engineering fill material provided the material can be produced to generate a well graded material. This may require using hammers or possibly cross-ripping the rock with tynes. The finer material is likely to require segregation from the oversize material (say >200 mm), with the coarser material requiring further processing such as crushing or additional hammering to produce a material suitable for engineered fill.

Unit 1A topsoil and silt are not considered suitable for re-use as engineered fill, but with the addition of at least 25% organic matter (i.e. mulch) and fertilises, it is likely to be suitable for re-use as topsoil for vegetation growth.

Moisture conditioning by adding water would be required for site won filling.

In accordance with the NSW POEO Act, all material that will be removed from site must be subject to a waste classification assessment in accordance with NSW EPA waste classification guidelines to facilitate off-site disposal to an appropriately licensed landfill / waste management facility, or appropriately assessed for its potential reuse on another site as either Virgin Excavated Natural Material (VENM) or an appropriate resource recovery exempt material (e.g. Excavated Natural Material (ENM)) in accordance with the appropriate NSW EPA resource recovery order (RRO). DP can assist with classification and assessment of materials to be removed from site, if required.

7.6 Excavation Batters

The following batters are recommended for slopes with a total height of up to 3.0 m.

Table 8: Recommended Temporary Batter Slopes

Strata	Temporary Maximum Slope (H:V)	Long Term Maximum Slope (H:V)
Engineered Fill	1H:1V (Less than 1.0 m depth)	3H:1V
Unit 2 – clay Unit 3A – extremely weathered rock	1H:1V	3H:1V
Unit 3B - Very Low to Low Strength Rock	0.75H:1V	1H:1V

Notes to Table:

Batter slopes within fill and rock are subject to geotechnical inspection during construction; dependent on jointing

Rock cuttings should be inspected by a suitably qualified engineering geologist / geotechnical engineer, during excavation / trimming, to confirm the above batter slopes and identify the need or otherwise for bolting or other temporary support measures.

All batter slopes should be protected from erosion. Surface water should be diverted away from slopes by installation of a dish drain at the crest of slopes.

7.7 Retaining Walls

Where support is to be provided to adjoining structures or services, the use of retaining walls up to 2 m in height is recommended. Design parameters for estimating long-term earth pressures on retaining walls with level back fill (i.e. no slopes) are presented in Table 9. These values are unfactored hence a suitable factor of safety should be used in design.

Table 9: Design Parameters for Retaining Structures (Unfactored)

Unit	Material	γ_b (kN/m^3)	Ka	Ko	Kp
-	Engineered fill	20	0.41	0.58	2.5
2	Very stiff to hard residual clay	20	0.36	0.53	2.8

Notes to table:
γb - bulk density
Ka - coefficient of active earth pressure
Ko - coefficient of 'at-rest' earth pressure
Kp - coefficient of passive earth pressure

7.8 Soil Aggressivity to Buried Structures

The results of pH, chloride and sulphate ion concentration analyses, along with the interpretation of the results for aggressivity classification for concrete and steel based on the Piling Code (AS 2159, 2009) are summarised in Table 10 below.

Table 10: Soil Aggressivity

Bore	Depth (m)	Description	Soil Condition	pH (concrete)	pH (steel)	Resistivity[1] (Ω.cm) (steel)	SO_4 (ppm) (concrete)	Cl (ppm) (steel)
9	1.0 - 1.45	Silty Sandy CLAY	B	5.2	5.2	1020	450	1200
10	1.0 - 1.35	Silty CLAY	B	7.8	7.8	1333	490	770
10	2.5 - 2.65	Silty CLAY	B	4.8	4.8	1786	350	610
14	1.0 - 1.20	Silty Sandy CLAY	B	7.8	7.8	13158	10	23
15	1.0 - 1.45	Silty Sandy CLAY	B	9.1	9.1	2381	65	170
23	2.5 - 2.7	Silty Sandy CLAY	B	7.4	7.4	1282	380	1300

Notes to Table:

Non-aggressive
Mildly aggressive
Moderately aggressive
Severely Aggressive
Very Severe
NT Not Tested
1 Resistivity calculated based on inverse of conductivity in aqueous solution results
Scale of aggressivity based on threshold values given in AS 2159 – 2009: Piling – Design and Installation.

Reference should be made to Tables 6.4.3 of AS 2159 (2009) to determine the minimum concrete cover to reinforcement required (for concrete piles), based on this exposure classification and the minimum concrete strength appropriate for the indicated site conditions.

7.9 Earthquake Design Parameters (Site Sub-Soil Class)

Sections 3 and 4 of AS 1170.4 (2007) provides details regarding hazard factors and site sub-soil classes.

Reference to Figure 3.2(G) of AS 1170.4 (2007) indicates that a hazard factor, Z, of 0.12 would be applicable for earthquake design at this site.

Conditions encountered during the investigation are summarised shallow topsoil, overlying residual very stiff clays and extremely weathered rock up to about 3 m depth, siltstone which grades from very low strength up to high strength rock from 10 m to 20 m depth. Based on these conditions, Section 4 of AS 1170.4 (2007) indicates that the site would be classed as a “shallow soil site”, for which a sub-soil ‘Class Ce’ would apply.

7.10 Soil Erosion

To minimise impacts of erosion and or dispersion the following measures may decrease the likelihood:

- Compaction of any proposed fill in accordance with Section 7.13 of this report;
- Permanent batter slopes should be vegetated as soon as possible, to reduce the risk of significant soil erosion occurring;
- Topsoil (with minimum thickness of 100 mm and a maximum of 200 mm thickness) and vegetation on exposed batters or cuts. Hydro-mulching, mulching and fertilisers should be considered to promote growth;
- Adequate surface drainage is provided to reduce surface and seepage water flows;
- Contour drains along the crest of both cut and fill batters should be provided to reduce the potential for erosion. Such drains should be vegetated or gravel-lined, as appropriate for the expected flows;
- Short term erosion measures such as silt fencing, hay bales etc., where required during construction; and
- Drains should be vegetated or concrete-lined, as appropriate for the expected flows. The use of rip-rap (rockfill) blankets or extensive re-vegetation may be required to dissipate stormwater flows at the location of drain outlets or previously eroded areas if encountered.

7.11 Pavement Thickness Design

The pavement thickness designs presented in this report is considered preliminary only and is based on assumed traffic loading data, and it is further understood that for specific pavements which may be traffic by forklifts / cranes or where stacking or structural point loads occur that Ausgrid will undertake specific pavement thickness designs.

7.11.1 Design Traffic Loading

It is understood that the majority of traffic will comprise light vehicles and light trucks during the operation of the substation. The construction period is likely to constitute the highest volume of road register trucks. No specific traffic volume data has been provided, whoever for the purpose of these preliminary pavement designs the design traffic loadings adopted for pavement thickness design has been provided within Table 11 below.

Table 11: Summary of Design Traffic Loading Adopted

Pavement	Pavement Type	Design Traffic Loading (ESA's)	Average ESA / HVAG	Design Traffic Loading HVAG
Access Road	Flexible	8×10^4	0.8	-
Substation Platform	Flexible			-
	Rigid - concrete	-		1×10^5

7.11.2 Design Subgrade CBR

The expected subgrade conditions for the access road pavements generally comprise natural silty clay Unit 2, and also the subgrade conditions for the substation platform will comprise Unit 2 materials given the lower parts of the platform is likely to be constructed using the Unit 2 materials.

Based on the results of the laboratory testing (CBR 1.5% to 4%) and experience with similar soils in the area a subgrade CBR of 1.5% has been adopted. Given the low CBR subgrade soils and their risk to soften with increase in moisture content a select subgrade layer is recommended to allow construction of overlying pavements and filling.

The recommended effective CBR is outlined below:

- Effective CBR of 5% being adopted for access pavement thickness design purposes, given that a 300 mm thick select subgrade layer (at least CBR 30%) is to be used;
- Effective CBR of 4% being adopted for platform pavement thickness design purposes, given that a 500 mm thick select subgrade layer (at least CBR 10%) is to be used;
- A design CBR of 7% has also been adopted for where rock subgrades are encountered.

It is noted that clay can be susceptible to softening upon inundation or exposure to moisture, hence care should be taken to protect excavations / subgrades against inclement weather or prolonged exposure to the elements.

7.11.3 Flexible Pavement Thickness Design

The flexible pavement thickness design was undertaken in accordance with the Austroads guideline for design of pavements (Austroads, 2017). The results are presented in below in Table 12.

Table 12: Flexible Pavement Thickness

Traffic Load	8×10^4 ESA		
Effective Design Subgrade CBR	4%	5%	7%
Design Life (years)	20		
Pavement Layer	Layer Thickness (mm)		
Asphalt	50 AC10 and Primer seal [1]		
Basecourse	100	100	180
Subbase	180	140	-
Total Pavement Thickness (including AC wearing course)	330+ Select	290 + Select	230 + Select

Notes to Table:

(1) A 7 mm - 10 mm prime seal should be placed over the basecourse.

(2) Incorporation of a select layer is recommended owing to the presence of expansive clay subgrade and has been considered in determining the design subgrade CBR. Additional select material may be required to allow for compaction of overlying pavement layers depending on the moisture condition of the clay subgrade at the time of construction.

It is expected that there may be a requirement for increased maintenance in areas of tightly turning trucks due to high shear / torsional stresses applied to the pavement surface. The use of a stiffer binder (i.e. Class 450 or Class 600 PMB bitumen) in the asphalt (if used) would be expected to reduce the damage to the asphalt surface in areas of tightly turning heavy vehicles.

It is recommended that where any new pavements abuts an existing pavement, it should be benched / keyed in a minimum width of 0.3 m. Vertical interface / joints between the new and existing sections of pavements should not be located within wheel paths.

7.11.4 Rigid Pavement Thickness Design

Based on the procedures outlined in (Austroads, 2017) the following rigid pavement thickness design, shown in Table 13, is suggested.

Table 13: Rigid Pavement Thickness Design

Traffic Load	1×10^5 HVAGs	
Design Subgrade CBR	4%	7%
Design Life (years)	20	
Load Safey Factor	1.2	
Pavement Layer	**Layer Thickness (mm)**	
Concrete Base	170	165
Subbase	100	100
Select Subgrade(2)	500	500
Total Pavement Thickness	270 + Select	265 + Select

Notes to Table:

This pavement thickness design is based on the use of concrete shoulders, a concrete flexural strength of at least 4 MPa and a design project load safety factor of 1.2.

The rigid pavement thickness given in Table 13 is based on a 28-day compressive strength of at least 32 MPa. Steel reinforcing and joint detail for the concrete pavement should be designed by the civil engineer for the project based on the procedures in Austroads.

7.12 Material Quality and Compaction Requirements

Recommended pavement material quality and compaction requirements are presented in below.

Table 14: Material Quality and Compaction Requirements – Flexible Pavement

Pavement Layer	Material Quality	Compaction
Asphalt	Conform to local Council requirements or TfNSW R116	NCC requirements or TfNSW R116
Unbound Basecourse	CBR > 80%, PI ≤ 6%, Grading in accordance with Council requirements	Compact to at least 98% dry density ratio Modified (AS 1289.5.2.1)
Subbase	CBR > 30%, PI ≤ 12%, Grading in accordance with Council requirements	Compact to at least 95% dry density ratio Modified (AS 1289.5.2.1)
Select Subgrade	CBR>30%, as per subbase – Access Road CBR ≥ 10% with no particles greater than 200 mm- Platform	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)

Table 15: Material Quality and Compaction Requirements – Concrete Pavement

Layer	Material Quality	Compaction
Concrete Base	Minimum 32 MPa 28 day compressive strength Flexural Strength of 4.0 MPa	-
Subbase	CBR > 30%, PI ≤ 12%, Grading in accordance with Council requirements	Compact to at least 95% dry density ratio Modified (AS 1289.5.2.1)
Select Subgrade	CBR ≥ 15%	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)
Select Subgrade	CBR>30%, as per subbase – Access Road	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)
Select Subgrade	CBR ≥ 10% with no particles greater than 200 mm Platform	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)

7.12.1 Pavement Drainage

The vehicular pavement designs provided above depend on the provision of adequate surface and subsoil drainage to maintain the subgrade as close to the optimum moisture content as possible and to ensure that the pavement layers do not become saturated.

Normally, subsoil drainage should be installed at least 0.5 m below subgrade level adjacent to pavements. Preparation of subgrade surfaces should be such that adequate crossfalls for surface drainage are achieved across the final pavement.

In the case where new pavement abuts existing pavement a subsoil drain should be installed at the interface. This drain should comprise a narrow trench backfilled with either ‘no-fines’ concrete or 14 mm aggregate and 100 mm diameter ‘Ag’ pipe wrapped in a geotextile. The drain should extend from the top of the subbase layer to within the subgrade and be connected to the subsurface drainage system, to ensure the release of any moisture trapped between the existing and new pavement materials.

7.13 Earthworks Preparation Measures

The recommended earthworks preparation measures are provided in the following sections.

Geotechnical inspection, compaction testing and proof rolling of all engineered fill is recommended. Subgrade inspections are also recommended. Earthworks construction procedures should be in accordance with AS 3798 (2007).

7.13.1 Substation Platform Fill

The construction of a filling under buildings should be carried out in accordance with Level 1 testing, as defined in AS 3798 (2007) and should include the following:

- Remove topsoil (Unit 1 and 1A) to expose a very stiff or stronger clay soils (Unit 2) and/or rock (Unit 3);
- Removal of tree root zone;
- Test roll and inspect the exposed subgrade and remove soft / weak material. Unsuitable material should be replaced with engineered fill;
- Compact the subgrade to at least 95% Standard dry density ratio, as measured by AS 1289.5.1.1, at a moisture content within the range from -2% OMC to OMC, where OMC is the optimum moisture content as measured by AS 1289.5.1.1;
- Place and compact the engineered fill (clay materials) within the range of 98% to 102% Standard dry density ratio, at a moisture content within the range ± 2% of OMC. The use of clay fill should only be undertaken when it is located at least 0.5 m below finished level;
- Non-reactive fill should be used within the upper 0.5 m of fill profile. Specific assessment of non-reactive fill thickness should be undertaken prior to construction to confirm these requirements and the impact on site classification. Place and compact the engineered fill (non-reactive materials) to at least 98% Standard dry density ratio, at a moisture content within the range ± 2% of OMC.;
- The ‘non-reactive’ fill material should be a low permeability crushed siltstone/sandstone or ridge gravel placed as engineered fill (Level 1 testing) in accordance with AS 3798 (2007), with shrink-swell index of less than 1%, and a soaked CBR value of 10% or greater;
- Engineered fill placed as above should surround structures / building footprint by at least a 2 m horizontal distance.

At the completion of earthworks, the surface heave movements and re-classification of the site should be confirmed by site specific laboratory testing and engineering assessment by this office.

7.13.2 Pavement Subgrade

A site entry pavement as well as pavements on the substation fill platform are anticipated. Pavement subgrade preparation should be as follows:

- Excavate to design subgrade level, incorporating select material where required. The surface should be sloped to ensure water does not pond over the materials;
- Strip all vegetation and topsoil (Unit 1 and 1A, which contains organic matter) and grub out all significant roots;
- The exposed subgrade material surface should be inspected by a geotechnical engineer to check for excessively wet areas or weak zones, and assess if pavement should be constructed over natural subgrade or of subgrade treatment such as drying back, removal and replacement, select and/or bridging layer if required;
- Where suitable subgrades are encountered, the subgrade should be compacted to at least 100% Standard dry density ratio, as measured by AS 1289.5.1.1, at a moisture content within the range from -4% OMC to OMC, where OMC is the optimum moisture content as measured by AS 1289.5.1.1;
- Where wet subgrades soils are exposed no compaction or test rolling is recommended, and the subgrade and select should be prepared as follows:
    - Excavate to design subgrade level to expose stiff or stronger clay soil. The surface clay should be sloped to ensure water does not pond over the clay;
    - The exposed clay surface should be inspected by a geotechnical engineer to check for excessively wet areas or weak zones which may require additional removal;
    - No compaction or test rolling should be undertaken at the exposed clay subgrade level as discussed above;
    - Vehicles with rubber tyres should not traffic the clay subgrade and hence temporary access roads may require to be installed to assist with construction of the select subgrade material (CBR > 30%). Furthermore overworking the select may cause an increase in pore pressure within the subgrade so excessive crushing of larger particles within select should be avoided;
    - Place select subgrade in a single 0.3 m layer over the clay;
    - The select layer should be compacted by a 8 to 10 tonne roller in static mode: Up to 8 to 10 passes of the roller is recommended, subject to geotechnical inspection;
    - The upper half of the select layer should be compacted to 100% standard compaction;
    - A smooth drum roller operating in static mode may be used for test rolling at the top of the select layer.
- Given the low soaked CBR values of the Unit 2 soils at least 0.4 m of select material (CBR 30%) is recommended below pavements outside of the platform substation area. It is noted that at least 0.5 m thick layer of non-reactive crushed rock fill (i.e. select layer with at least soaked CBR of 10%) is to be used over the clay filling within the substation platform, which will also act as a select for overlying pavements;

- If rock is encountered at subgrade level, it should be ripped to a depth of at least 100 mm and recompacted prior to placement of pavement layers, subject to assessment by the geotechnical engineer; The ripped rock should be compact to at least 100% Standard dry density ratio, as measured by AS 1289.5.1.1, at a moisture content within the range from -4% OMC to OMC, where OMC is the optimum moisture content as measured by AS 1289.5.1.1;
- Placement of pavement as required in accordance with requirements outlined above.

Earthworks construction procedures for pavement subgrade preparation should be subject to Level 2 geotechnical inspections and testing as detailed in AS 3798 (2007), which requires at least one field density test per layer of filling per 50 m lineal distance placed.

7.13.3 General

- Engineered fill should be placed in near horizontal layers not exceeding 300 mm loose thickness, and with a maximum particle size not exceeding two-thirds of the compacted layer thickness;
- The fill layers should be keyed or benched at least 0.3 m into batter slopes;
- Adequate surface drainage should be provided to direct surface water away from engineered filling;
- Excavations should be wide enough to allow access for adequately sized compaction equipment;
- Embankments should be over-filled at the batters and trimmed back to the design batter angle to ensure the filling is compacted for the full design width.

7.14 Mine Subsidence

Verbal correspondence with SA NSW on 11 May 2023 indicated the following:

- The site is not within a proclaimed mine subsidence district;
- SA NSW confirmed that the subject site is currently assigned **Guideline 8**, and as such, the property is assessed by SA NSW as not being at risk of mine subsidence and no mine subsidence related restrictions apply to the site;

Prior to any development of the site, it should be confirmed by the client with SA NSW that no restrictions apply to the development.

8. References

AS 2159. (2009). *Piling - Design and Installation.* Standards Australia.

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

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

Austroads. (2017). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Publication No. AGPT02-17: Austroads Ltd.

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Braybrooke, J. C. (1988). *The State of the Art Rock Cuttability and Rippability Prediction, Prediction versus Performance.* Sydney, pp 13-42: Proc. Fifth Australia-New Zealand Conference on Geomechanics.

CSIRO. (2021). *Building Technology File 18: Foundation Maintenance and Footing Performance – A Homeowner's Guide.* BTF-18: CSIRO Publishing, Commonwealth Scientific and Industrial Research Organisation.

DP. (2023a). *Report on Preliminary Contamination Assessment and Waste classification.* Report 224674.01.R.001.Rev0: Proposed 132KV Sub-Transmission Substation, Hebden Road, Muswellbrook.

Pells, P. J. (1999). State of Practice for the Design fo Socketed Piles in Rock. *8th Australia New Zealand Conference on Geomechanics.* Hobart.

Pells, P. J., Mostyn, G., & Walker, B. F. (1998). Foundations on Sandstone and Shale in the Sydney Region. *Australian Geomechanics, No 33 Part 3*, 17-29.

9. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at Hebden Road, Muswellbrook in accordance with DP's proposal dated 18 August 2023 and acceptance received from Paul Hurst / Sulev Kalamae dated 20 September 2023. The work was carried out under period contract terms between DP and Ausgrid. This report is provided for the exclusive use of Ausgrid for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

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

Douglas Partners Pty Ltd

Appendix A

About this Report
Terminology, Symbols and Abbreviations
Soil Descriptions
Rock Descriptions
Sampling, Testing and Excavation Methodology
CSIRO 2021
Borehole Logs 1 to 29 and 27A
Core Photographs (Bores 3, 20, 24, 27, 27A, 29)

About this Report

November 2020

Introduction

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

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

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

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

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

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

continued next page

Site Anomalies
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection
The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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Terminology, Symbols and Abbreviations

November 2020

Introduction to Terminology, Symbols and Abbreviations

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

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

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

Abbreviation Codes

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

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

Data Integrity Codes

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

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

Graphic Symbols

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

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Soil Descriptions

Introduction

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

classification | name | detailed description

(SC) Clayey SAND, trace silt; grey, fine to medium grained

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

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

Particle size designation and Behaviour Model

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

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

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

[1] – refer grain size subdivision descriptions below

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

Component proportions

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

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

[1] As defined in AS1726-2017 6.1.4.4
[2] In the detailed material description, minor components are split into two further sub-categories. Refer “identification of minor components” below.

Composite Materials

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

Classification

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

Soil Name

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

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

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

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

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

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

Identification of minor components

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

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

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

Soil Composition

Plasticity

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

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

Grain Size

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

Grading

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

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

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Soil Condition

Moisture

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

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

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

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

Consistency/Density/Compaction/Cementation/Extremely Weathered Material

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

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

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

Consistency (fine grained soils)

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

Relative Density (coarse grained soils)

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

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

Compaction (anthropogenically modified soil)

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

Cementation (natural and anthropogenic)

Cementation Term	Abbreviation Code
Moderately cemented	MOD
Weakly cemented	WEK

Extremely Weathered Material

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

Soil Origin

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

Cobbles and Boulders

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

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

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Rock Strength

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

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

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

[1] Rock strength classification is based on UCS. The UCS to $I_{s(50)}$ ratio varies significantly for different rock types and specific ratios may be required for each site. The point load Index ranges shown above are as suggested in AS1726 and should not be relied upon without supporting evidence.

The following abbreviation codes are used for soil layers or seams of material "within rock" but for which the equivalent UCS strength is less than 0.6 MPa.

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

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

Degree of Alteration

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

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

Degree of Fracturing

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

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

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Defect Descriptions

Defect Type

Term	Abbreviation Code
Bedding plane	B
Infilled seam	IS
Cleavage	CV
Crushed zone	CZ
Decomposed seam	DS
Fault	F
Joint	JT
Lamination	LAM
Parting	P
Shear zone	SZ
Vein	VN
Drilling/handling break	DB , HB
Fracture	FC

Rock Defect Orientation

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

Rock Defect Coating

Term	Abbreviation Code
Clean	CN
Coating	CT
Healed	HE
Infilled	INF
Stained	SN
Tight	TI
Veneer	VNR

Rock Defect Infill

Term	Abbreviation Code
Calcite	CA
Carbonaceous	CBS
Clay	CLAY
Iron oxide	FE
Manganese	MN

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Rock Defect Shape/Planarity

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

Rock Defect Roughness

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

Defect Orientation

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

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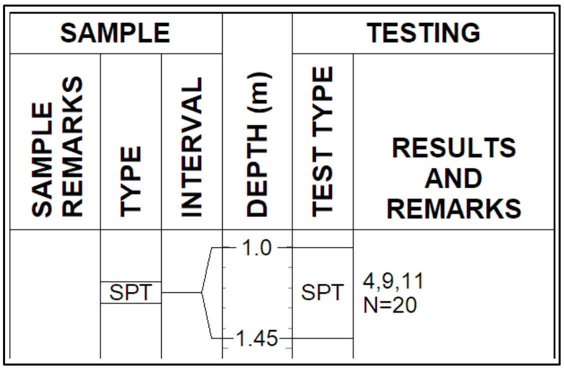
Sampling, Testing and Excavation Methodology

Terminology
Symbols
Abbreviations

September 2023

Sampling and Testing

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



Sampling

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

Sample Type	Code
Auger sample	A
Bulk sample	B
Core sample	C
Disturbed sample	D
Sample from SPT test	SPT
Environmental sample	ES
Gas sample	G
Undisturbed tube sample	U[1]
Water sample	W
Piston sample	P
Core sample for unconfined compressive strength testing	UCS
Material Sample	MT

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

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

Field and Laboratory Testing

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

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

Field and laboratory testing (continued)

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

Groundwater Observations

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

Drilling or Excavation Methods/Tools

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

Method	Abbreviation Code
Toothed bucket	TB[1]
Mud/blade bucket	MB[1]
Ripping tyne/ripper	R
Rock breaker/hydraulic hammer	RB
Hand auger	HA[1]
NMLC series coring	NMLC
HMLC series coring	HMLC
NQ coring	NQ3
HQ coring	HQ3
PQ coring	PQ3
Push tube	PT[1]
Rock roller	RR[1]
Solid flight auger. Suffixes: /T = tungsten carbide tip, /V = v-shaped tip	AD[1]
Sonic drilling	SON[1]
Vibrocore	VC[1]
Wash bore (unspecified bit type)	WB[1]
Existing exposure	X
Hand tools (unspecified)	HAND
Predrilled	PD
Diatube	DT[1]
Hollow flight auger	HSA[1]
Vacuum excavation	VE

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

FOUNDATION MAINTENANCE AND FOOTING PERFORMANCE

Understanding and preventing soil-related building movement

This Building Technology Resource is designed to identify causes of soi -related building movement, and to suggest methods of prevention of resultant cracking.

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the home owner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

SOIL TYPES

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. Table 1 below is a reproduction of Table 2.1 from Australian Standard AS 2870-2011, Residential slabs and footings.

CAUSES OF MOVEMENT

SETTLEMENT DUE TO CONSTRUCTION

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction but has been known to take many years in exceptional cases.

These problems may be the province of the builder and should be taken into consideration as part of the preparation of the site for construction.

EROSION

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

SATURATION

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

SEASONAL SWELLING AND SHRINKAGE OF SOIL

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below, from AS 2870). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

SHEAR FAILURE

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

TREE ROOT GROWTH

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.

TABLE 1. GENERAL DEFINITIONS OF SITE CLASSES.

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Source: Reproduced with the permission of Standards Australia Limited © 2011. Copyright in AS 2870-2011 Residential slabs and footings vests in Standards Australia Limited.

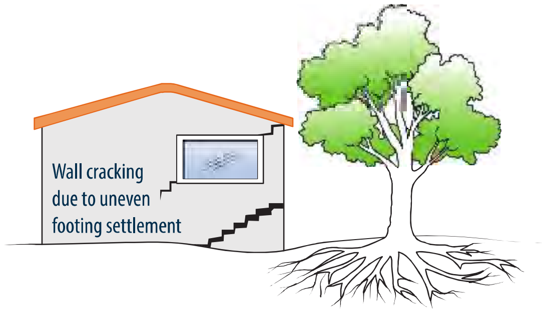


FIGURE 1 Trees can cause shrinkage and damage.

- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

UNEVENNESS OF MOVEMENT

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior through absorption. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Shrinkage usually begins on the side of the building where the sun's heat is greatest.

EFFECTS OF UNEVEN SOIL MOVEMENT ON STRUCTURES

EROSION AND SATURATION

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

SEASONAL SWELLING/SHRINKAGE IN CLAY

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated, and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry, and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

MOVEMENT CAUSED BY TREE ROOTS

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

COMPLICATIONS CAUSED BY THE STRUCTURE ITSELF

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

EFFECTS ON FULL MASONRY STRUCTURES

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

EFFECTS ON FRAMED STRUCTURES

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

EFFECTS ON BRICK VENEER STRUCTURES

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

WATER SERVICE AND DRAINAGE

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

SERIOUSNESS OF CRACKING

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. Table 2 below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

PREVENTION AND CURE

PLUMBING

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

GROUND DRAINAGE

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject may be regarded as an area for an expert consultant.

PROTECTION OF THE BUILDING PERIMETER

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill.

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

CONDENSATION

In buildings with a subfloor void, such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

TABLE 2. CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS.

Description of typical damage and required repair	Approximate crack width limit	Damage category
Hairline cracks	<0.1 mm	0 – Negligible
Fine cracks which do not need repair	<1 mm	1 – Very Slight
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2 – Slight
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3 – Moderate
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4 – Severe

Warning: Although this Building Technology Resource deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders, and mould.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

THE GARDEN

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

EXISTING TREES

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

INFORMATION ON TREES, PLANTS AND SHRUBS

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information.

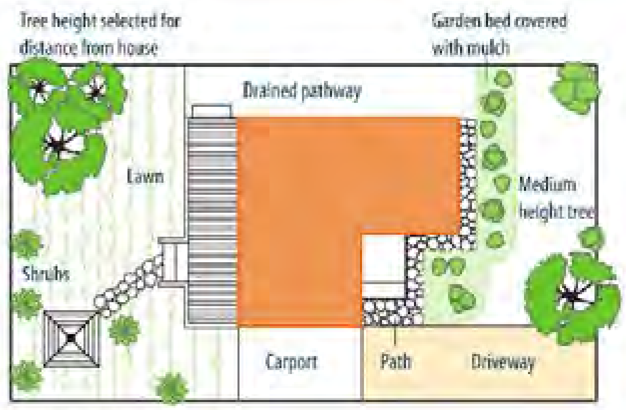


FIGURE 2 Gardens for a reactive site.

EXCAVATION

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

REMEDIATION

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the home owner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 137.9 AHD
COORDINATE: E:311993.3, N:6418611.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 1
PROJECT No: 224764.00
DATE: 06/10/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL	TS									
	137	1.04	Silty CLAY (CI), trace sand: brown; medium plasticity; fine to medium sand. 0.00m-0.10m: trace rootlets		RS	H	w<PL	x2	B		0.10 – 0.60	PP	>400kPa
									U75		0.75 – 1	PP	>400kPa
			Borehole discontinued at 1.04m depth. Limit of investigation.								1.04		

RL (m) scale: 137, 136, 135. Depth scale: 1, 2.

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

PLANT: Hanjin 8D
METHOD: 300mm Auger
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Chaplin

Generated with CORE-GS by Geroc - Soil Log - 17/11/2023 1:53:08 PM

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 136.8 AHD
COORDINATE: E:311953.6, N:6418626.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 2
PROJECT No: 224764.00
DATE: 25/09/23
SHEET: 1 of 1

Depth (m)	Description of Strata	Origin(#)	Consis.(*) / Density.(*)	Moisture	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
0.05	TOPSOIL		VSt to H	w<PL	A	0.10	PID	ppm
0.20	Clayey SILT: brown; trace rootlets.	RS						
	Sandy CLAY: dark brown; medium plasticity.				A	0.50	PID	ppm
					U50	0.68	PP	>400kPa
	From 0.70m: pale brown							
							SPT	3,6,10 N=16
							PP	>400kPa
	From 2.00m: pale brown mottled grey, grading to extremely weathered rock	RS	H	w<PL				
	2.50m: v bit refusal, grading to extremely weathered material							
							SPT	11,19,24 N=43
							PP	>400kPa
4.00	Borehole discontinued at 4.00m depth. Terminated.							

RL (m): 136, 135, 134, 133, 132

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger with V bit, TC bit from 2.5m
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 135.7 AHD
COORDINATE: E:311940.9, N:6418600.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 3
PROJECT No: 224764.00
DATE: 29/09/23
SHEET: 1 of 3

Groundwater: No free groundwater observed

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks
0.05	TOPSOIL								
1.70	Silty CLAY (CI): brown; medium plasticity. 0.00m-0.10m: trace rootlets	RS	H / VSt	w<PL / w=PL to w>PL					
3.25	Silty CLAY (CI): brown mottled grey and orange; medium plasticity.	XWM	H to Fr	w<PL					
	SILTSTONE: brown with orange brown; iron staining				HW to XW	VL	100	0	3.25-6.20m: FC

Sample Type	Interval (m)	Test Depth (m)	Test Type	Results and Remarks
U50	0.50–0.80	0.80	PP	>400kPa
		1.00–1.45	SPT	4,5,9 N=14
			PP	350kPa
		2.50–2.95	SPT	17,21,25/100 Ref
			PP	>400kPa
			PLT	PL(I)=0.06MPa
			PLT	PL(I)=0.04MPa

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: Solid flight auger to 3.25, NMLC to 10.3m depth
CASING: HWT to 3.2m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 135.7 AHD
COORDINATE: E:311940.9, N:6418600.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 3
PROJECT No: 224764.00
DATE: 29/09/23

CONDITIONS ENCOUNTERED

DESCRIPTION OF STRATA: [CONT] SILTSTONE: brown with orange brown; iron staining

RL (m): 130, 129, 128, 127, 126. DEPTH (m): 6, 7, 8, 9.

Depth (m)	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks
to 6.20	HW to XW	VL	100	0	
6.20–6.25	HW	L	100	11	
6.25–6.29	SEAM	SEAM			6.25-6.29m: CS
6.29–6.60	HW	L			6.55m: P, SH, PR, Fe, SM
6.60–6.96	HW	VL			
6.96–7.27	SEAM	SEAM			6.96-7.27m: CS, clay seam contains quartz
7.27–7.47	HW	VL			
7.47–7.58	SEAM	SEAM			7.47-7.58m: CS
7.58–8.35	HW	VL to L	100	0	7.83m: JT/45°, PR, TI Fe, SM; 8.03m: P, SH, PR, Fe, SM; 8.10m: P, S, PR, Fe, SM; 8.17m: P, SH, PR, Fe, SM
8.35–8.41	SEAM	SEAM			8.35-8.41m: CS
8.41–8.48	HW	VL to L			
8.48–8.51	SEAM	SEAM			8.48-8.51m: CS
8.51–8.57	HW	VL to L			
8.57–8.60	SEAM	SEAM			8.57-8.60m: CS
8.60–	HW	VL			8.73m: JT/50°, PR, Fe, SM; 8.84m: P, SH, PR, Fe, SM; 8.92m: JT/60°, PR, Fe, SM; 9.05m: JT/75°, PR, Fe, SM; 9.09m: JT/45°, PR, Fe, RF; 9.25m: JT/15°, PR, Fe, SM; 9.27m: JT/15°, PR, Fe, SM; 9.36-9.45m: FC
			100	0	

TESTING

Test Type	Results and Remarks
PLT	PL(I)=0.05MPa
PLT	PL(I)=0.1MPa
PLT	PL(A)=0.07MPa
PLT	PL(D)=0.06MPa
PLT	PL(A)=0.02MPa
PLT	PL(D)=0.03MPa
PLT	PL(D)=0.07MPa
PLT	PL(A)=0.11MPa
PLT	PL(D)=0.19MPa
PLT	PL(A)=0.19MPa

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

PLANT: Hanjin 8D
METHOD: Solid flight auger to 3.25, NMLC to 10.3m depth
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: HWT to 3.2m
LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 135.7 AHD
COORDINATE: E:311940.9, N:6418600.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 3
PROJECT No: 224764.00
DATE: 29/09/23
SHEET: 3 of 3

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] SILTSTONE: brown with orange brown; iron staining					HW		VL	100	0		10.10m: P, SH, PR, Fe, SM					PLT PLT	PL(D)=0.01MPa PL(A)=0.03MPa
		10.30	Borehole discontinued at 10.30m depth. Limit of Investigation.																	
		11																11		
		12																12		
		13																13		
		14																14		

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

PLANT: Hanjin 8D
METHOD: Solid flight auger to 3.25, NMLC to 10.3m depth
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: HWT to 3.2m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Bore 3 – 3.25 m to 7.00 m

Bore 3 – 7.00 m to 10.30 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates** **New Sub-Transmission Substation** **Lot 9 DP250890 Hebden Road, Muswellbrook**	PROJECT:	224764.00
		PLATE No:	1
		REV:	0
	CLIENT: Ausgrid	DATE:	3-Nov-23

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.8 AHD
COORDINATE: E:311931.3, N:6418569.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 4
PROJECT No: 224764.00
DATE: 06/10/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL	TS									
	134	1.10	Silty CLAY (CI), trace sand: brown; medium plasticity; fine to coarse sand. 0.00m-0.10m: trace rootlets		RS	H	w<PL	x2	B		0.10–0.60	PP	>400kPa
									U75		0.75–1.10	PP	>400kPa
	133, 132		Borehole discontinued at 1.10m depth. Limit of investigation.										

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

PLANT: Hanjin 8D
METHOD: 300mm Auger
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL:
COORDINATE:
DATUM/GRID:
DIP/AZIMUTH: 90°/---°

LOCATION ID: 5
PROJECT No: 224764.00
DATE: 27/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE INTERVAL (m)	TEST TYPE / DEPTH (m)	RESULTS AND REMARKS	BACKFILL
No free groundwater observed	0.05	TOPSOIL								Bentonite Concrete
	0.60	Clayey SILT, trace gravel: brown; fine gravel; rootlets.	RS	H	w<PL	B	0.10–0.50			
	2.70	Sandy CLAY, trace gravel: brown; medium plasticity; fine to medium sand; fine gravel. From 1.00m: grey mottling grading into extremely weathered sandstone	RS	H	w<PL	A, A/U50	0.50–0.60	PP	>400kPa	Gravel backfill
								SPT	8,12,12 N=24	
								PP	>400kPa	
								SPT	11,25/50 refusal	
								PP	>400kPa	
		Borehole discontinued at 2.70m depth.								

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger with TC bit
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil
LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL:
COORDINATE:
DATUM/GRID:
DIP/AZIMUTH: 90°/---°

LOCATION ID: 6
PROJECT No: 224764.00
DATE: 27/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m) DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.05	TOPSOIL	TS					A				
	0.20	Clayey SILT: brown; trace rootlets.		RS	VSt to H	w<PL				0.10		
	2.55	Sandy CLAY, trace gravel: brown; medium plasticity; fine gravel. 1.00m: v bit refusal From 1.50m: pale brown grading to extremely weathered rock		RS	H	w<PL		A U50		0.50 0.62	PP SPT PP SPT PP	>400kPa 9,25/50 ref >400kPa 25/50 ref >400kPa
		Borehole discontinued at 2.55m depth. refusal.										

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger with v bit, TC bit from 1.2m
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL:
COORDINATE:
DATUM/GRID:
DIP/AZIMUTH: 90°/---°

LOCATION ID: 7
PROJECT No: 224764.00
DATE: 06/10/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free water observed		0.05	TOPSOIL	TS									
			Silty CLAY (CI), trace sand: brown; medium plasticity; fine to coarse sand. 0.00m-0.10m: trace rootlets		RS	H	w<PL	x2	B		0.10–0.60	PP	>400kPa
		1.00							U75		0.85–1.00	PP	>400kPa
			Borehole discontinued at 1.00m depth. Limit of investigation.										

Depth scale: 2

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

PLANT: Hanjin 8D
METHOD: 300mm Auger
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL:
COORDINATE:
DATUM/GRID:
DIP/AZIMUTH: 90°/---°

LOCATION ID: 8
PROJECT No: 224764.00
DATE: 25/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.05	TOPSOIL	TS		VSt to H	w<PL		A		0.10		
	0.20	Clayey SILT: brown; low plasticity; trace rootlets.		RS								
	1.10	Sandy CLAY: brown; medium plasticity. From 0.70m: pale brown grading to weathered rock. 1.00m: v bit refusal		RS	H	w<PL		A		0.50	SPT / PP	12,25/50 ref / >400kPa
	2.60	Silty CLAY (CI): pale brown and grey; medium plasticity; grading to extremely weathered siltstone.		XWM	H	w<PL					SPT / PP	25/100 ref / >400kPa
		Borehole discontinued at 2.60m depth. refusal.										

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger with v bit, TC bit from 1.0m
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL:
COORDINATE:
DATUM/GRID:
DIP/AZIMUTH: 90°/---°

LOCATION ID: 9
PROJECT No: 224764.00
DATE: 25/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.05	TOPSOIL							
	0.30	Clayey SILT, trace gravel: brown; low plasticity; fine gravel; rootlets.	RS	VSt to H	w<PL	A	0.10		
	2.55	Silty Sandy CLAY: pale brown mottled red orange; medium plasticity. 1.50m: grading to extremely weathered rock. 2.00m: v bit refusal	RS	H	w<PL	A	0.50	SPT; PP; SPT; PP	5,7,15 N=22; >400kPa; 25/50 ref; >400kPa
		Borehole discontinued at 2.55m depth. refusal.							

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Gilmour
METHOD: 100mm solid flight auger with v bit, TC bit from 2.0m
CASING: Nil
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 135.8 AHD
COORDINATE: E:312028.9, N:6418515.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 10
PROJECT No: 224764.00
DATE: 25/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL	TS					A	0.00–0.10		
			Silty CLAY, trace gravel: brown; medium plasticity; fine gravel; rootlets.		RS	H	w<PL		A	0.40–0.50		
			From 0.60m: pale brown						U50	0.50–0.79	PP	>400kPa
			From 1.00m: grading to extremely weathered rock								SPT	25,14,25/50 ref
											PP	>400kPa
		2.65									SPT	25 ref
			Borehole discontinued at 2.65m depth. refusal.								PP	<400kPa

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

PLANT: Hanjin 8D
METHOD: 100mmm solid flight auger
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 137.4 AHD
COORDINATE: E:312047.6, N:6418548.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 11
PROJECT No: 224764.00
DATE: 25/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.05	TOPSOIL					A	0.10		
	0.20	Clayey SILT, trace gravel: brown; fine gravel; rootlets.	RS	VSt to H	w<PL					
	2.55	Sandy CLAY, trace gravel: brown; medium plasticity; fine to medium sand; fine gravel. From 0.70m: pale brown mottled orange and grey. From 2.00m: grading to extremely weathered rock	RS	H	w<PL		A	0.40–0.50		
							U50	0.50–0.82	PP	>400kPa
									SPT	6,7,3 N=10
									PP	>400kPa
									SPT	25/50 ref
									PP	>400kPa
		Borehole discontinued at 2.55m depth. refusal.								

RL (m): 137, 136, 135, 134, 133

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger, TC bit from
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.9 AHD
COORDINATE: E:311918.1, N:6418609.7
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 12
PROJECT No: 224764.00
DATE: 29/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL	TS									
			Silty CLAY (CI): brown; medium plasticity. 0.00m-0.10m: trace rootlets		RS	VSt to H	w<PL to w=PL					PP	>400kPa
								x2	B	0.50–0.90	0.50		
												PP	360kPa
											0.90		
	134	1.00	Borehole discontinued at 1.00m depth. Limit of investigation.								1		
	133	2									2		
	132												

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

PLANT: Hanjin 8D
METHOD: 300mm Auger
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 138.8 AHD
COORDINATE: E:312101.9, N:6418614.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 13
PROJECT No: 224764.00
DATE: 29/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL / DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.05	TOPSOIL					ES	0.10		
	1.00	Silty CLAY (CI): brown; medium plasticity. 0.00m-0.10m: trace rootlets	RS	H	w<PL				PP	>400kPa
							ES	0.40–0.50	PP	>400kPa
						x2	B	0.50–0.90		
		Borehole discontinued at 1.00m depth. Limit of investigation.								

RL (m): 138, 137, 136

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

PLANT: Hanjin 8D
METHOD: 300mm Auger
REMARKS:
OPERATOR: Total Drilling (D Tranter)
CASING: Nil
LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 136.3 AHD
COORDINATE: E:312055.8, N:6418520.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 14
PROJECT No: 224764.00
DATE: 26/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL	TS					A		0.10		
	136		Silty Sandy CLAY, trace gravel: brown; medium plasticity; fine to medium sand; fine gravel.						A		0.50		
	135	1	From 1.00m: grading to extremely weathered rock		RS	H	w<PL				1	SPT	13,25/50
												PP	>400kPa
	134	2.20	Borehole discontinued at 2.20m depth. TC bit refusal.								2		

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

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PLANT: Hanjin 8D
METHOD: 100mm solid flight auger with TC bit
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 137.5 AHD
COORDINATE: E:312068.2, N:6418552.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 15
PROJECT No: 224764.00
DATE: 26/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL (DEPTH m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL	TS					A	0.10		
	137, 136, 135	2.65	Silty Sandy CLAY, with gravel: brown-dark brown; low plasticity; fine to medium sand; fine to coarse, (natural) gravel. From 0.20m: brown, trace fine to coarse gravels. From 0.70m: pale brown, grading into extremely weathered rock		RS	H	w<PL		A	0.50	SPT	7,13,12 N=25
											PP	>400kPa
											SPT	25 ref
											PP	>400kPa
			Borehole discontinued at 2.65m depth. refusal.									

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger with TC bit
REMARKS:
OPERATOR: Total Drilling (D Tranter)
CASING: Nil
LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 138.0 AHD
COORDINATE: E:312076.1, N:6418566.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 16
PROJECT No: 224764.00
DATE: 26/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	138	0.05	TOPSOIL	TS					A		0.10		
			Sandy CLAY, with gravel: brown; medium plasticity; fine to medium sand; fine to coarse gravel; trace rootlets.		RS	H	w<PL		A		0.50		
			From 0.70m: pale brown, grading into extremely weathered rock						U50		0.82	PP	>400kPa
	137	1	1.00m: V bit refusal								1	SPT	9,25/50 ref
												PP	>400kPa
	136	2									2		
												SPT	11,25/50 ref
		2.80	Borehole discontinued at 2.80m depth. refusal.									PP	>400kPa

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger with V bit, TC bit from 1.0m
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

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Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 137.0 AHD
COORDINATE: E:312100.3, N:6418552.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 17
PROJECT No: 224764.00
DATE: 26/09/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL						A		0.10		
		0.80	Silty Sandy CLAY, trace gravel: brown-dark brown; medium plasticity; fine to medium sand; fine gravel.		RS	H	w<PL		A		0.50		
	136	1	Sandy CLAY, trace gravel: brown-pale brown mottled grey-orange; medium plasticity; fine to medium sand; fine gravel.		RS	H	w<PL				1	SPT	8,12,14 N=26
												PP	>400kPa
	135	2	2.00m: grading to extremely weathered rock								2	SPT	9,25 ref
		2.70	Borehole discontinued at 2.70m depth. refusal.									PP	>400kPa

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight with TC bit
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 135.1 AHD
COORDINATE: E:312167.8, N:6418532.5
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 18
PROJECT No: 224764.00
DATE: 06/10/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	135	0.05	TOPSOIL	TS									
			Silty CLAY (CI), trace sand: brown; medium plasticity; fine to coarse sand. 0.00m-0.10m: trace rootlets		RS	H	w<PL	x2	B		0.10 – 0.60	PP	>400kPa
	134	1							U75		0.74 – 1.14		
		1.14	Borehole discontinued at 1.14m depth. Limit of investigation.								1.14	PP	>400kPa
	133	2									2		

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

PLANT: Hanjin 8D
METHOD: 300mm Auger
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	136.5 AHD	**LOCATION ID:**	19
PROJECT:	New Eastern Hub Sub-Transmission Substation	**COORDINATE:**	E:312128.7, N:6418553.2	**PROJECT No:**	224764.00
LOCATION:	Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW	**DATUM/GRID:**	MGA2020 Zone 56	**DATE:**	06/10/23
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free water observed		0.05	TOPSOIL	TS									
	136	1.10	Silty CLAY (CI), trace sand: brown; medium plasticity; fine to coarse sand. 0.00m-0.10m: trace rootlets		RS	H	w<PL	x2	B		0.10–0.60	PP	>400kPa
									U75		0.75–1.10	PP	>400kPa
	135		Borehole discontinued at 1.10m depth. Limit of investigation.										
	134	2									2		

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

PLANT:	Hanjin 8D	**OPERATOR:**	Total Drilling (D Tranter)	**LOGGED:**	Chaplin
METHOD:	300mm Auger	**CASING:**	Nil		
REMARKS:					

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 135.4 AHD
COORDINATE: E:312143.6, N:6418527.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 20
PROJECT No: 224764.00
DATE: 28/09/23
SHEET: 1 of 3

No free groundwater observed

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Fracture Spacing	Defects & Remarks
0.05	TOPSOIL										
	Silty CLAY (CI): brown; medium plasticity. 0.00m-0.30m: trace rootlets	RS	H	w<PL							
			VSt to H	w=PL							
2.00	Silty CLAY (CI): pale brown mottled orange and grey; medium plasticity.	XWM	H to Fr	w<PL							
3.04	SILTSTONE: brown with orange brown; iron staining				HW	3.04	VL				
					SEAM	3.13	SEAM			SEAM	3.13-322m: CS
					HW	3.22	VL				
					SEAM	3.33	SEAM			SEAM	3.33-3.44m: CS
					MW to HW	3.44	L				
					SEAM	3.52	SEAM			SEAM	3.52-3.56m: CS
					MW to HW	3.56	L	100	23		3.68m: P, SH, PR, Fe, SM; 3.80m P, SH, PR, Clay, SM; 3.87m: P, SH, PR, SM; 3.94-4.04m: FC; 4.11m: JT/60°, PR, RF; 4.19m: P, SH, PR, Clay, SM; 4.27m: JT/50°, PR, SM; 4.30m P, SH, PR, Clay, SM; 4.44m: P, SH, PR, Fe, SM
					HW	4.54	VL				4.60m: P, SH, PR, Clay, SM; 4.90m: JT/50°, PR, Fe, RF

RL (m): 135, 134, 133, 132, 131

Sample Type	Interval / Depth (m)	Test Type	Results and Remarks
D	0.10		
D	0.40-0.50		
U50	0.50-0.68	PP	>400kPa
		SPT	6,9,15 N=15
		PP	380-400kPa
		SPT	16,17,22 N=39
		PP	>400kPa
		PLT	PL(I)=0.16MPa
		PLT	PL(I)=0.16MPa
		PLT	PL(A)=0.05MPa

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: Solid Flight Auger to 3.04m, then NMLC to 10.3m depth
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 135.4 AHD
COORDINATE: E:312143.6, N:6418527.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 20
PROJECT No: 224764.00
DATE: 28/09/23

CONDITIONS ENCOUNTERED | **SAMPLE** | **TESTING**

DESCRIPTION OF STRATA

[CONT] SILTSTONE: brown with orange brown; iron staining

7.65m-7.69m: carbonate (limestone) band

ROCK

Depth (m)	Weath.	Strength
to 5.10	HW	VL
5.10 – 5.90	MW to HW	L
5.90 – 6.30	HW	L
6.30 – 6.36	SEAM	SEAM
6.36 – 6.63	HW	VL to L
6.63 – 6.69	SEAM	SEAM
6.69 – 6.96	HW	VL to L
6.96 – 7.02	SEAM	SEAM
7.02 – 7.56	HW	VL to L
7.56 – 7.65	SEAM	SEAM
7.65 – 7.69		H
7.69 – 7.88	HW	VL to L
7.88 – 8.30	SEAM	SEAM
8.30 – 9.04	HW	L
9.04 –	MW	L to M

Recovery (%)	RQD
100	23
100	32
100	0
100	32

DEFECTS & REMARKS

- 4.99m: JT/50°, PR, Fe, RF
- 5.21m: P, SH, PR, Fe, SM
- 5.23m: P, SH, PR, Fe, SM
- 5.31m: P, SH, PR, Fe, SM
- 5.33m: P, SH, PR, Fe, SM
- 5.41m: P, SH, PR, Fe, SM
- 5.48m: P, SH, PR, Fe, SM
- 5.67m: P, SH, PR, Fe, SM
- 5.75m: P
- 5.77m: P
- 5.85m: JT/10°, PR, SM
- 5.88m: P, SH, PR, SM
- 5.97m: P, SH, PR, Clay, SM
- 6.16m: P, SH, PR, SM
- 6.30-6.36m: CS
- 6.47m: P, SH, PR, SM, Clay/Fe
- 6.58m: P, SH, PR, Fe, SM
- 6.63-6.69m: CS
- 6.74m: P, SH, PR
- 6.80m: JT/60°, PR, Fe, SM
- 6.96-7.02m: CS
- 7.45m: JT/30°, PR, Fe, SM
- 7.56-7.65m: CS
- 7.69m: P, SH, PR, Clay, SM
- 7.74m: JT, 40-50°/35°, PR, Fe, RF
- 7.80m: JT/60°, PR, Fe, RF
- 7.88-8.30m: CS, SH, PR, SM
- 8.55m: JT/30°, PR, Fe, SM
- 8.57-8.61m: CS
- 8.71m: P, SH, PR, SM
- 8.87m: P, SH, PR, SM
- 8.97m: JT/10°, PR, SM
- 9.05m: P, SH, PR, SM, Clay/Fe
- 9.18m: JT/35°, PR, SM
- 9.32m: P, SH, PR, Fe, SM
- 9.46m: P, SH, PR, Fe, SM
- 9.54m: JT/45°, PR, Fe, SM
- 9.60-9.66m: FC
- 9.78-9.90m: FC

TESTING

Test Type	Results and Remarks
PLT	PL(I)=0.03MPa
PLT	PL(I)=0.24MPa
PLT	PL(D)=0.1MPa
PLT	PL(A)=0.17MPa
PLT	PL(D)=0.16MPa
PLT	PL(A)=0.1MPa
PLT	PL(A)=0.17MPa
PLT	PL(D)=0.1MPa
PLT	PL(D)=0.15MPa
PLT	PL(A)=0.2MPa

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: Solid Flight Auger to 3.04m, then NMLC to 10.3m depth
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 135.4 AHD
COORDINATE: E:312143.6, N:6418527.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 20
PROJECT No: 224764.00
DATE: 28/09/23

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] SILTSTONE: brown with orange brown; iron staining					MW		L to M	100	32		10.01m: P, SH, PR, Fe, SM 10.06-10.18m : SZ, jointed at 60 to 30 degrees 10.20m : P, SH, PR, Fe, SM 10.22m: P, SH, PR, Fe, SM 10.28m: P, S, PR, Fe, SM					PLT PLT	PL(D)=0.15MPa PL(A)=0.3MPa
		10.30	Borehole discontinued at 10.30m depth. Limit of Investigation.																	
		11																11		
		12																12		
		13																13		
		14																14		

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: Solid Flight Auger to 3.04m, then NMLC to 10.3m depth
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

Bore 20 – 3.04 m to 7.00 m

Bore 20 – 7.00 m to 10.30 m

Douglas Partners Geotechnics / Environment / Groundwater	Core Photoplates New Sub-Transmission Substation Lot 9 DP250890 Hebden Road, Muswellbrook	PROJECT: 224764.00
		PLATE No: 1
		REV: 0
	CLIENT: Ausgrid	DATE: 3-Nov-23

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 136.4 AHD
COORDINATE: E:312117.3, N:6418543.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 21
PROJECT No: 224764.00
DATE: 03/10/23
SHEET: 1 of 5

CONDITIONS ENCOUNTERED

Groundwater: No free groundwater observed

Depth (m)	Description of Strata	Origin(#)	Consis./Density(*)	Moisture	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks
0.05	TOPSOIL								
0.90	Silty CLAY (CI): brown; medium plasticity. 0.00m-0.10m: trace rootlets	RS	H	w<PL					
3.00	Silty CLAY (CI): pale brown mottled grey and orange; medium plasticity.	RS	H	w<PL					
3.00–4.43	SILTSTONE: pale brown with orange brown iron staining				HW	L	100	0	3.00-3.03m: FC; 3.11m: P, SH, PR, Clay, SM; 3.15m: P, SH, PR, SM; 3.21-3.30m: FC; 3.41m: P, SH, PR, Fe, SM; 3.52m: P, SH, PR, Fe, SM; 3.61m: P, SH, PR, Fe, SM; 3.68m: FC; 4.05m: P, SH, PR, Fe, SM; 4.26m: P, SH, PR, Fe, SM; 4.34m: P, SH, PR, Fe, SM
4.43–4.45									4.43-4.45m: CS
4.45–4.66				HW	VL	100	0	
4.66–4.67									4.66-4.67m: CS
4.67–				HW	VL			4.82m: P, SH, PR, Fe, SM

RL (m): 136, 135, 134, 133, 132

SAMPLE

Type	Depth (m)
ES	0.00–0.10
ES	0.40–0.50
U50	0.50–0.63

TESTING

Depth (m)	Test Type	Results and Remarks
0.63	PP	>400kPa
1.00	SPT	9,12,13 N=25
	PP	>400kPa
2.50	SPT	11,21,25/100 ref
	PP	>400kPa
	PLT	PL(A)=0.16MPa
	PLT	PL(D)=0.01MPa
	PLT	PL(A)=0.09MPa

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

PLANT: Hanjin 8D
METHOD: Solid flight auger to 3.0m, then NMLC to 20.74m depth
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: HWT to 2.5m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 136.4 AHD
COORDINATE: E:312117.3, N:6418543.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 21
PROJECT No: 224764.00
DATE: 03/10/23
SHEET: 2 of 5

CONDITIONS ENCOUNTERED — GROUNDWATER | RL (m) | DEPTH (m) | DESCRIPTION OF STRATA | GRAPHIC | SOIL: ORIGIN(#), CONSIS.(*) DENSITY.(*), MOISTURE | ROCK: WEATH., DEPTH (m), STRENGTH (VL L M H VH EH), RECOVERY (%), RQD, FRACTURE SPACING (m) (0.005 0.01 0.05 0.10 0.50 1.00 5.00), DEFECTS & REMARKS | **SAMPLE** — SAMPLE REMARKS, TYPE, INTERVAL, DEPTH (m) | **TESTING** — TEST TYPE, RESULTS AND REMARKS

RL (m): 131, 130, 129, 128, 127
DEPTH (m): 6, 7, 8, 9

Description of Strata

[CONT] SILTSTONE: pale brown with orange brown iron staining

5.52m-5.33m: carbonate (limestone) band

From 6.05m: becoming dark grey

8.84m-8.85m: quartz

Rock

Weath.	Depth (m)	Strength
HW	to 5.52 / 5.55	VL (H at 5.52–5.55)
	5.55–6.05	L
MW	6.05–8.74	VL
SEAM	8.74–8.85	SEAM
SW	8.85–8.96	VL
FR	from 9.06 (8.96)	H

Recovery (%)	RQD
100	0
100	0
100	83

Defects & Remarks

- 5.03m: P , SH, PR, Fe, SM
- 5.15m: P , SH, PR, SM, Fe/Clay
- 5.36m: P, SH, PR, Tl Fe, SM
- 5.52m : P, SH, PR, Clay, SM
- 5.66m: P, SH, PR, Fe, SM
- 5.69m: P, SH, PR, Fe, SM
- 5.78m: P , SH, PR, SM, Fe/Clay
- 5.96m: P, SH, PR, Fe, SM
- 5.99-6.02m: FC
- 6.15m : P, SH, PR, Fe, SM
- 6.48m: P, SH, PR, Fe, SM
- 6.68m : P, SH, PR, Tl Fe, SM
- 6.80m: P, SH, PR, Tl Fe, SM
- 6.91m: JT, 50°, PR, Fe, SM
- 7.16m: P, SH, PR, Fe
- 7.27m : JT, 30°, PR, Fe, SM
- 7.50m: JT, 20° , PR, Fe, RF
- 7.62m : JT, 20°, PR, Fe, RF
- 7.78m: P, SH, PR, Fe, SM
- 7.81m: P, SH, PR, Fe, SM
- 7.93m : P, SH, PR, Fe, SM
- 7.96m: JT, 20°, PR, Tl Fe, SM
- 8.12m: P, SH, PR, Fe, SM
- 8.17m: JT, 15°, PR, Fe, RF
- 8.22m : JT, 60°, PR, Fe, SM
- 8.32m : JT, 15°, PR, Fe, RF
- 8.41-8.55m: FC
- 8.55-8.62m: FC
- 8.69m: JT, 60°, PR, Fe, SM
- 8.74-8.85m: CS
- 8.86m: P, SH, PR, Fe, SM
- 8.87m: P, SH, PR, Fe, SM
- 8.96m: P, SH, PR, Fe, RF
- 9.02m : P, SH, PR, SM
- 9.05m : P, SH, PR, SM

Sample

Type	Depth (m)
UCS	9.06

Testing

Test Type	Results and Remarks
PLT	PL(A)=0.05MPa
PLT	PL(A)=0.11MPa
PLT	PL(D)=0.02MPa
PLT	PL(A)=0.01MPa
PLT	PL(A)=0.08MPa
PLT	PL(A)=0.06MPa
PLT	PL(D)=0.04MPa
PLT	PL(A)=0.05MPa
PLT	PL(D)=0.37MPa
PLT	PL(A)=1.52MPa

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

PLANT: Hanjin 8D
METHOD: Solid flight auger to 3.0m, then NMLC to 20.74m depth
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: HWT to 2.5m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 136.4 AHD
COORDINATE: E:312117.3, N:6418543.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 21
PROJECT No: 224764.00
DATE: 03/10/23

RL (m)	Depth (m)	Description of Strata	Weath.	Strength	Recovery (%)	RQD	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
126		[CONT] SILTSTONE: pale brown with orange brown iron staining	FR	H	100	83			PLT	PL(A)=1.37MPa
125	11								PLT	PL(A)=1.37MPa
124	12				100	100	UCS	12.35	PLT	PL(A)=1.2MPa
123	13									
122	14								PLT	PL(A)=1.29MPa
					100	100				

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: Solid flight auger to 3.0m, then NMLC to 20.74m depth
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 136.4 AHD
COORDINATE: E:312117.3, N:6418543.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 21
PROJECT No: 224764.00
DATE: 03/10/23
SHEET: 4 of 5

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	WEATH.	STRENGTH	RECOVERY (%)	RQD	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
		[CONT] SILTSTONE: pale brown with orange brown iron staining							
121					100	100			
	16						16	PLT	PL(A)=1.17MPa
120									
	17				100	100	17	PLT	PL(A)=2.07MPa
119			FR	H					
	18	18.08m-18.22m: grey fine grained sandstone					18		
118									
	19				100	100	19		
117									

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: Solid flight auger to 3.0m, then NMLC to 20.74m depth
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 136.4 AHD
COORDINATE: E:312117.3, N:6418543.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 21
PROJECT No: 224764.00
DATE: 03/10/23
SHEET: 5 of 5

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	116		[CONT] SILTSTONE: pale brown with orange brown iron staining					FR		H	100	100								
		20.74	Borehole discontinued at 20.74m depth. Limit of Investigation.																	

Depth scale: 21, 22, 23, 24

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: Solid flight auger to 3.0m, then NMLC to 20.74m depth
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.0 AHD
COORDINATE: E:311956.3, N:6418499.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 22
PROJECT No: 224764.00
DATE: 29/09/23
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL						D/ES		0.10		
		0.20	Silty CLAY (CL): brown; low plasticity.		RS	H	w<PL					PP	>400kPa
	133	1.00	Silty CLAY (CI): brown; medium plasticity.		RS	H	w<PL		D/ES		0.40		
									U50		0.50	PP	>400kPa
											0.75		
	132	2	Silty CLAY (CI): brown mottled grey and orange; medium plasticity.		XWM	H to Fr	w<PL				1	SPT	7,10,14 N=25
												PP	>400kPa
											2	SPT	9,20,25/100 Ref
	131											PP	>400kPa

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

PLANT: Hanjin 8D
METHOD: Solid flight auger (TC)
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 134.0 AHD
COORDINATE: E:311956.3, N:6418499.2
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 22
PROJECT No: 224764.00
DATE: 29/09/23
SHEET: 2 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
			[CONT] Silty CLAY (CI): brown mottled grey and orange; medium plasticity. 3.50m: increased drill resistance, indicative of rock		XWM	H to Fr	w<PL						
		3.50	Borehole discontinued at 3.50m depth. TC refusal.										
	130	4									4		
	129	5									5		
	128												

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

PLANT: Hanjin 8D
METHOD: Solid flight auger (TC)
REMARKS:
OPERATOR: Total Drilling (D Tranter)
CASING: Nil
LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 136.5 AHD
COORDINATE: E:312091.8, N:6418532.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 23
PROJECT No: 224764.00
DATE:
SHEET: 1 of 1

Depth (m)	Description of Strata	Origin(#)	Consis./Density	Moisture	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
0.05	TOPSOIL				A	0.10		
0.40	Clayey SILT, trace gravel: brown; low plasticity; trace rootlets.	RS	H	w<PL				
2.70	Silty Sandy CLAY, trace gravel: brown-dark brown; medium plasticity; fine to medium sand; fine gravel. From 0.90m: pale brown mottled orange	RS	H	w<PL	A	0.50		
					U50	0.77	PP	>400kPa
							SPT	5,7,7 N=14
							PP	>400kPa
							SPT	12,25/50
							PP	>400kPa
	Borehole discontinued at 2.70m depth.							

Backfill: Concrete; Bentonite; Gravel backfill

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

PLANT: Hanjin 8D
METHOD: Solid flight auger with TC bit to 2.7m
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 135.5 AHD
COORDINATE: E:312102.4, N:6418510.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 24
PROJECT No: 224764.00
DATE: 28/09/23
SHEET: 1 of 2

CONDITIONS ENCOUNTERED

GROUNDWATER: No free groundwater observed

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD
0.05	TOPSOIL		VSt	w<PL					
0.70	Silty CLAY (CH), with sand: brown; high plasticity; fine to coarse sand.	RS		w=PL to w<PL					
2.50	Silty CLAY (CI-CH), with sand: pale brown grey mottled orange; medium to high plasticity; fine to coarse sand.	RS	H	w<PL					
2.60 – 3.10	Silty CLAY (CI-CH): grey brown mottled orange; medium to high plasticity; trace rock fragments as gravel.	XWM							
3.10 – 3.33					HW	3.10 – 3.33	VL	100	24
3.33 – 3.86	Silty CLAY (CI): grey mottled orange; medium plasticity; borderline silty clay / siltstone, crumbling in hand.	XWM	H	w<PL	SEAM	3.33 – 3.86	SEAM		
3.86	SILTSTONE: grey orange				HW	3.86 – 5.31	VL	100	19
	Silty CLAY (CI): grey brown mottled orange; medium plasticity; borderline silty clay / siltstone, crumbling in hand.								
	SILTSTONE: orange grey								
5.31 – 5.52			H	w<PL	SEAM	5.31 – 5.52	SEAM		
5.56 – 5.77			H	w<PL	SEAM	5.56 – 5.77	SEAM		
5.77 – 7.63					MW to SW	5.77 – 7.63	VL	100	10
7.63 – 8.00			H	w<PL	SEAM	7.63 – 8.00	SEAM		
8.00 – 8.48					SW to FR	8.00 – 8.48			
8.48 –	8.87m-10.10m: pyrite nodules				FR	8.48 –	M to H	100	100

RL (m): 135, 134, 133, 132, 131, 130, 129, 128, 127, 126

FRACTURE SPACING (m): 0.005, 0.05, 0.06, 0.20, 0.50, 1.00, 5.00 — SEAM at 3.33–3.86, 5.31–5.52, 5.56–5.77, 7.63–8.00

DEFECTS & REMARKS

- 2.70-2.80m: JT, 50°, ST, HE Clay, SM
- 2.82-292m: JT, 50°, PR, CN, SM
- 2.95-3.20m: JT, 70°, CU, TI, SM
- 3.25m: JT, 70°, ST, SN Fe, RF
- 4.10m: P, 10°, PR, SN Fe, RF
- 4.11-430m: JT, 85°, PR, HE Clay, SM
- 4.45m: JT, 30°, PR, SN Fe, SM
- 4.60m: JT, 70°, PR, SN Fe, SM
- 4.70-4.82m: JT xx9, 60°, PR, HE Clay, SM
- 5.17m: JT, 30°, ST, SN Fe, SM
- 5.21m: JT, 30°, PR, TI, SM
- 5.30m: JT, 30°, PR, SN Fe, SM
- 5.80-605m: JT xx12, 20°, PR Fe, SM, SN/HE, 002-0.03m spacing
- 6.10-6.15m: JT, 60°, PR, HE Fe, RF
- 6.38-6.48m: JT, 70°, CU, HE Fe, SM
- 6.55m: JT, 30°, PR, SM, FE/Clay, SN/HE
- 6.63-6.75m: JT, 70°, PR, HE Fe, SM
- 6.75m: JT, 30°, PR, SM
- 6.85m: JT, 30°, CU, CN CA, SM
- 6.87-6.95m: JT, 70°, PR, SN Fe, SM
- 6.98m: JT, 60°, PR, SN Fe, SM
- 7.20-7.33m: JT xx2, 60°, PR, SN Fe, RF
- 7.43m: JT, 40-60°, CU, HE Fe, SM
- 7.50m: JT, 10°, CU, HE Fe, SM
- 7.56-7.60m: JT, 40°, CU, SN Fe, RF
- 8.10m: P, 5°, PR, HE Fe, SM
- 8.15m: P, 5°, PR, SN Fe, RF
- 8.17m: P, 5°, PR,

SAMPLE

SAMPLE REMARKS	TYPE	DEPTH (m)
Jar	D/ES	0.20
Jar	D/ES	0.40 – 0.50
	D	0.70 – 0.90
	UCS	9.40 – 9.73

TESTING

DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
0 – 1.0	DCP9/150	5, 10, 15 … 22
1.0	PP	550-580kPa
	SPT	3,8,10 N=18
	PP	>600kPa
	SPT	15,5/50
	PP	>600kPa
	PLT	PL(D)=0.01MPa
	PLT	PL(A)=0.01MPa
	PLT	PL(A)=0.12MPa
	PLT	PL(D)=0.02MPa
	PLT	PL(A)=0.03MPa
	PLT	PL(D)=0.02MPa
	PLT	PL(A)=0.02MPa
	PLT	PL(D)=0.02MPa
	PLT	PL(A)=0.01MPa
	PLT	PL(A)=0.02MPa
	PLT	PL(D)=0.02MPa
	PLT	PL(D)=0.02MPa
	PLT	PL(A)=0.05MPa
	PLT	PL(D)=0.05MPa
	PLT	PL(A)=0.07MPa
	PLT	PL(D)=0.79MPa
	PLT	PL(A)=1.02MPa
	PLT	PL(D)=0.39MPa

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Runge
METHOD: Solid flight auger with TC bit to 2.6m, NMLC coring to 11.5
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 135.5 AHD
COORDINATE: E:312102.4, N:6418510.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 24
PROJECT No: 224764.00
DATE: 28/09/23
SHEET: 2 of 2

CONDITIONS ENCOUNTERED																SAMPLE				TESTING	
					SOIL			ROCK													
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)		TEST TYPE	RESULTS AND REMARKS
	125, 124	11	[CONT] SILTSTONE: orange grey					FR		M 15 H	100	100		HE Fe, RF 8.24-8.27m: JT xx2, 10-20°, CU, SN, RF, HE/SN 8.30m: JT, 10°, PR, SN, RF 8.96m: P, 10°, CU, CN, RF 9.42m: P, 10°, CU, CN, RF				11		PLT PLT	PL(A)=1.12MPa PL(D)=0.97MPa
		11.53	Borehole discontinued at 11.53m depth. Limit of investigation.																		
		12																12			
		13																13			
		14																14			
		15																15			
		16																16			
		17																17			
		18																18			
		19																19			

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Runge
METHOD: Solid flight auger with TC bit to 2.6m, NMLC coring to 11.5
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Bore 29 – 2.60 m to 7.00 m

Bore 29 – 7.00 m to 11.53 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	224764.00
	New Sub-Transmission Substation	PLATE No:	1
	Lot 9 DP250890 Hebden Road, Muswellbrook	REV:	0
	CLIENT: Ausgrid	DATE:	3-Nov-23

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.7 AHD
COORDINATE: E:312087.5, N:6418487.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 25
PROJECT No: 224764.00
DATE: 26/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL / DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL	TS								
		0.60	Clayey SILT, trace gravel: brown; fine gravel; rootlets.		RS	H	w<PL		A	0.10		
									A	0.50		
	134		Sandy CLAY, trace gravel: brown; medium plasticity; fine to medium sand; fine to medium gravel.			H	w<PL		U50	0.81	PP	>400kPa
		1									SPT	4,5,9 N=14
											PP	>400kPa
	133											
		2										
	132										SPT	10,16,25/50 ref
		2.85	Borehole discontinued at 2.85m depth. refusal on siltstone.								PP	>400kPa

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger with TC bit
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 133.6 AHD
COORDINATE: E:312146.6, N:6418477.6
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 26
PROJECT No: 224764.00
DATE: 26/09/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE		REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	0.05	TOPSOIL							A		0.10		
		Silty Sandy CLAY, trace gravel: dark brown; medium plasticity; fine to medium sand; fine gravel. From 0.30m: sandy clay		RS	H	w<PL			A		0.50		
									U50		0.85	PP	>400kPa
												SPT	4,7,13 N=20
												PP	>400kPa
	2.05	Borehole discontinued at 2.05m depth. refusal on siltstone.										SPT	25/50 ref
												PP	>400kPa

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

PLANT: Hanjin 8D
METHOD: 100mm solid flight auger
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: Nil

LOGGED: Gilmour

Refer to explanatory notes for symbol and abbreviation definitions

Generated with CORE-GS by Geroc - Soil Log - 17/11/2023 1:55:06 PM

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.8 AHD
COORDINATE: E:312132.2, N:6418502.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 27
PROJECT No: 224764.00
DATE: 05/10/23
SHEET: 1 of 4

CONDITIONS ENCOUNTERED

Depth (m)	Description of Strata	Origin(#)	Consis.(*) / Density(*)	Moisture
0.05	TOPSOIL			
0.90	Silty CLAY (CH), trace sand: brown; high plasticity; fine to coarse sand.	RS	H	w<PL
2.50	Silty CLAY (CI-CH), trace sand: pale brown mottled orange grey; medium to high plasticity; fine to medium sand.	RS	H	w<PL
3.90	Sandy CLAY (CI): grey orange; medium plasticity; fine to medium sand.	XWM	H	w<PL
4.00	Silty Sandy CLAY (CI): grey mottled orange; medium plasticity; fine to medium sand.	XWM	H	w<PL
	SILTSTONE: orange grey			

ROCK

Weath.	Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks
MW	4.00 – 4.70	VL to L	100	10	4.00-4.05m: JT, 70°, PR, HE, SM 4.05-4.15m: JT xx5, 40-70°, PR, Fe, SM, SN/TI 4.17m: P, 5°, PR, SN Fe, SM 4.19m: P, 5°, PR, SN Fe, SM 4.24-4.29m: JT, 10°, PR, HE Fe, SM 4.36-4.43m: JT, 50°, PR, SN Fe, RF 4.47m: P, 10°, PR, SN Fe, RF 4.59-4.65m: JT, 70°, PR, Fe, RF, SN/TI 4.71-4.75m: CS
SEAM	4.71 – 4.75	SEAM			
MW	4.75 – 4.88	VL to L			
SEAM	4.88 – 4.97	SEAM			

SAMPLE

Sample Remarks	Type	Depth (m)
Jar	D/ES	0.20
Jar	D/ES	0.40 – 0.50
	D	0.70 – 0.90

TESTING

Depth (m)	Test Type	Results and Remarks
0.20	PP	>600kPa
1.00	PP	>600kPa
	SPT	7,10,10 N=20 >600kPa
	PP	
2.50	PP	>600kPa
	SPT	15,15,18 N=33 >600kPa
	PP	
4.00	SPT	20/100 ref
	PLT	PL(D)=0.13MPa
	PLT	PL(A)=0.16MPa

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

PLANT: Hanjin 8D
METHOD:
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: HWT to 2.5m

LOGGED: Runge

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.8 AHD
COORDINATE: E:312132.2, N:6418502.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 27
PROJECT No: 224764.00
DATE: 05/10/23

CONDITIONS ENCOUNTERED

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA
		[CONT] SILTSTONE: orange grey
129	6	5.70m-5.76m: fragmented due to drilling
128	7	7.41m-7.43m: quartz band
127	7.79	CORE LOSS
	8.05	SILTSTONE: orange grey
126	9	
125		

ROCK

WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)
	– 5.51	VL to L	100	10	
SEAM	5.51 – 5.55	SEAM			SEAM
MW	5.55 – 5.76	VL to L			
SEAM	5.76 – 5.87	SEAM	100	17	SEAM
MW	5.87 – 6.12	L			
SEAM	6.12 – 6.19	SEAM			SEAM
MW	6.19 – 6.53	VL			
SEAM	6.53 – 6.56	SEAM			SEAM
MW	6.56 – 7.75	L			
SEAM	7.75 – 7.79	SEAM			SEAM
CORE LOSS	7.79 – 8.05		100	27	
MW	8.05 – 8.31	VL			
SEAM	8.31 – 8.34	SEAM			SEAM
MW to SW	8.34 – 8.66	L			
SEAM	8.66 – 8.68	SEAM			SEAM
SW to MW	8.68 – 9.25	L			
SEAM	9.25 – 9.35	SEAM			SEAM
MW	9.35 – 9.43				
SW to FR	9.43 –	M			

DEFECTS & REMARKS

4.75-4.87m: JT, 60°, PR, SM, Fe/Clay, SN/HE
4.88-4.97m: CS
5.15m: P, 5°, PR, SN Fe, SM
5.22-5.33m: JT, 60°, PR, INF CA, SM
5.36m: P, t, PR, SN Fe, SM
5.47-5.51m: JT, 30°, CU, SN Fe, SM
5.51-5.55m: CS
5.56m: JT, 20°, PR, SN Fe, SM
5.64m: JT, 30°, CU, HE Fe, SM
5.69-5.70m: JT, 50°, PR, SN Fe, SM
5.70-5.76m: FG
5.76-5.87m: CS
5.94-5.95m: JT, 70°, PR, SN Fe, SM
6.03m: P, 5°, PR, SN Fe, RF
6.12-6.19m: CS
6.19m: JT, 70°, ST, SN Fe, RF
6.29-6.34m: JT, 50-70°, CU, HE Fe, SM
6.40-6.46m: JT, 70°, PR, SM, Fe/Clay, SN/HE
6.53-6.56m: CS
6.56-6.64m: JT, 70°, CU, Fe, SM, ST/TI
6.82-6.86m: JT, 80°, PR, SN Fe, RF
6.82m: P, 5°, PR, SN Fe, RF
6.94m: P, 5°, PR, SN Fe, RF
6.99m: P, 5°, PR, SN Fe, RF
7.05-7.10m: JT xx3, 20-50°, CU, Fe, PO, SN/HE
7.23m: P, 10°, PR, SN Fe, RF
7.31-7.39m: JT, 50°, PR, Fe, SM, TI/HE
7.43-7.44m: JT, 50°, PR, SN Fe, SM
7.61m: P, 10°, CU, SN Fe, SM
7.67-7.75m: JT
7.75-7.79m: CS, 70°, CU, Fe, SM, HE/SN
7.80m: JT, 70°, PR, Fe, SM, SN/TI
8.05-8.14m: FG
8.20-8.25m: JT, 60°, PR, HE Fe, SM
8.31-8.34m: CS
8.42m: JT, 20°, CU, HE Fe, SM
8.45m: P, 5°, PR, CN Fe, RF
8.52m: JT, 20°, CU, CN, SM
8.66-8.68m: CS
8.68-8.76m: JT, 60°, PR, SN Fe, RF
8.70m: P, 5°, PR, HE Fe, RF
8.72m: P, 5°, PR, SN Fe, RF
8.80m: P, 10°, PR, SN Fe, RF
8.83-8.89m: JT, 70°, ST, SN Fe, RF
8.94m: P, 10°, PR, SN Fe, RF
9.00m: JT, 20°,

TESTING

DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	PLT	PL(D)=0.06MPa
	PLT	PL(A)=0.06MPa
6	PLT	PL(A)=0.25MPa
	PLT	PL(A)=0.16MPa
7	PLT	PL(A)=0.11MPa
	PLT	PL(D)=0.11MPa
8	PLT	PL(A)=0.31MPa
	PLT	PL(A)=0.23MPa
9	PLT	PL(A)=0.18MPa
	PLT	PL(A)=0.65MPa
	PLT	PL(D)=0.69MPa

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

PLANT: Hanjin 8D
METHOD:
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: HWT to 2.5m

LOGGED: Runge

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.8 AHD
COORDINATE: E:312132.2, N:6418502.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 27
PROJECT No: 224764.00
DATE: 05/10/23
SHEET: 3 of 4

CONDITIONS ENCOUNTERED

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD
		[CONT] SILTSTONE: orange grey	SW to FR	10.43	M / M	100	27
			MW to SW	10.65	VL to L		
124	10.87		XW	10.80 / 10.87			
	11.00	CORE LOSS		11.00			
		SILTSTONE: grey	SEAM	11.17	SEAM		
123	12	12.01m-13.43m: pyrite nodules			M	96	82
122	13		FR	13.15	M / H		
121	14			14.15			
120		14.49m-16.20m: pyrite nodules			M	100	95

DEFECTS & REMARKS

PR, SN Fe, RF
9.06m: P, 20°, PR, SN Fe, RF
9.07-9.17m: JT xx2, 40-60°, PR, SM, FE/CA, SN/HE
9.18m: P, 20°, PR, HE Fe, RF
9.25-9.35m: CS
9.35-9.44m: JT, 70°, ST, TI Fe, RF
9.59m: P, 20°, PR, SN Fe, RF
9.78m: P, 5°, PR, CN, RF
9.85m: JT xx2, 5°, CU, RF, CA/FE, HE/SN
10.06m: JT, 20°, CU, HE CA, RF
10.34-10.59m: JT, 60°, PR, SN Fe, RF
10.65-10.80m: JT, 70°, ST, Fe, RF, SN/HE
10.80-10.87m: CS
11.00-11.17m: CS
11.09-11.33m: JT, 50°, PR, CN, RF
11.57m: P, 10°, PR, CN, RF
11.78m: P, 10°, PR, CN, RF
11.86m: P, 60°, PR, CN, RF
12.12m: P, 0°, PR, CN, RF
12.36m: JT, 30°, PR, TI, SM
13.41m: P, 20°, CU, CN, SM
13.56m: P, 10°, CU, CN, RF
13.70m: P, 10°, CU, RF
13.74m: P, 10°, PR, TI, RF
13.81m: JT, 10°, PR, HE, RF
14.22m: P, 10°, PR, CN, SM
14.67m: P, 5°, PR, CN, RF
14.76m: JT, 30°, PR, CN, RF

TESTING

DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	PLT	PL(D)=0.45MPa
	PLT	PL(A)=0.43MPa
11		
	PLT	PL(D)=0.65MPa
	PLT	PL(A)=0.7MPa
12		
	PLT	PL(D)=0.68MPa
	PLT	PL(A)=0.62MPa
13		
	PLT	PL(D)=0.92MPa
	PLT	PL(A)=1.06MPa
14		
	PLT	PL(D)=0.62MPa
	PLT	PL(A)=0.81MPa

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

PLANT: Hanjin 8D
METHOD:
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: HWT to 2.5m

LOGGED: Runge

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.8 AHD
COORDINATE: E:312132.2, N:6418502.0
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 27
PROJECT No: 224764.00
DATE: 05/10/23

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	WEATH.	ROCK DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS	TEST TYPE	RESULTS AND REMARKS
119		[CONT] SILTSTONE: grey	FR	15.10	M / H	100	95	15.32m: JT, 20°, PR, HE CA, SM 15.54m: P, 5°, PR, TI, SM	PLT PLT PLT	PL(A)=0.93MPa PL(D)=0.64MPa PL(A)=1.36MPa
	16.40	Borehole discontinued at 16.40m depth. Limit of investigation.								

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

PLANT: Hanjin 8D
METHOD:
REMARKS:

OPERATOR: Total Drilling (D Tranter)
CASING: HWT to 2.5m

LOGGED: Runge

Refer to explanatory notes for symbol and abbreviation definitions

Bore 27 – 4.00 m to 8.00 m

Bore 27 – 8.00 m to 13.00m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates** **New Sub-Transmission Substation** **Lot 9 DP250890 Hebden Road, Muswellbrook**	PROJECT: 224764.00
		PLATE No: 1
		REV: 0
	CLIENT: Ausgrid	DATE: 3-Nov-23

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.9 AHD
COORDINATE: E:312134.5, N:6418503.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 27A
PROJECT No: 224764.00
DATE: 09/10/23
SHEET: 1 of 3

CONDITIONS ENCOUNTERED																SAMPLE				TESTING	
					SOIL			ROCK													
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)	RECOVERY (%)	RQD	FRACTURE SPACING (m) (0.005 0.02 0.05 0.10 0.20 0.50 1.00 2.00 5.00)	DEFECTS & REMARKS		SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	134.9	0.00	0.00m: Refer to Bore 27 for details of upper 15.8m																		
	134	1																	1		
	133	2																	2		
	132	3																	3		
	131	4																	4		
	130	5																	5		
	129	6																	6		
	128	7																	7		
	127	8																	8		
	126	9																	9		
	125																				

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: SFA with TC bit to 3.0m, PCD to 15.8m, NMLC to 20.58m
CASING: HWT to 2.6m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.9 AHD
COORDINATE: E:312134.5, N:6418503.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 27A
PROJECT No: 224764.00
DATE: 09/10/23
SHEET: 2 of 3

DEPTH (m)	DESCRIPTION OF STRATA	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS	TEST TYPE	RESULTS AND REMARKS
15.80	SILTSTONE: dark grey	FR	15.80	H	100	100		PLT PLT	PL(A)=1.74MPa PL(D)=1MPa
17							17.34m: P, SH, PR, SM	PLT	PL(A)=1.73MPa
18	18.16m-18.27m: fine grained, grey sandstone				100	100	18.52m: JT, 60°, PR, SM 18.72m: JT, 60°, PR, SM	PLT	PL(A)=1.75MPa
19								PLT	PL(A)=1.95MPa

RL (m): 124 (11 m), 123 (12 m), 122 (13 m), 121 (14 m), 120 (15 m), 119 (16 m), 118 (17 m), 117 (18 m), 116 (19 m), 115

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: SFA with TC bit to 3.0m, PCD to 15.8m, NMLC to 20.58m
CASING: HWT to 2.6m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 134.9 AHD
COORDINATE: E:312134.5, N:6418503.1
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 27A
PROJECT No: 224764.00
DATE: 09/10/23
SHEET: 3 of 3

CONDITIONS ENCOUNTERED																SAMPLE				TESTING	
				SOIL			ROCK														
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	
			[CONT] SILTSTONE: dark grey					FR		H	100	100							PLT	PL()=1.26MPa	
		20.58	Borehole discontinued at 20.58m depth. Limit of investigation.															21			
		21																			
		22																22			
		23																23			
		24																24			
		25																25			
		26																26			
		27																27			
		28																28			
		29																29			

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Chaplin
METHOD: SFA with TC bit to 3.0m, PCD to 15.8m, NMLC to 20.58m
CASING: HWT to 2.6m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Bore 27A – 15.80 m to 20.00 m

Bore 27A – 20.00 m to 20.58 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates** **New Sub-Transmission Substation** **Lot 9 DP250890 Hebden Road, Muswellbrook**	PROJECT:	224764.00
		PLATE No:	1
		REV:	0
	CLIENT: Ausgrid	DATE:	3-Nov-23

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 135.6 AHD
COORDINATE: E:312074.3, N:6418506.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 28
PROJECT No: 224764.00
DATE: 26/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.05	TOPSOIL				A	0.10		
		0.60	Clayey SILT, trace gravel: dark brown; fine gravel; rootlets.	RS	H	w<PL	A	0.50		
	135	2.70	Sandy CLAY; medium plasticity; fine to medium sand. 1.00m: V bit refusal	RS	H	w<PL			SPT	13,13,14 N=27
	134								PP	>400kPa
	133								SPT	13,25/50 ref
									PP	>400kPa
			Borehole discontinued at 2.70m depth. refusal.							

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

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Gilmour
METHOD: 100mm solid flight auger with V bit, TC bit from 1.0m
CASING: Nil
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 132.4 AHD
COORDINATE: E:311938.3, N:6418467.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 29
PROJECT No: 224764.00
DATE: 28/09/23
SHEET: 1 of 3

CONDITIONS ENCOUNTERED / SAMPLE / TESTING

GROUNDWATER: No free groundwater observed

DEPTH (m)	DESCRIPTION OF STRATA	SOIL STRENGTH (where encountered) / SOIL MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS
0.05	TOPSOIL								
0.60	Silty Sandy CLAY, trace gravel: brown; low plasticity; fine to medium sand; fine gravel.	w<PL							
2.50	Sandy CLAY, with gravel: pale brown; low plasticity; fine to medium sand; fine gravel. From 0.80m: pale brown/orange and grey mottling. From 2.00m: grading into extremely weathered sandstone	w<PL							
3.22	Silty CLAY (CI), with gravel: grey orange; medium plasticity; fine to medium, sub-angular gravel; gravel is siltstone fragments, borderline silty clay / siltstone.	H / w<PL				100	0		
	SILTSTONE: orange grey		HW	3.22–3.90	EL	100			3.22-3.27m: JT, 70°, PR, SN Fe, RF; 3.29-3.36m: JT, 50°, PR, SN Fe, RF; 3.43m: P, 5°, PR, SN Fe, RF; 3.50-3.61m: JT, 50°, PR, SN Fe, RF; 3.78m: JT, 30°, PR, TI Fe, RF
			SEAM	3.90–4.00	SEAM			SEAM	
			HW	4.00–4.54	EL	100	40		4.10-4.17m: JT, 70°, CU, SN Fe, RF; 4.20-4.25m: JT xx2, 30°, CU, SN Fe, RF; 4.31-4.55m: JT, 40°, ST, SN Fe, RF; 4.40-4.47m: JT, 80°, ST, SN Fe, RF
			SEAM	4.54–4.75	SEAM			SEAM	4.75-4.80m: JT, 80°, PR, CN, RF
			HW	4.75–	VL to EL				

RL (m): 132, 131, 130, 129, 128

SAMPLE TYPE	DEPTH (m)
A	0.10
A	0.50

TEST TYPE	RESULTS AND REMARKS
SPT	9,12,19 N=31
PP	>400kPa
PLT	PL(A) =0.04MPa
PLT	PL(D)=0.17MPa
PLT	PL(A)=0.15MPa
PLT	PL(A)=0.16MPa

BACKFILL: Bentonite Concrete
WELL PIPE

NOTES: [a]Soil origin is "probable" unless otherwise stated.

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Runge
METHOD: 100mm solid flight auger with TC bit, from 2.5m NMLC c
CASING: HWT to 2.5m
REMARKS:

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW

SURFACE LEVEL: 132.4 AHD
COORDINATE: E:311938.3, N:6418467.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 29
PROJECT No: 224764.00
DATE: 28/09/23

CONDITIONS ENCOUNTERED | SAMPLE | TESTING

Columns: GROUNDWATER | RL (m) | DEPTH (m) | DESCRIPTION OF STRATA | SOIL STRENGTH (where encountered) | SOIL MOISTURE | GRAPHIC | WEATH. (RS XW HW DW MW SW FR) | DEPTH (m) | STRENGTH (VL L M H VH EH) | RECOVERY (%) | RQD | FRACTURE SPACING (m) (0.005 0.01 0.05 0.10 0.50 1.00 5.00) | DEFECTS & REMARKS | SAMPLE REMARKS | TYPE | INTERVAL | DEPTH (m) | TEST TYPE | RESULTS AND REMARKS | BACKFILL | WELL PIPE

RL (m): 127, 126, 125, 124, 123. Depth (m): 6, 7, 8, 9.

Description of strata: [CONT] SILTSTONE: orange grey

Depth interval (m)	Weathering	Strength	Recovery (%)	RQD
to 5.47	HW	VL to L	100	40
5.47–5.54	SEAM	SEAM		
5.54–5.81	HW	L		
5.81–5.93	SEAM	SEAM		
5.93–9.58	HW	L	100	10
			100	-
9.58–9.78	SEAM	SEAM		
9.78–	HW	VL to L		

Defects & Remarks:
- 5.18-5.24m: JT, 40°, CU, SN Fe, RF
- 5.26-5.32m: JT, 60°, CU, TI, SM
- 5.75m: JT, 40°, CU, SN Fe, RF
- 6.13m: JT, 30°, ST, SN Fe, RF
- 6.18m: JT, 30°, CU, HE Fe, SM
- 6.26-6.37m: JT, 60°, ST, SN Fe, RF
- 6.46m: JT, 50°, ST, SN Fe, RF
- 6.65m: JT, 30°, CU, SN Fe, RF
- 6.90m: JT, 40°, PR, SN Fe, RF
- 7.10m: JT, 50°, CU, SN Fe, RF
- 7.16-7.23m: JT, 70°, CU, SN Fe, RF
- 7.30-7.36m: JT, 10°, PR, SN Fe, RF
- 7.44m: JT, 30°, PR, SN Fe, RF
- 7.60-7.65m: JT, 50°, PR, SN Fe, SM
- 7.67-7.90m: JT, 70-80°, PR, SN Fe, RF
- 8.15m: JT, 30°, CU, SN Fe, RF
- 8.24-8.30m: JT, 60°, PR, SN Fe, RF
- 8.31-8.40m: JT, 60°, CU Fe, RF, SN/HE
- 8.50m: JT, 30°, CU, SN Fe, RF
- 8.61m: P, 10°, PR, SN Fe, RF
- 8.88m: JT, 40°, CU, SN Fe, RF
- 9.06m: P, 10°, PR, CN, RF
- 9.27-9.36m: JT, 70°, PR, SN Fe, RF
- 9.89m: JT, 30°, PR, SN Fe, RF

Testing:
- PLT — PL(A)=0.26MPa
- PLT — PL(D)=0.14MPa
- PLT — PL(A)=0.23MPa
- PLT — PL(D)=0.21MPa
- PLT — PL(A)=0.15MPa
- PLT — PL(D)=0.11MPa
- PLT — PL(A)=0.16MPa
- PLT — PL(A)=0.13MPa

Backfill: Gravel backfill

NOTES: [#]Soil origin is "probable" unless otherwise stated.

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Runge
METHOD: 100mm solid flight auger with TC bit, from 2.5m NMLC c
CASING: HWT to 2.5m
REMARKS:

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: New Eastern Hub Sub-Transmission Substation
LOCATION: Lot 9 DP1193430 Hebden Road, Musewllbrook, NSW
SURFACE LEVEL: 132.4 AHD
COORDINATE: E:311938.3, N:6418467.3
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: 29
PROJECT No: 224764.00
DATE: 28/09/23
SHEET: 3 of 3

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS	BACKFILL	WELL PIPE
			[CONT] SILTSTONE: orange grey		HW		VL to	100	-		10.16-10.23m: JT, 60°, PR, SN Fe, RF					PLT PLT	PL(D) =0.08MPa PL(A) =0.08MPa		
	122	10.30	Borehole discontinued at 10.30m depth. Limit of investigation.																
	121	11													11				
	120	12													12				
	119	13													13				
	118	14													14				

NOTES: [a]Soil origin is "probable" unless otherwise stated.

PLANT: Hanjin 8D
OPERATOR: Total Drilling (D Tranter)
LOGGED: Runge
METHOD: 100mm solid flight auger with TC bit, from 2.5m NMLC c
CASING: HWT to 2.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

Bore 29 – 2.50 m to 6.00 m

Bore 29 – 6.00 m to 10.3 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	224764.00
	New Sub-Transmission Substation	PLATE No:	1
	Lot 9 DP250890 Hebden Road, Muswellbrook	REV:	0
	CLIENT: Ausgrid	DATE:	3-Nov-23

Appendix B

Laboratory Testing

Laboratory Testing – Thermal Resistivity by Geotherm Australia

Material Test Report

Report Number: **224764.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224764.00
Project Name: New Eastern Hub Sub-Transmission Substation
Project Location: Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request: 10681
Sample Number: NC-10681A
Date Sampled: 06/10/2023
Dates Tested: 07/10/2023 - 19/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Sample Location: **BH3, Depth: 0.5-0.8m**
Material: Silty Clay

Douglas Partners Pty Ltd
Newcastle Laboratory
15 Callistemon Close Warabrook Newcastle NSW 2310
Phone: (02) 4960 9600
Email: Peter.Gorseski@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Peter Gorseski
Laboratory Manager
Laboratory Accreditation Number: 828

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	42		
Plastic Limit (%)	14		
Plasticity Index (%)	**28**		

Material Test Report

Douglas Partners
Geotechnics | Environment | Groundwater

Douglas Partners Pty Ltd
Newcastle Laboratory
15 Callistemon Close Warabrook Newcastle NSW 2310
Phone: (02) 4960 9600
Email: Peter.Gorseski@douglaspartners.com.au

Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681B
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 18/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH10, Depth: 0.5-0.79m**
Material:	Silty Clay

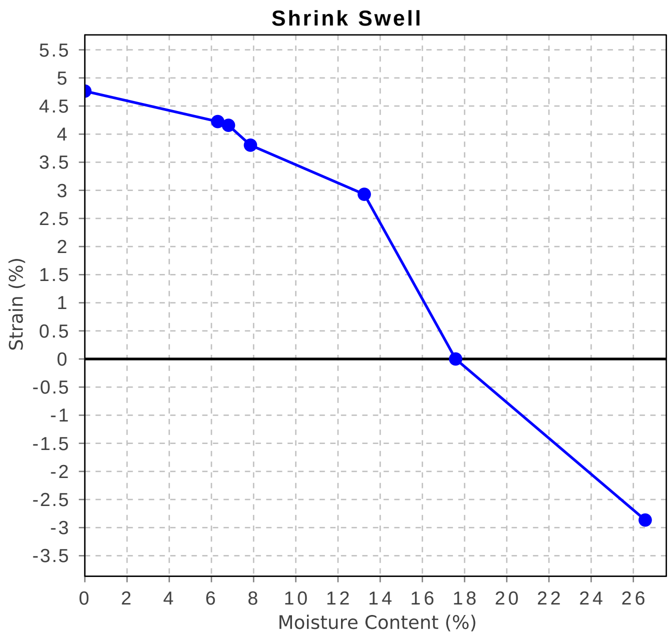
Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Peter Gorseski
Laboratory Manager
Laboratory Accreditation Number: 828

Shrink Swell Index (AS 1289 7.1.1 & 2.1.1)	
Iss (%)	**3.4**
Visual Description	Silty Clay
* Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.	

Core Shrinkage Test	
Shrinkage Strain - Oven Dried (%)	**4.8**
Estimated % by volume of significant inert inclusions	0
Cracking	Slightly Cracked
Crumbling	No
Moisture Content (%)	17.6

Swell Test	
Initial Pocket Penetrometer (kPa)	>600
Final Pocket Penetrometer (kPa)	100
Initial Moisture Content (%)	12.3
Final Moisture Content (%)	26.6
Swell (%)	**2.9**
* NATA Accreditation does not cover the performance of pocket penetrometer readings.	



Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Newcastle Laboratory
15 Callistemon Close Warabrook Newcastle NSW 2310
Phone: (02) 4960 9600
Email: Peter.Gorseski@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Peter Gorseski
Laboratory Manager
Laboratory Accreditation Number: 828

Report Number: **224764.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224764.00
Project Name: New Eastern Hub Sub-Transmission Substation
Project Location: Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request: 10681
Sample Number: NC-10681C
Date Sampled: 06/10/2023
Dates Tested: 07/10/2023 - 19/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Sample Location: **BH11, Depth: 0.5-0.82m**
Material: Silty Clay

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	53		
Plastic Limit (%)	15		
Plasticity Index (%)	**38**		

Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater

Douglas Partners Pty Ltd
Newcastle Laboratory
15 Callistemon Close Warabrook Newcastle NSW 2310
Phone: (02) 4960 9600
Email: Peter.Gorseski@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Peter Gorseski
Laboratory Manager
Laboratory Accreditation Number: 828

Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681D
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 19/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH22, Depth: 0.5-0.75m**
Material:	Silty Clay

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	44		
Plastic Limit (%)	16		
Plasticity Index (%)	**28**		

Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater

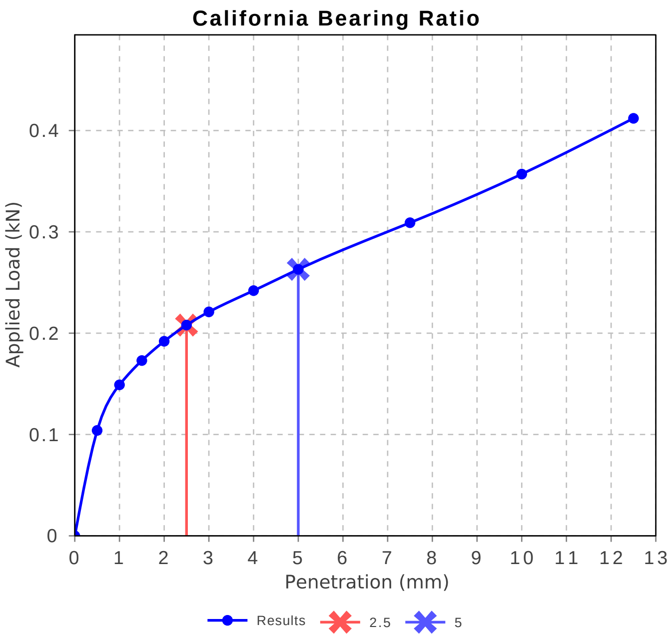
Douglas Partners Pty Ltd
Newcastle Laboratory
15 Callistemon Close Warabrook Newcastle NSW 2310
Phone: (02) 4960 9600
Email: Peter.Gorseski@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Peter Gorseski
Laboratory Manager
Laboratory Accreditation Number: 828

Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681E
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 17/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH1, Depth: 0.1-0.6m**
Material:	Silty Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**1.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.54		
Optimum Moisture Content (%)	22.5		
Laboratory Density Ratio (%)	100.5		
Laboratory Moisture Ratio (%)	99.0		
Dry Density after Soaking (t/m^3)	1.49		
Field Moisture Content (%)	17.6		
Moisture Content at Placement (%)	22.4		
Moisture Content Top 30mm (%)	33.4		
Moisture Content Rest of Sample (%)	25.5		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	48.4		
Swell (%)	4.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Douglas Partners
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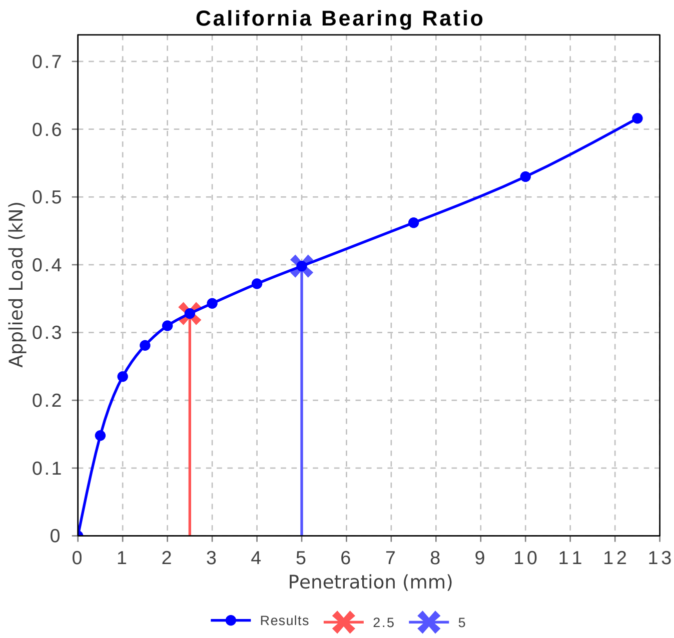
Approved Signatory: Peter Gorseski
Laboratory Manager
Laboratory Accreditation Number: 828

Report Number: **224764.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224764.00
Project Name: New Eastern Hub Sub-Transmission Substation
Project Location: Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request: 10681
Sample Number: NC-10681F
Date Sampled: 06/10/2023
Dates Tested: 07/10/2023 - 17/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Sample Location: **BH4, Depth: 0.1-0.6m**
Material: Silty Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**2.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.58		
Optimum Moisture Content (%)	21.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	98.5		
Dry Density after Soaking (t/m^3)	1.53		
Field Moisture Content (%)	17.5		
Moisture Content at Placement (%)	20.9		
Moisture Content Top 30mm (%)	30.5		
Moisture Content Rest of Sample (%)	25.5		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	93.7		
Swell (%)	3.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681G
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 17/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH5, Depth: 0.0-0.6m**
Material:	Silty Clay

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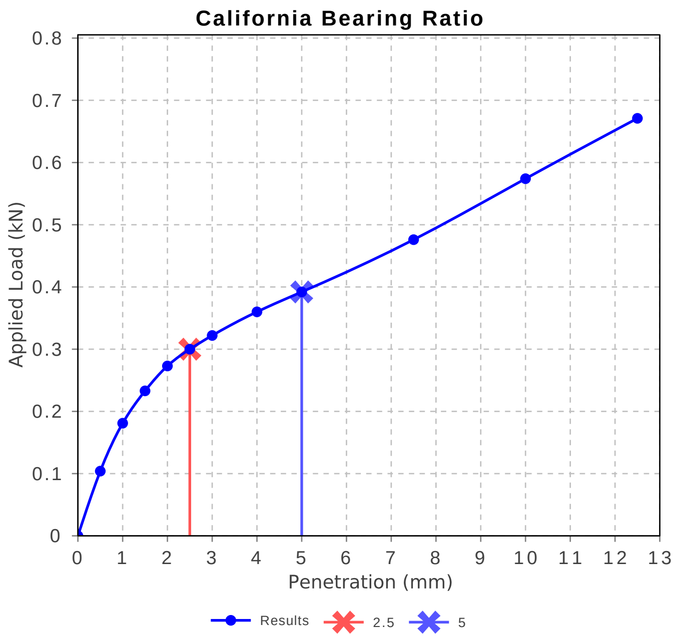
California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**2.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.54		
Optimum Moisture Content (%)	24.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	99.0		
Dry Density after Soaking (t/m^3)	1.49		
Field Moisture Content (%)	16.3		
Moisture Content at Placement (%)	23.8		
Moisture Content Top 30mm (%)	32.5		
Moisture Content Rest of Sample (%)	27.3		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	94.8		
Swell (%)	3.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



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Report Number: **224764.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224764.00
Project Name: New Eastern Hub Sub-Transmission Substation
Project Location: Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request: 10681
Sample Number: NC-10681H
Date Sampled: 06/10/2023
Dates Tested: 07/10/2023 - 17/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Sample Location: **BH7, Depth: 0.1-0.6m**
Material: Silty Clay

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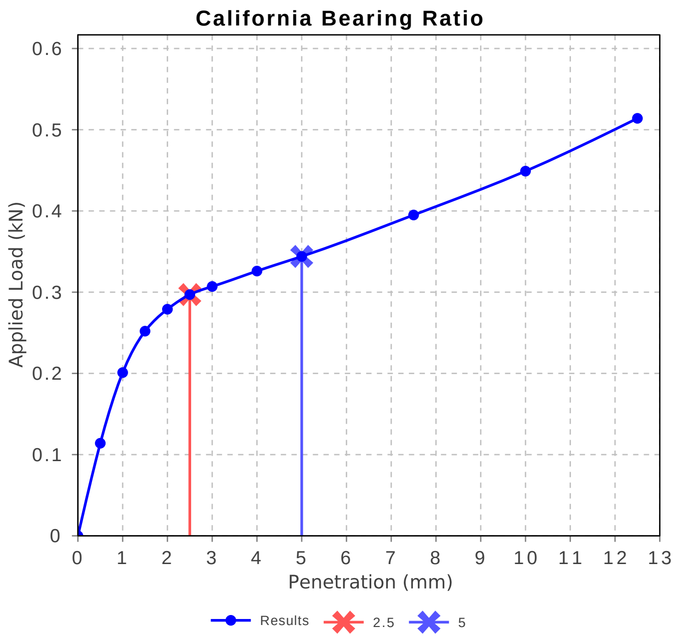
California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**2.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.45		
Optimum Moisture Content (%)	28.0		
Laboratory Density Ratio (%)	99.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.39		
Field Moisture Content (%)	21.2		
Moisture Content at Placement (%)	28.0		
Moisture Content Top 30mm (%)	38.7		
Moisture Content Rest of Sample (%)	30.1		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	49.8		
Swell (%)	3.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681I
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 17/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH12, Depth: 0.5-0.9m**
Material:	Silty Clay

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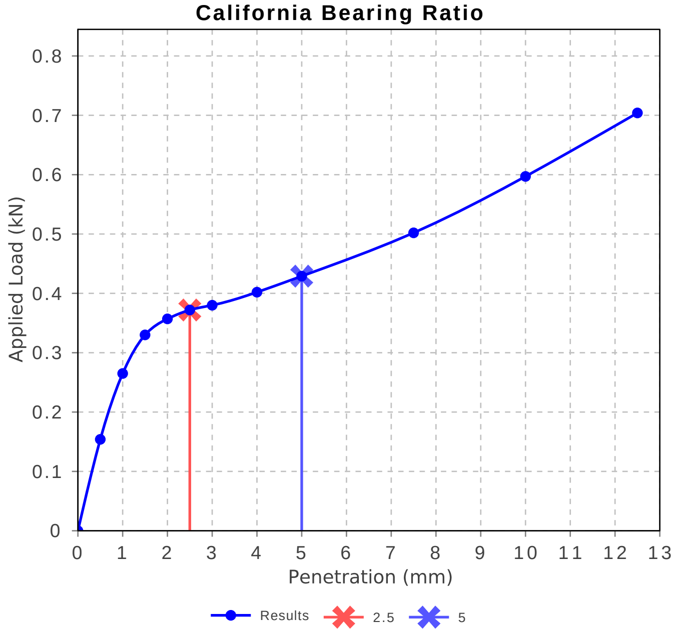
California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**3.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.49		
Optimum Moisture Content (%)	26.0		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	99.0		
Dry Density after Soaking (t/m^3)	1.47		
Field Moisture Content (%)	19.0		
Moisture Content at Placement (%)	25.8		
Moisture Content Top 30mm (%)	35.3		
Moisture Content Rest of Sample (%)	26.7		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	95.2		
Swell (%)	1.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		

California Bearing Ratio



Material Test Report

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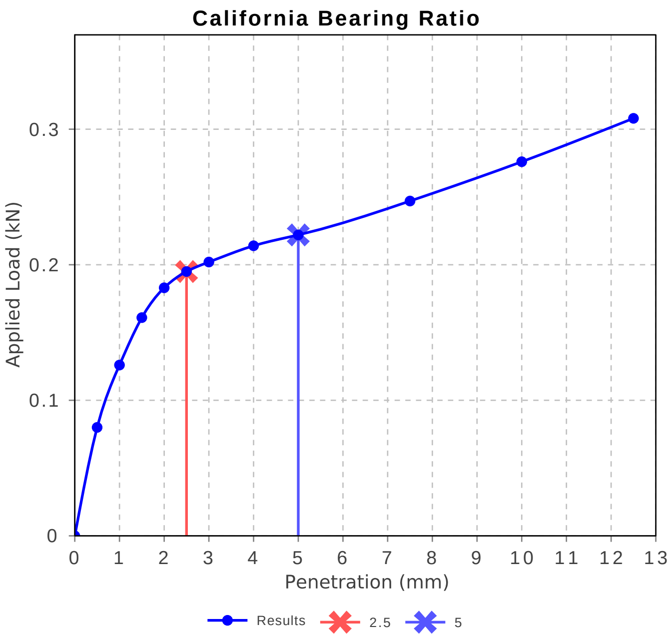
Laboratory Manager
Laboratory Accreditation Number: 828

Report Number: **224764.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224764.00
Project Name: New Eastern Hub Sub-Transmission Substation
Project Location: Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request: 10681
Sample Number: NC-10681J
Date Sampled: 06/10/2023
Dates Tested: 07/10/2023 - 17/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Sample Location: **BH13, Depth: 0.5-0.9m**
Material: Silty Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**1.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.59		
Optimum Moisture Content (%)	23.0		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	97.5		
Dry Density after Soaking (t/m^3)	1.52		
Field Moisture Content (%)	19.8		
Moisture Content at Placement (%)	22.6		
Moisture Content Top 30mm (%)	34.8		
Moisture Content Rest of Sample (%)	25.7		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	95.6		
Swell (%)	4.5		
Oversize Material (mm)	191		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

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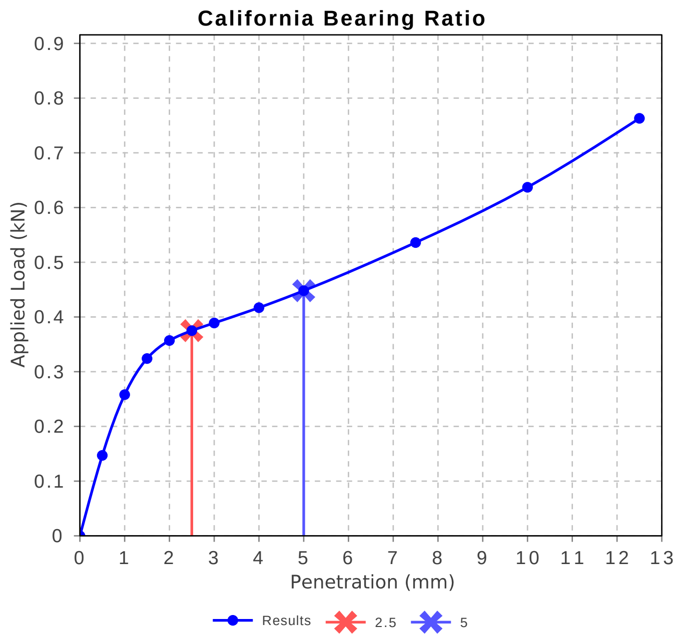
Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681K
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 17/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH18, Depth: 0.1-0.6m**
Material:	Silty Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 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 Assessment		
Maximum Dry Density (t/m^3)	1.47		
Optimum Moisture Content (%)	26.0		
Laboratory Density Ratio (%)	101.0		
Laboratory Moisture Ratio (%)	99.5		
Dry Density after Soaking (t/m^3)	1.45		
Field Moisture Content (%)	19.6		
Moisture Content at Placement (%)	25.6		
Moisture Content Top 30mm (%)	34.6		
Moisture Content Rest of Sample (%)	27.6		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	48.4		
Swell (%)	2.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



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Results relate only to the items tested/sampled.

Material Test Report

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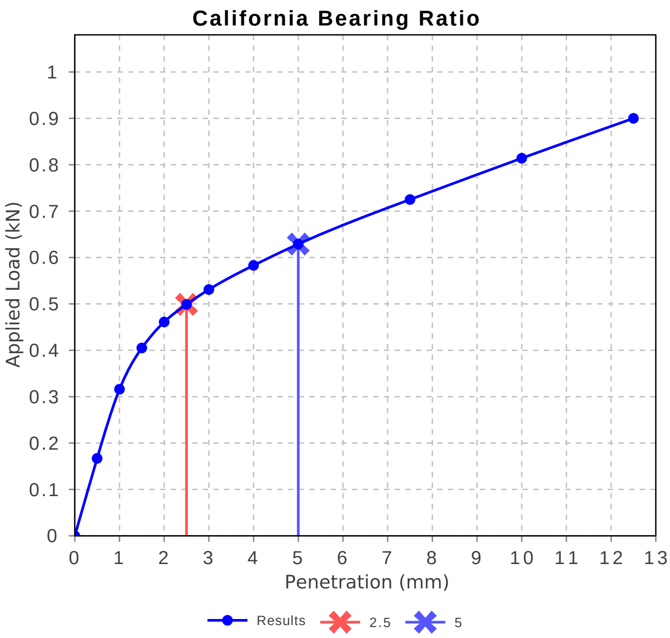
Laboratory Manager
Laboratory Accreditation Number: 828

Report Number: **224764.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224764.00
Project Name: New Eastern Hub Sub-Transmission Substation
Project Location: Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request: 10681
Sample Number: NC-10681L
Date Sampled: 06/10/2023
Dates Tested: 07/10/2023 - 17/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Sample Location: **BH19, Depth: 0.1-0.6m**
Material: Silty Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**4.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.49		
Optimum Moisture Content (%)	25.5		
Laboratory Density Ratio (%)	101.0		
Laboratory Moisture Ratio (%)	99.5		
Dry Density after Soaking (t/m^3)	1.48		
Field Moisture Content (%)	19.2		
Moisture Content at Placement (%)	25.2		
Moisture Content Top 30mm (%)	32.8		
Moisture Content Rest of Sample (%)	28.5		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	49.3		
Swell (%)	1.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



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Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681M
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 10/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH16, Depth: 2.5-2.8m**
Material:	Silty Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Silty Clay		
Nature of Water	Distilled water		
Temperature of Water (^{o}C)	19.3		

Material Test Report

Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681N
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 10/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH22, Depth: 0.0-0.1m**
Material:	Silty Clay

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Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**6**		
Soil Description	Silty Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19.3		

Material Test Report

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Report Number: **224764.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224764.00
Project Name: New Eastern Hub Sub-Transmission Substation
Project Location: Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request: 10681
Sample Number: NC-10681O
Date Sampled: 06/10/2023
Dates Tested: 07/10/2023 - 10/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Sample Location: **BH27, Depth: 1.0-1.45m**
Material: Silty Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Silty Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19.3		

Material Test Report

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Report Number: **224764.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224764.00
Project Name: New Eastern Hub Sub-Transmission Substation
Project Location: Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request: 10681
Sample Number: NC-10681P
Date Sampled: 06/10/2023
Dates Tested: 07/10/2023 - 12/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Sample Location: **BH3 , Depth: 1.0-1.45m**
Material: Silty Clay

Moisture Content (AS 1289 2.1.1)		Min	Max
Moisture Content (%)	12.7		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	72		
Plastic Limit (%)	21		
Plasticity Index (%)	**51**		

Material Test Report

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Report Number:	**224764.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224764.00
Project Name:	New Eastern Hub Sub-Transmission Substation
Project Location:	Lot 9 DP1193430 Hebden Road, Musewllbrook NSW
Work Request:	10681
Sample Number:	NC-10681Q
Date Sampled:	06/10/2023
Dates Tested:	07/10/2023 - 12/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Sample Location:	**BH21 , Depth: 1.0-1.45m**
Material:	Silty Clay

Moisture Content (AS 1289 2.1.1)		Min	Max
Moisture Content (%)	13.5		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	51		
Plastic Limit (%)	24		
Plasticity Index (%)	**27**		

Geotherm Australasia

Test Report

Client : Douglas Partners	Project Number : 2135
	Project Details : Muswellbrook - Lake Liddell
	Order/Request Number :
Report Date : 2/11/2023	Report Number : 213506

Sample Details

Sample ID / Name / Number	BH1 - 0.75-1.0m
Soil Description	Light brown clay
Sampled by	Client
Sample Type	Undisturbed
Date Sampled	6/10/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (^oC)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
6/10/2023	Probe inserted into floor of hole at 0.9m depth	As found	600	17.8	37.30	1.27	0.79

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (^oC)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
17/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	17.5%	600	19.1	20.10	1.22	0.82
19/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	12.8%	600	20.4	21.70	1.15	0.87
23/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	6.4%	500	19.6	21.60	0.89	1.12
25/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	2.8%	400	19.9	21.80	0.75	1.34
31/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	600	19.7	21.70	0.62	1.61

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^3)
A	163	73	1165.9	1710

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BH. Wet specimens tested by BL. Dry and partially dry specimens tested by NA, BH,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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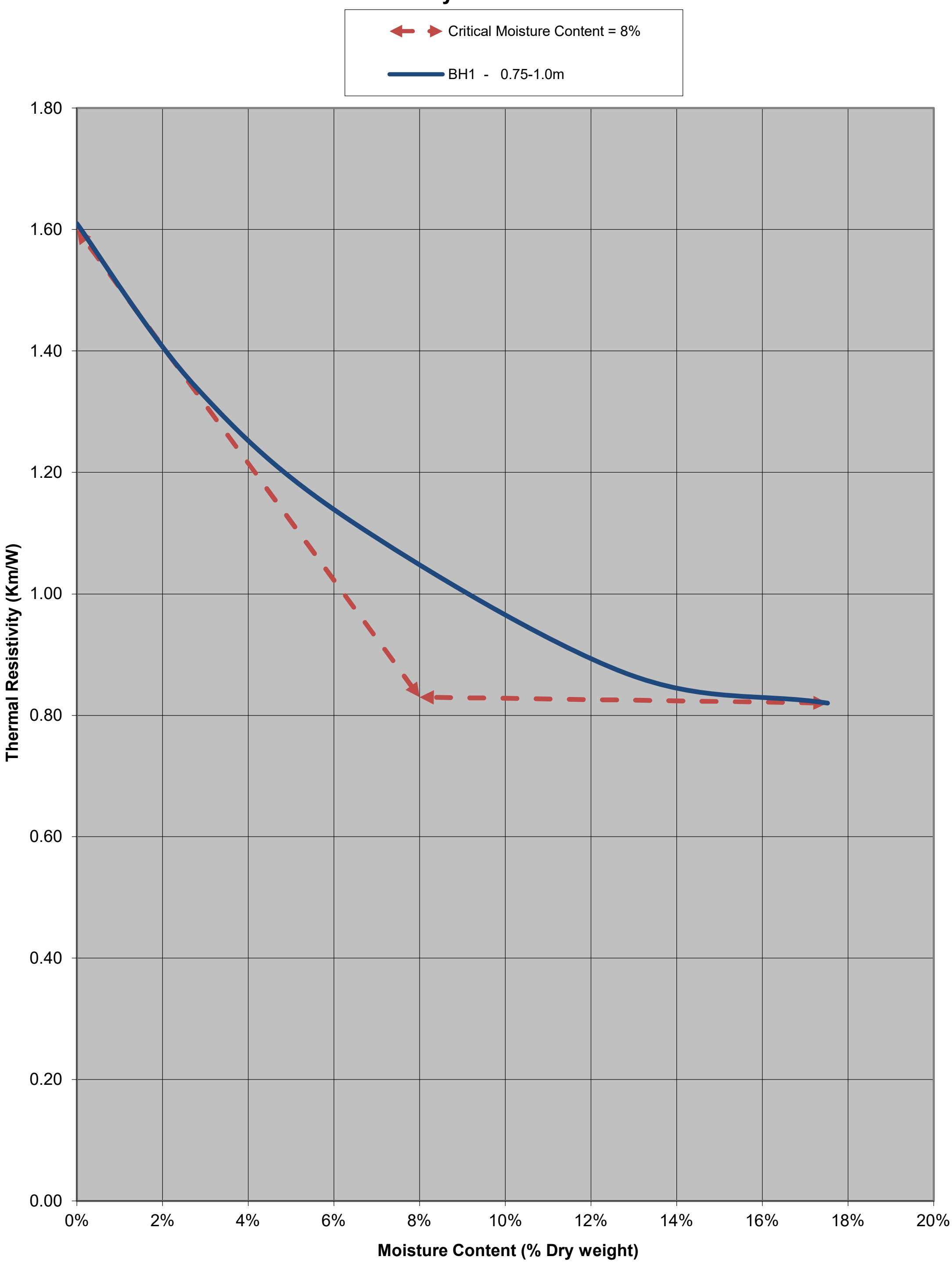
ABN 35 097 576 611
NATA Accreditation Number 20321 – Site 24277

NATA
Accredited for compliance with ISO/IEC 17025 - Testing

Dry-out Curve



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ABN 35 097 576 611
NATA Accreditation Number 20321 – Site 24277

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Test Report

Client : Douglas Partners	**Project Number :** 2135
	Project Details : Muswellbrook - Lake Liddell
	Order/Request Number :
Report Date : 2/11/2023	**Report Number :** 213507

Sample Details

Sample ID / Name / Number	BH4 - 0.75-1.1m
Soil Description	Brown silty clay
Sampled by	Client
Sample Type	Undisturbed
Date Sampled	6/10/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
6/10/2023	Probe inserted into floor of hole at 0.9m depth	As found	700	18.5	37.40	1.39	0.72

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
17/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	17.3%	600	19.1	20.10	1.30	0.77
19/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	11.3%	400	20.1	21.70	1.09	0.92
20/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	7.7%	400	19.9	20.40	0.94	1.06
23/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	3.6%	400	19.8	21.60	0.71	1.40
28/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	600	19.5	20.40	0.54	1.85

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^3)
A	150	73	1021.4	1630

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BH. Wet specimens tested by BL. Dry and partially dry specimens tested by NA, BH,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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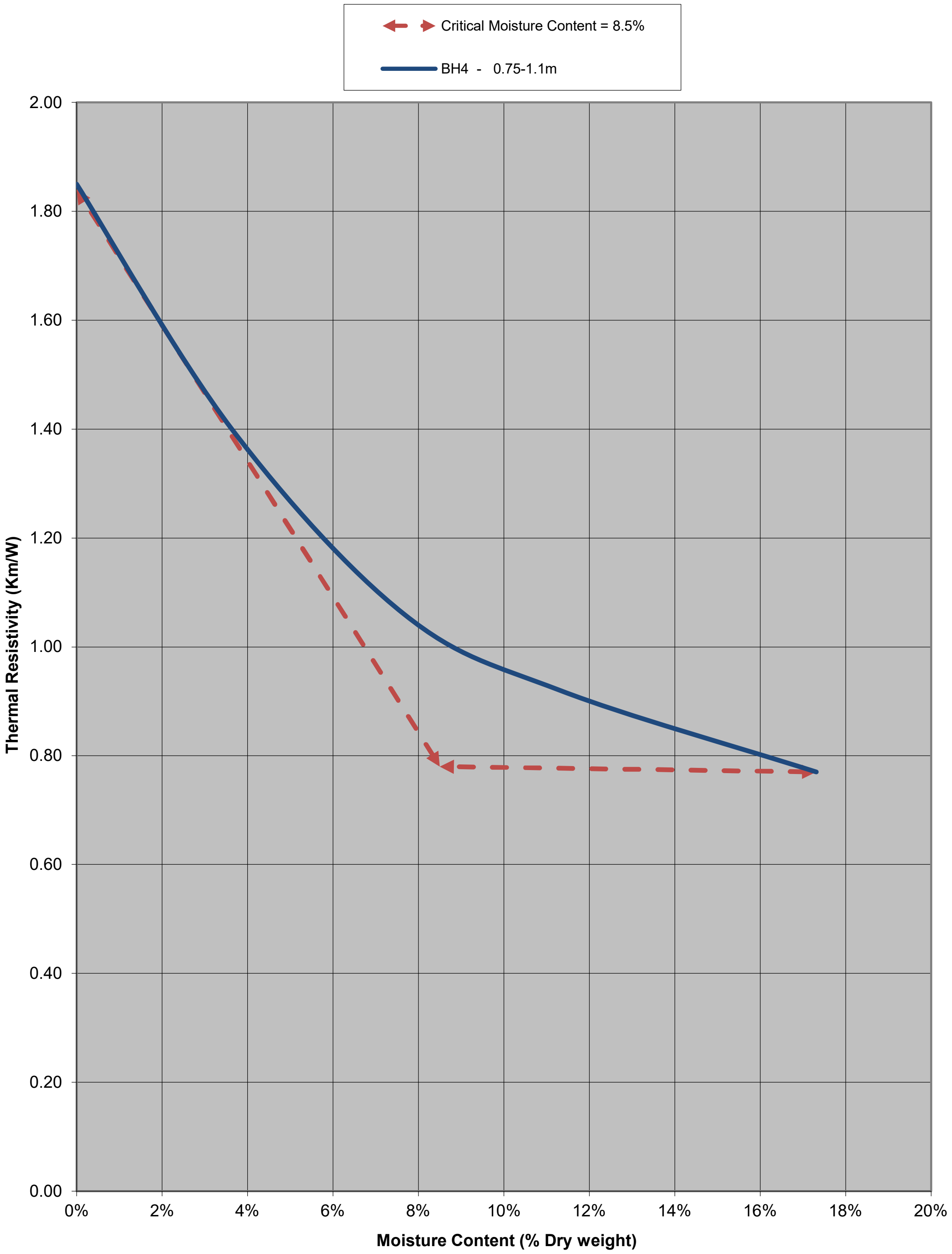
Dry-out Curve



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NATA Accreditation Number 20321 – Site 24277

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Geotherm Australasia

Test Report

Client : Douglas Partners	Project Number : 2135
	Project Details : Muswellbrook - Lake Liddell
	Order/Request Number :
Report Date : 2/11/2023	Report Number : 213508

Sample Details

Sample ID / Name / Number	BH7 - 0.85-1.0m
Soil Description	Brown silty clay
Sampled by	Client
Sample Type	Undisturbed
Date Sampled	6/10/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (^{o}C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
6/10/2023	Probe inserted into floor of hole at 0.5m depth	As found	800	17.2	37.60	1.20	0.83

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (^{o}C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
17/10/2023	Compacted to estimated field density. As found moisture content.	A	15.9%	600	18.9	20.10	0.69	1.45
19/10/2023	Compacted to estimated field density. Partially dry	A	10.3%	600	20.1	21.80	0.56	1.78
23/10/2023	Compacted to estimated field density. Partially dry	A	5.4%	600	19.7	21.60	0.50	2.00
26/10/2023	Compacted to estimated field density. Partially dry	A	1.4%	500	20.0	22.10	0.43	2.33
31/10/2023	Compacted to estimated field density. Fully dry	A	0.0%	600	19.9	21.70	0.39	2.55

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^{3})
A	120	73	685.5	1360

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BH. Wet specimens tested by BL. Dry and partially dry specimens tested by NA, BH,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.
- Laboratory test specimen density may not be representative of field density

Brett Hobson
Approved Signatory

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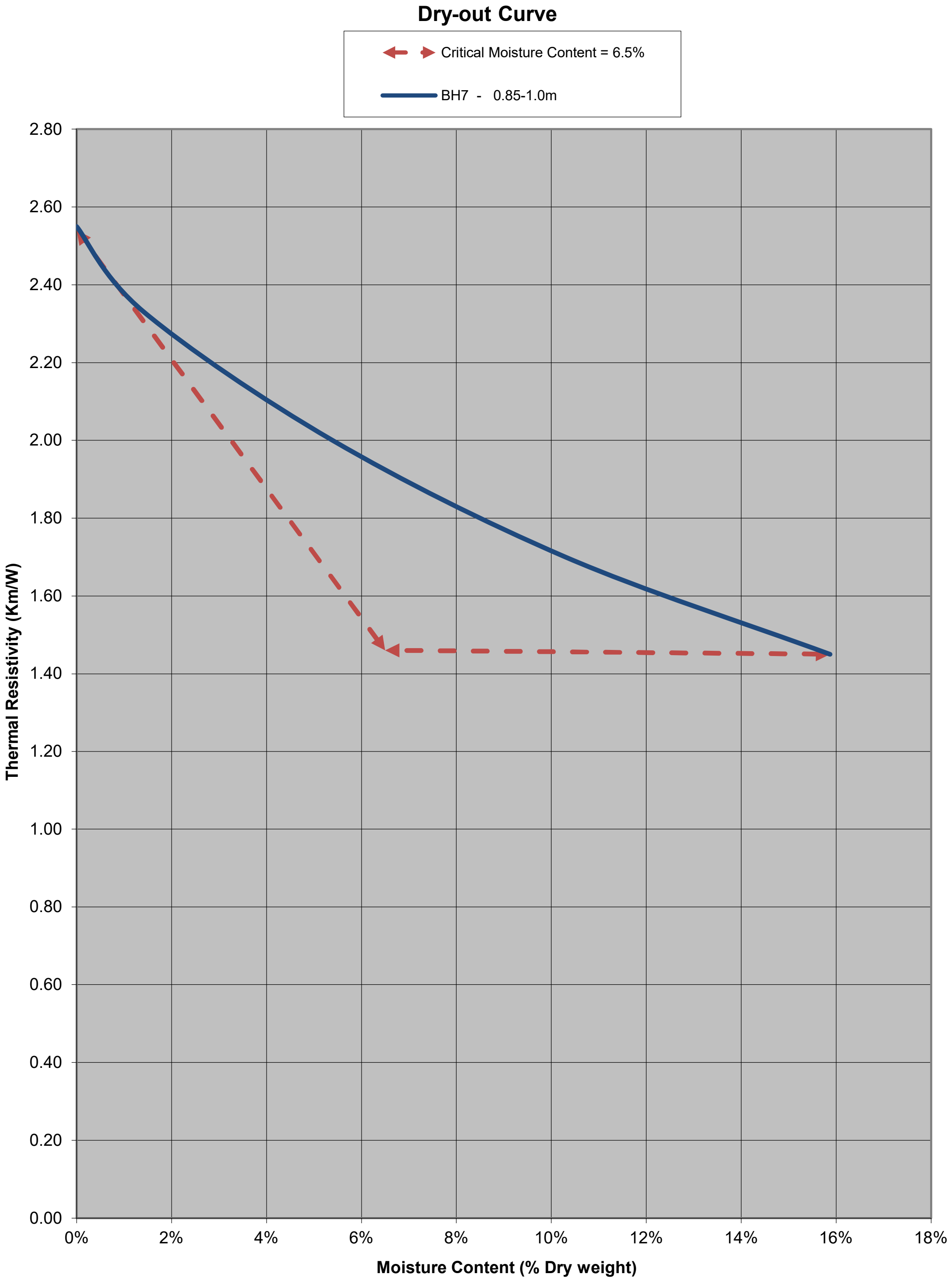
Geotherm Australasia



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Geotherm Australasia

Test Report

Client : Douglas Partners	Project Number : 2135
	Project Details : Muswellbrook - Lake Liddell
	Order/Request Number :
Report Date : 2/11/2023	Report Number : 213509

Sample Details

Sample ID / Name / Number	BH18 - 0.75-1.1m
Soil Description	Brown silty clay
Sampled by	Client
Sample Type	Undisturbed
Date Sampled	6/10/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (^{o}C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
6/10/2023	Probe inserted into floor of hole at 0.8m depth	As found	700	17.4	37.30	1.16	0.86

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (^{o}C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
17/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	19.7%	600	18.5	20.10	1.23	0.81
19/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	13.0%	600	19.7	21.80	1.19	0.84
23/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	7.3%	500	18.9	21.60	0.90	1.11
25/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	3.3%	400	19.6	21.80	0.73	1.37
31/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	600	19.0	21.70	0.57	1.76

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^{3})
A	160	73	1113.3	1660

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BH. Wet specimens tested by BL. Dry and partially dry specimens tested by NA, BH,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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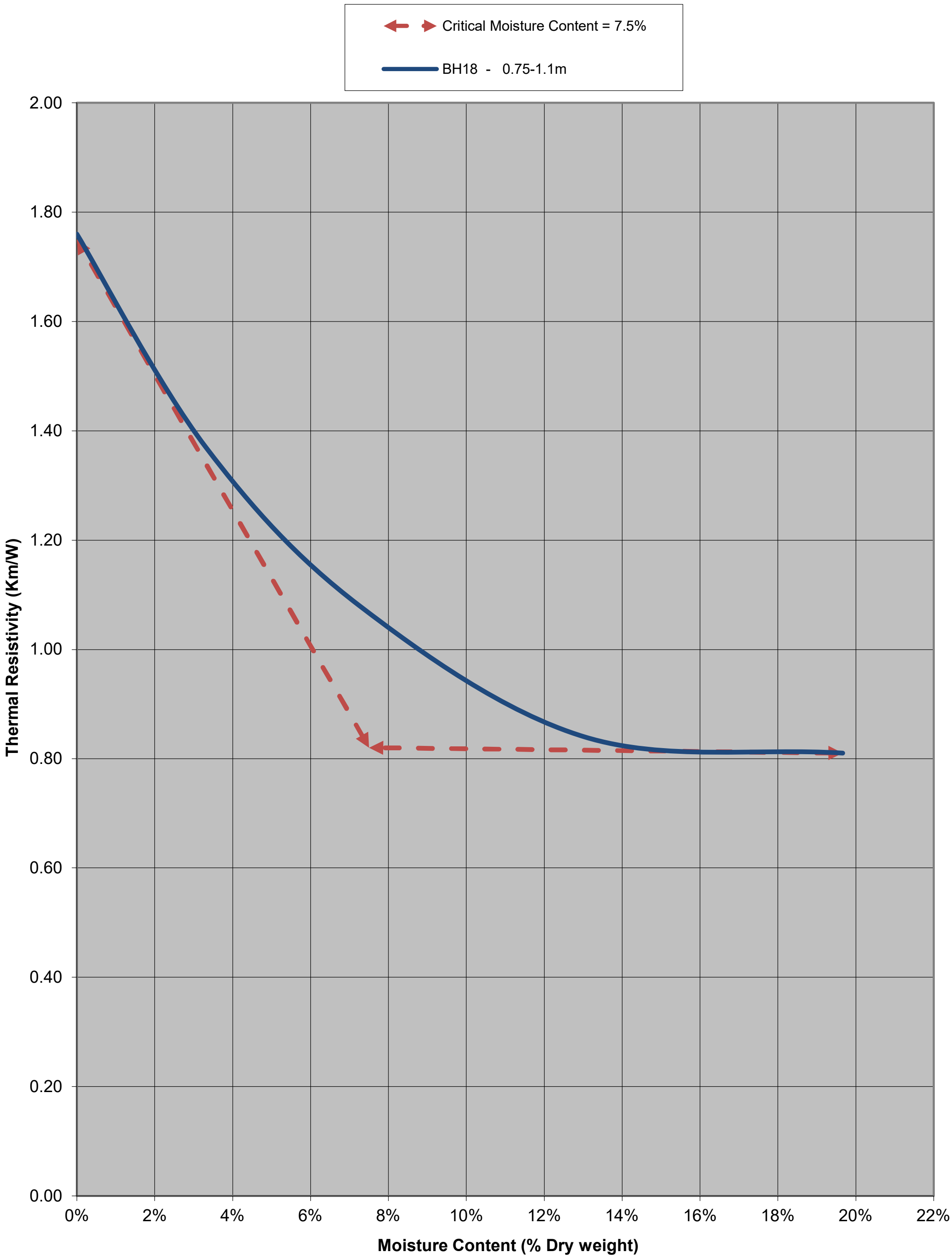
Dry-out Curve



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NATA Accreditation Number 20321 – Site 24277

Geotherm Australasia

Test Report

Client : Douglas Partners	**Project Number :** 2135
	Project Details : Muswellbrook - Lake Liddell
	Order/Request Number :
Report Date : 2/11/2023	**Report Number :** 213510

Sample Details

Sample ID / Name / Number	BH19 - 0.75-1.1m
Soil Description	Brown silty clay
Sampled by	Client
Sample Type	Undisturbed
Date Sampled	6/10/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (^{o}C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
6/10/2023	Probe inserted into floor of hole at 0.8m depth	As found	700	17.4	37.30	1.16	0.86

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (^{o}C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
17/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	22.4%	600	18.6	20.10	1.25	0.80
19/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	15.4%	600	20.0	21.80	1.10	0.91
23/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	9.6%	500	18.9	21.60	0.89	1.12
25/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	3.6%	400	19.5	21.80	0.73	1.37
31/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	600	19.3	21.70	0.58	1.71

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^{3})
A	160	73	1060.8	1580

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BH. Wet specimens tested by BL. Dry and partially dry specimens tested by NA, BH,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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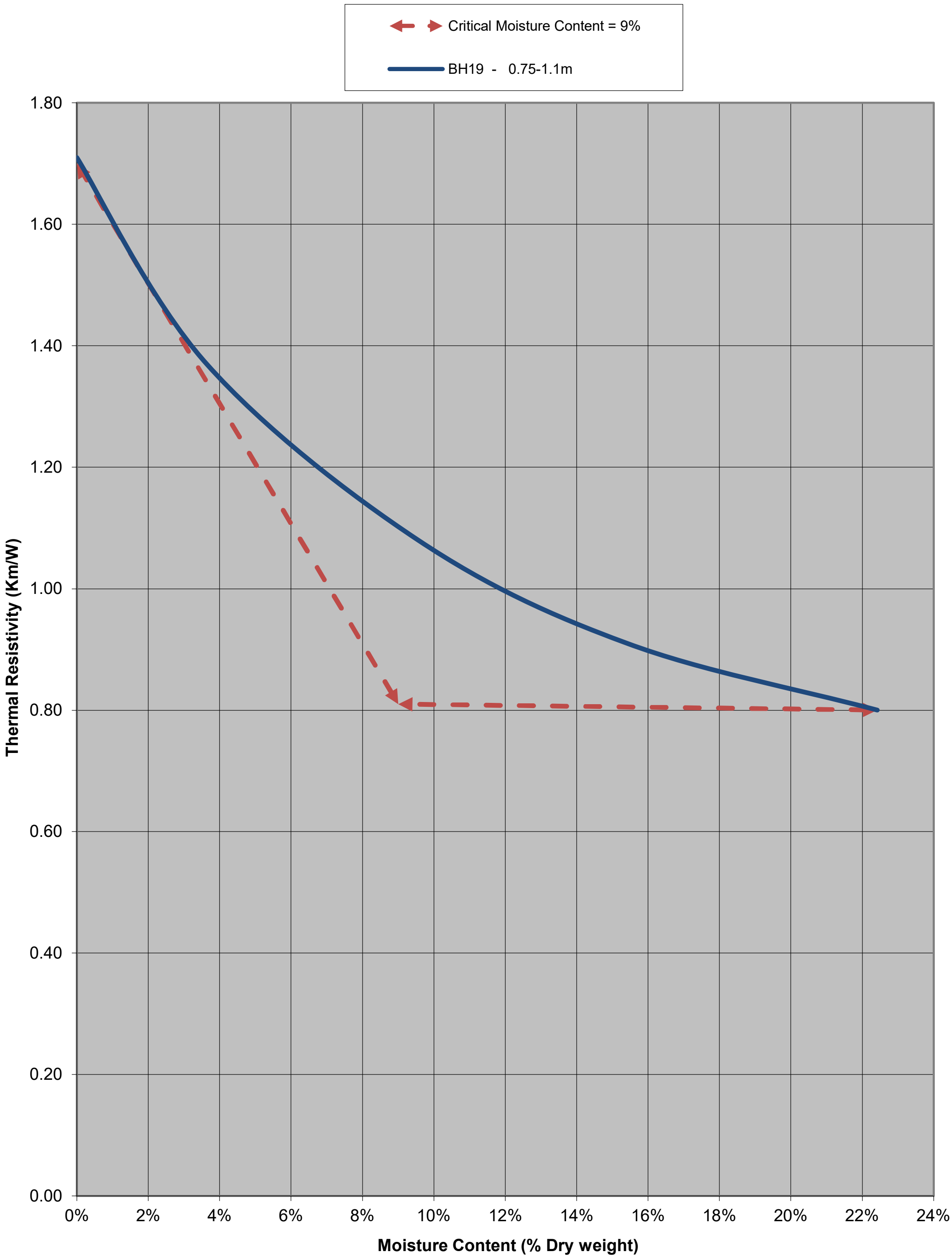

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NATA Accreditation Number 20321 – Site 24277

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Appendix C

Drawing 1 - Test Location Plan
ZN 228 Stockton – 33/11kV Substation 11 kV
Switchgear Replacement Civil & Structural Works Transportable 11 kV
Switch Building Support Structure Details – Sheet 1

Locality Plan

Legend

- Borehole Location
- Lot Boundary
- Access Road
- Approx Location of Proposed Switchyard
- Approx Location of Proposed SynCons

0 10 20 30 40 50 m

NOTE:
1. Drawing adapted from Metromap Image dated 12.02.2023 and plan by AECOM, Ref 265405, Sheet 01, AMD C dated 30.08,2023.
2. Test locations are approximate only and were located using dPGS.

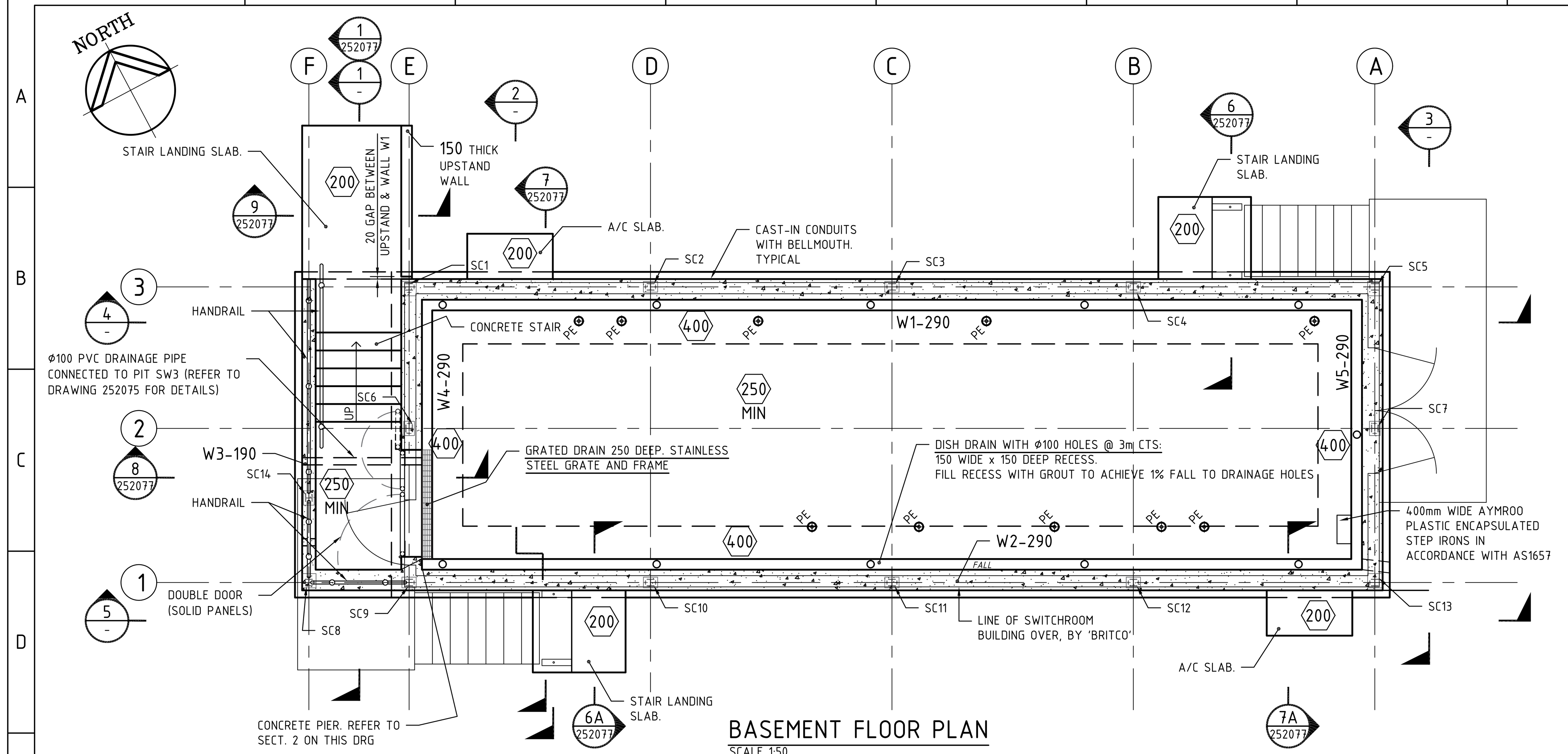
Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Ausgrid		TITLE:	Test Location Plan
OFFICE: Newcastle	DRAWN BY: PLH		Geotechnical and Contamination Services
SCALE: 1:2000@A3	DATE: 16.October.2023		Hebden Road, Muswellbrook, NSW

N

Project:	224764.00
DRAWING No:	1
REVISION:	0

DP.QGIS.A3LandscapeDrawingLayout.3.26.3 - P:\224764.00 - MUSWELLBROOK, Eastern Hub Sub-Station\7.0 Drawings\7.2 Out\224764.00.D.001.Mapping.qgz



BASEMENT FLOOR PLAN

SCALE 1:50

'SC' ON PLAN DENOTES STEEL SUPPORT COLUMNS.
NOTE: TOP OF COLUMNS TO BE WITHIN ±1mm

DENOTES REINFORCED CAST-INSITU CONCRETE WALLS

PULLING EYE CAST INTO SLAB. FOR SET-OUT REFER TO ELECTRICAL LAYOUT DRG. No. 244789. FOR DETAIL REFER TO DRG No. 252077. TYP.

SLAB TO BE POURED ON A 75mm THICK WORKING SLAB

SLAB REINFORCEMENT NOTES:

UNLESS NOTED OTHERWISE
SLAB TO BE REINFORCED WITH SL82 FABRIC TOP & N16-200 BOTH WAYS BOTTOM.

COGS TO BE STANDARD

BARS IN THIS DIRECTION TO BE LAID 1ST BOTTOM

REINFORCEMENT TO HAVE 40mm COVER.

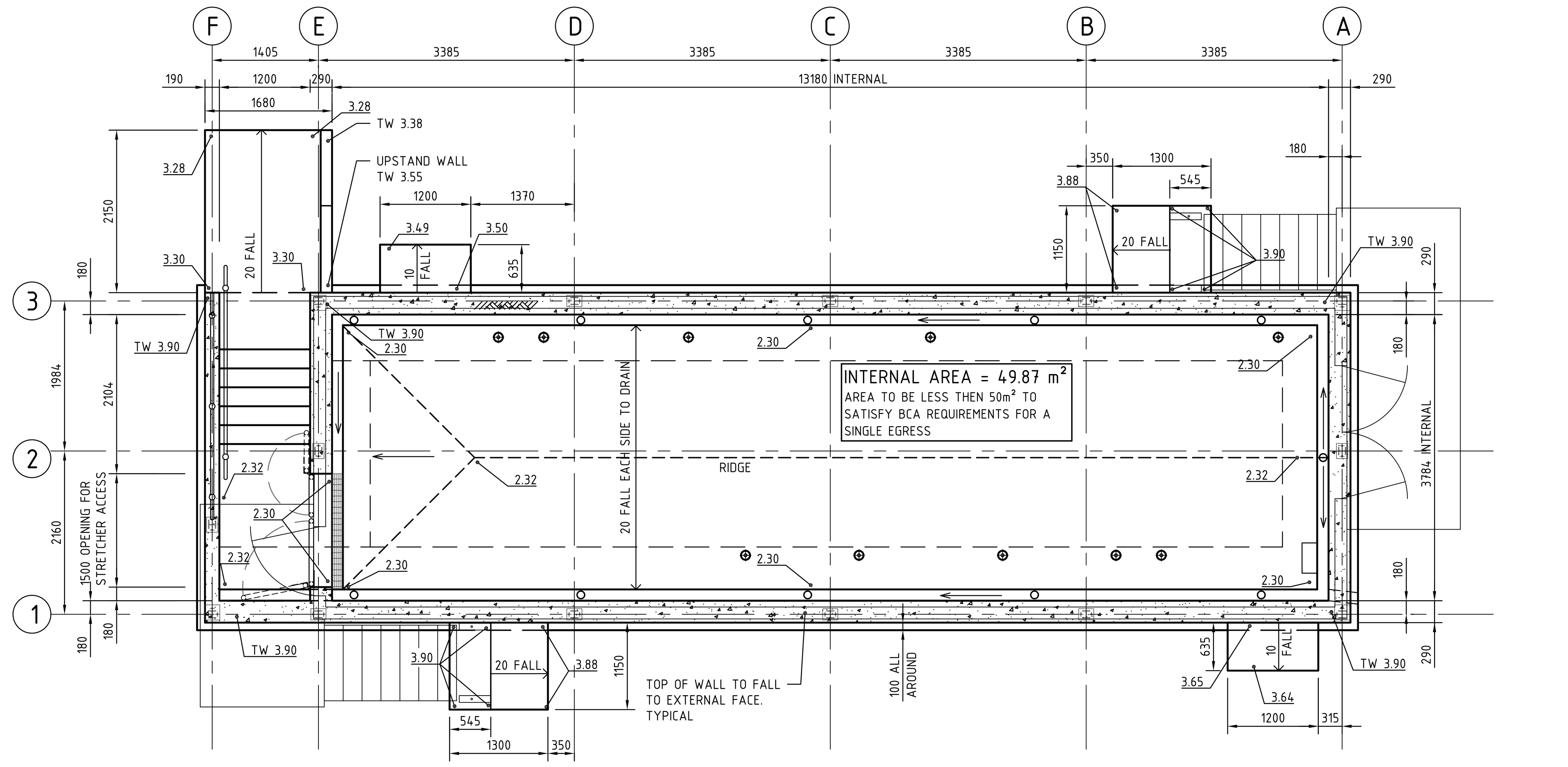
LAP BARS 650 WHERE REQ'D

2E DENOTES 2 x N16-100 EXTRA BARS BOTH FACES

FOR REINFORCEMENT DETAILS REFER TO DRG No. 252077
FOR WALL REINFORCEMENT DETAILS ON DRG No. 252077
FOR EARTHING DETAILS REFER TO DRG No.244800

CONSTRUCTION JOINT NOTE (NOTED C.J. ON DRAWINGS):

WHERE CONSTRUCTION JOINT NOTED REMOVE LAITANCE AND LIGHTLY SCABBLE SURFACE OF CONCRETE



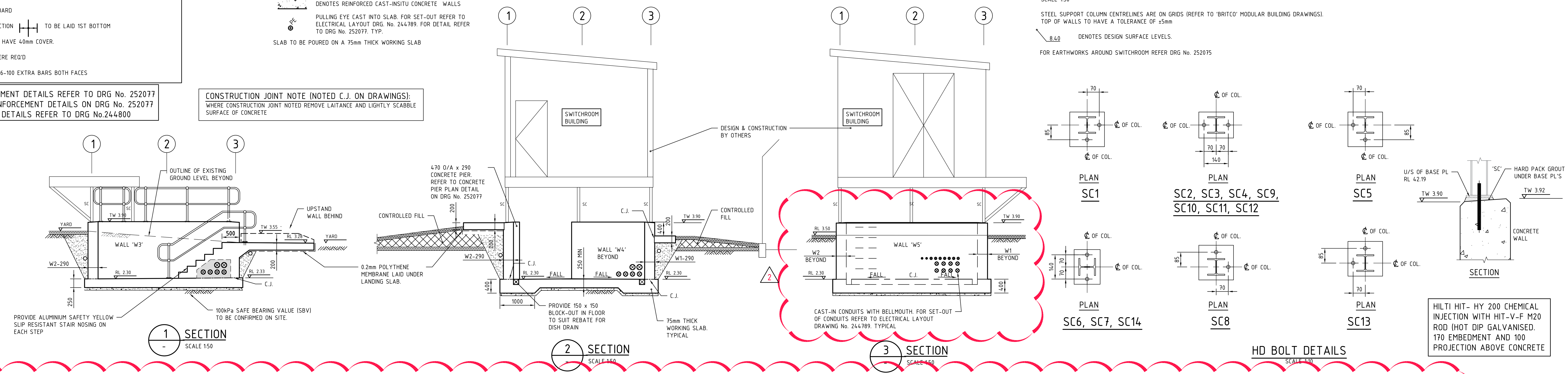
BASEMENT FLOOR SET-OUT PLAN

SCALE 1:50

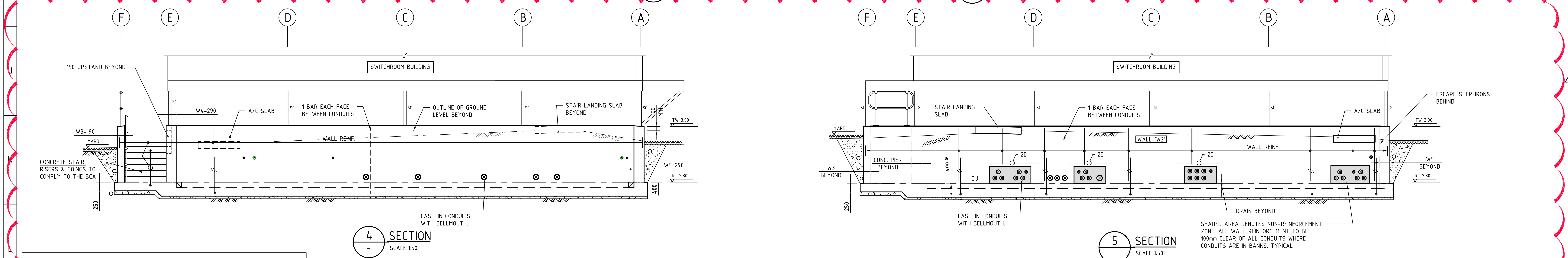
STEEL SUPPORT COLUMN CENTRELINES ARE ON GRIDS (REFER TO 'BRITCO' MODULAR BUILDING DRAWINGS). TOP OF WALLS TO HAVE A TOLERANCE OF ±5mm

8.40 DENOTES DESIGN SURFACE LEVELS.

FOR EARTHWORKS AROUND SWITCHROOM REFER DRG No. 252075



HILTI HIT- HY 200 CHEMICAL INJECTION WITH HIT-V-F M20 ROD (HOT DIP GALVANISED. 170 EMBEDMENT AND 100 PROJECTION ABOVE CONCRETE



FOR SAFETY AND CONSTRUCTION NOTES REFER TO DRAWING No. 252073

CAD DRAWING
DO NOT MANUALLY AMEND

AMENDMENTS

AMD	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY
0	07-11-2019	TENDER ISSUE	MARKO LJOLJIC	DAVID STANBURY	PAUL LOVARINI	KATINA GALLEN
1	10/03/2020	CONSTRUCTION ISSUE	M.LJOLJIC	D.STANBURY	P.LOVARINI	K.GALLEN
2	29/09/2020	CONDUIT LAYOUT ADJUSTED. ISSUED FOR CONSTRUCTION	M.LJOLJIC	D.STANBURY	P.LOVARINI	K.GALLEN

Ausgrid
24-28 Campbell Street
SYDNEY NSW 2000

ISSUED FOR
CONSTRUCTION ISSUE

SCALE	AS SHOWN
DESIGNED	DAVID STANBURY
DRAWN	MARKO LJOLJIC
CHECKED	PAUL LOVARINI
APPROVED	KATINA GALLEN
DATE	07-11-2019
TRIM REF	2019/441/2
PROJECT NUMBER	SJ-00278

ZN 228 STOCKTON - 33/11 kV SUBSTATION
11 kV SWITCHGEAR REPLACEMENT
CIVIL & STRUCTURAL WORKS
TRANSPORTABLE 11kV SWITCH BUILDING
SUPPORT STRUCTURE DETAILS - SHEET 1

DRAWING No 252076 | SHEET 1 | AMD 2 | SIZE B1

Appendix D

GBG Geophysical Report

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28/7 Salisbury Road,
Castle Hill, NSW. 2154.
Tel: (02) 9890 2122. Fax: (02) 9890 2922.
E-Mail: info@gbgoz.com.au
ABN 77 009 550 869

Report

VSP GEOPHYSICAL INVESTIGATION AT HEBDEN ROAD, MUSWELLBROOK NSW

Date: 20 November 2023

Job Number: GBGA2673

SHALLOW

GEOPHYSICAL

INVESTIGATIONS

DETAILS

Project Number:	GBGA2673
Document Title:	VSP Geophysical Investigation at Hebden Road, Muswellbrook NSW
Site Address:	Hebden Road, Muswellbrook, NSW
Client Details:	Name: Jeremy Hill Company: Douglas Partners Pty Ltd
Client Address:	15 Callistemon Close Warabrook, NSW
Contact Information:	Email: Adrian.Chaplin@douglaspartners.com.au M: 0475 727 914

DOCUMENT HISTORY

Revision	Prepared by	Reviewed by	Date issued
Draft	Prue Warner	Taylor Willick	24/10/23
1st	Eric Takam	Taylor Willick	01/11/23
2nd	Eric Takam	Taylor Willick	10/11/23
Final	Eric Takam	Taylor Willick	20/11/23

DISTRIBUTION

Revision	Electronic	Paper	Issued to	Date issued
Draft	1	0	Adrian Chaplin	24/10/23
1st	1		Adrian Chaplin	01/11/23
2nd	1		Adrian Chaplin	10/11/23
Final	1		Adrian Chaplin	20/11/23

Contents

**The conclusions drawn represent the best professional opinions of the authors, based on their experience in analysis of similar geophysical data and correlation with available subsurface information, obtained from previous geophysical investigations, test pits and boreholes carried out within or near to this investigation area.*

1 INTRODUCTION

At the request of Douglas Partners (DP), GBG Australia (GBGA) has conducted a geophysical investigation to assist in the geotechnical design parameters for the construction of the new Eastern Hub Sub-Transmission Substation at Hebden Road, Muswellbrook. Vertical Share wave and Seismic Profiling (VSP) of two Boreholes were conducted on the conducted-on the 12th of October 2023.

The data collected as part of this VSP investigation, is to assist in assessing the current geotechnical design parameters. The information includes determination of seismic compressional (P-) and shear (S-) wave velocities for calculating insitu modulus values at set intervals between the surface and the bottom of the core-holes. This report describes the data collection techniques and presents the results obtained from each core-hole.

1.1 Aim

To supply P- and S-wave velocity values following ASTM Standard D7400.29032-1, for input into geotechnical calculations to create a table of moduli against depth at each core-hole investigated.

2 GEOPHYSICAL INVESTIGATION SITE

The investigation area is located on Hebden Road, South-east of Muswellbrook NSW. The site was in a large flat paddock with minimal obstructions.

The two boreholes were prepared as requested by GBG – PVC cased, grouted, and with casings extending above the surface. The areas around the boreholes were clear of obstructions which allowed for easy positioning of the field vehicle and equipment.

The weather conditions during acquisition were quite windy. While wind typically does not have a significant direct effect on VSP data because VSP measurements are made deep within the Earth's subsurface, wind can indirectly affect VSP data in a couple of ways:

Surface Vibrations: While the seismic sensors used for VSP are typically placed deep into the ground or boreholes to minimize surface interference, strong winds can still induce surface vibrations that may propagate down to the sensor location. These vibrations can introduce noise into the VSP data, making it more challenging to interpret the subsurface structures accurately.

Signal-to-Noise Ratio: VSP data quality is critical for its interpretation. Wind-induced surface vibrations can increase the background noise level in the recorded signals. In some cases, this may affect the signal-to-noise ratio, making it more difficult to identify and interpret subsurface reflectors (first arrivals) accurately.

2.1 Location and Positioning

All GNSS data presented in this report is given in MGA2020 zone 56 (GDA2020). The coordinates of the boreholes were measured using an Emlid Reach RS2 multi-band, RTK-enabled GNSS receiver. Table 1 summarises the coordinates of the boreholes.

Figure 1: Sitemap showing location of the two boreholes.

Table 1: Locations of the measured boreholes

Hole ID	Easting (m)	Northing (m)	Elevation (m AHD)	Datum
BH21	312116.779	6418544.064	136.4	MGA2020 Zone 56
BH27A	312133.202	6418502.736	134.9	

3 DATA ACQUISITION

Vertical Seismic Profiling (VSP) is a technique used to evaluate subsurface seismic properties. It involves measuring the travel times of P- and S-waves between a surface source and receivers located at known depths within a borehole. By analysing these distances and times, the average velocity between the source and receiver can be determined. When combined with density information for subsurface materials, this data enables the calculation of dynamic modulus values along the borehole. VSP data is collected using a three-axis multi-component borehole geophone, which is connected to a digital seismograph recording device.

In the context of soft ground boreholes, it is customary to employ a PVC casing with screw threads, typically of HQ size, characterized by 5 mm thick walls and an internal diameter ranging between 65 mm and 85 mm. In scenarios involving hard ground, a protective casing is essential for the upper borehole segment, encompassing soft soils and weathered rock, to avoid borehole collapse. The data can be gathered in boreholes that are either dry or water-filled. This is facilitated by the unit's ability to secure itself to the borehole wall, allowing for the transmission of S-waves, which cannot travel through liquids.

3.1 Methodology

The VSP survey was undertaken using a Geometrics Geode digital seismograph, a Geostuff BHGC-1 Geophone Controller, and a BHG-3 Borehole Geophone. The BHG-3 Borehole Geophone is a 3-component borehole 14 Hz geophone with a motor-driven clamp mechanism to hold the geophone in place against the borehole wall. The geophone elements are oriented in the x, y and z planes with a flux-gate compass and servo mechanism which allows for alignment of the horizontal geophones along north-south and east-west respectively.

The investigation process consisted of using a wooden sleeper, laid on the ground a short distance from the borehole and oriented in a north-south direction (S-wave). The two front wheels of the vehicle were driven on top of the plank to ensure good coupling with the ground surface, and to maximise the shear wave energy transferred to the subsurface. A metal plate was placed near to the borehole (P-wave). The distance from the borehole to the centre of the wooden plank and borehole to the metal plate were recorded for distance and geometry calculations that were to be performed during processing.

The BHG-3 tool was lowered down the hole by the seismic cable using reference marks on the cable to monitor the depth of the sensor. When the bottom of the hole was reached, the tool was raised to the nearest metre, clamped against the borehole wall and the geophones were oriented north south. A sledgehammer with a piezo-electric trigger was used as the seismic source for both P- and S- Wave measurements. To produce the seismic P-wave data component, several impacts of a sledgehammer on the metal plate are shot and stacked, to enhance the signal to noise ratio.

To generate the seismic S-wave data component, multiple impacts of the sledgehammer on each side of the weighted wooden plank generating positive and negative energy, are conducted and the recorded. A typical field set up is shown below.

Figure 2: A typical VSP field equipment set up

Each seismic data record was collected with a record length of 0.512 s and a 31.25 µs sample interval. Readings were taken every 1 m until the last reading when the tool was 1 m below the ground surface or until coupling was no adequate to supply a seismic signal. Detailed acquisition parameters are summarised in table 2.

Table 2: Summary of VSP acquisition parameters

Parameter	BH-21	BH-27A
Max Depth	18.6m	18.75m
Record Length	0.512 s	0.512 s
Sample Interval	31.25 µs	31.25 µs
Depth Interval	1m	1m

These depths achieved do not agree with the termination depths of the supplied borehole logs. GBGA is unsure where this discrepancy has arisen. The borehole tool has distance markers on the cable. It's obvious when the probe has reached the bottom as it can be felt through the cable.

4 GEOPHYSICAL DATA QUALITY AND PROCESSING

4.1 Data Quality

The data quality was of deemed satisfactory across the two boreholes. The two main influences affecting the data were the wind and nearby train movement. To minimise interference from the trains, the timing of shots was planned in between passing trains to avoid any disturbance. There was some influence from wind gusts which were primarily associated with shallower depths.

4.2 Processing

Data was initially sorted to separate the P-wave recordings and the S-wave recordings before being processed in ReflexW v9.5 (KJ Sandmeier, 2020). Three channels of data were displayed for each shot. The first channel is the geophone oriented vertically, while channels 2 and 3 were oriented horizontally. Records from each P-wave shot for each hole were concatenated and the relevant channels (channel 1) containing the P-wave extracted. P-wave analysis involved simply picking the first arrival times ('break points') at each depth interval.

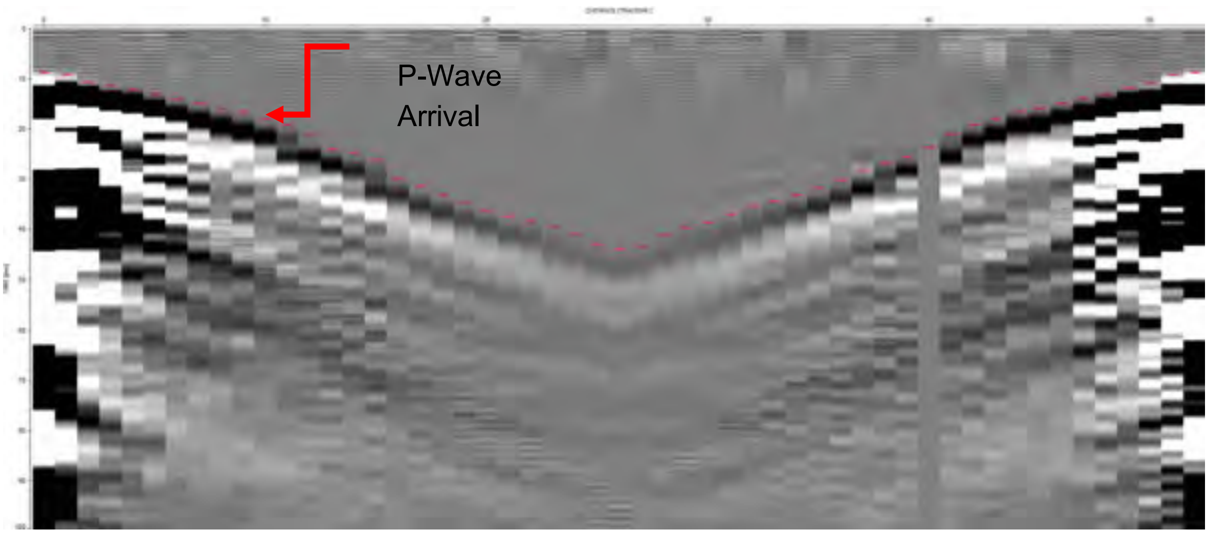


Figure 3: Example VSP data from the vertical geophone which was utilised to pick P-wave arrivals. This example shows shots taken from the top-down, then from the bottom-up.

As mentioned in Section 3.1, for a given depth interval, the 2nd and 3rd recordings correspond to the two opposing-polarity S-wave shots. Data from these records was overlaid to identify the time at which the S-wave signal shows as equal amplitude and opposite polarity on the data traces. The S-wave arrival time can then be picked. Average s-wave velocities are calculated using the determined arrival times and the corrected straight-line distance from the source to receiver.

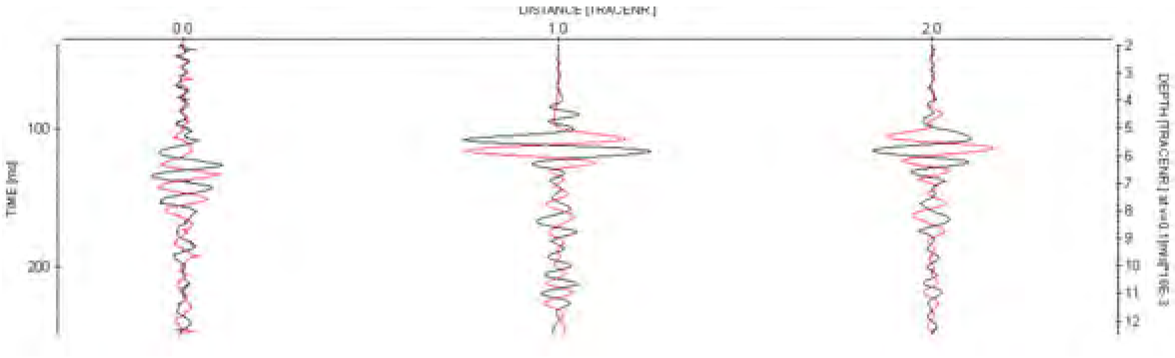


Figure 4: Example of the S-Wave channels of a single shot being overlain on one another (note that channel on shows data recorded by the vertical geophone).

P-wave and S-wave velocities were calculated from the picked P-wave and S-wave arrival times relevant to the known source-receiver distance. The velocities were utilised along with supplied material density to calculate Shear Modulus, Young's Modulus and Poisson's ratio.

Density estimates were provided by Douglas Partners Pty Ltd, and are based on their experience on previous projects in similar geology.

4.3 Determination of Engineering Parameters

The relationship between the P- and S-wave velocities with the elastic moduli and density are calculated using the equations below:

Bulk Modulus (k): $$k = \rho(V_p^2 - \frac{3}{4}V_s^2)$$

Shear Modulus (G): $$G = \rho V_s^2$$

Young's Modulus (E): $$\epsilon = \rho V_s^2 \frac{3V_p^2 - 4V_s^2}{V_p^2 - V_s^2}$$

Poisson's Ratio (v): $$\nu = \frac{V_p^2 - 2V_s^2}{2(V_p^2 - V_s^2)}$$

Where, Vs = S-Wave velocity (m/s), Vp = P-Wave velocity (m/s), ρ = material density.

(McDowekk, P.W. 1992. The determination of the dynamic elastic moduli of rock masses by geophysical methods. Pg. 166-167. Butterworth-Heinemann Ltd. Linacre House, Jordan Hill, Oxford.)

(Ogawa, T. 2016.Acoustic wave velocity measurements on Piezoelectric single crystals; In, Piezoelectric Materials, Chapter 3. DOI:10.5772/62711.)

5 RESULTS AND INTERPRETATION

The results of the geophysical investigation carried out Douglas Partners, have been provided in the following drawings attached in Appendix A of this report:

- GBGA2673_01 – SITE MAP
- GBGA2673_02 – VSP BH-21 Average Seismic Velocity Profiles
- GBGA2673_03 – VSP BH-27A Average Seismic Velocity Profiles
- GBGA2673_04 – VSP BH-21 Interval Seismic Velocity Profiles
- GBGA2673_05 – VSP BH-27A Interval Seismic Velocity Profiles

The VSP survey results are presented graphically and in tabular format within each drawing. The average seismic velocities gradually increase with depth. Simplified borehole logs have been overlaid on the graph with descriptions of each layer added. The results are of a standard quality to complete additional moduli calculations. GBG provides tabulated results of P and S-Wave velocities in addition to Shear Modulus, Youngs Modulus and Poisson's ratio. The density values have been approximately only.

6 CONCLUSIONS

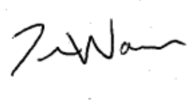
At the request of Douglas Partners, GBG completed a VSP geophysical survey of two boreholes near Muswellbrook NSW. The fieldwork was conducted on the 12th of October 20233.

The quality of data recorded during the investigation was generally observed to be suitable for interpretation.

The ratio of the P to S wave values is within the expected range. In addition, the gradual average increase in velocity is considered normal in relation to the geology and the observed material composition within the boreholes.

The techniques used during the investigation are of a geophysical nature and as such the processing, interpretation and results are based on indirect measurements of seismic wave signals. The findings in this report represent the best professional opinions of the authors, based on experience gained during previous similar investigations and with correlation to known and assumed subsurface ground conditions at the site.

For and on behalf of GBG Australia



Prudence Warner

Geophysicist

Appendix A - Drawings

MUSWELLBROOK VSP - GEOPHYSICAL INVESTIGATION

N

Borehole Location

SCALE

0 50 100

NOTES: Drawing to be used in conjunction with Report GBGA2673 Coordinates in MGA2020 Zone 56	CLIENT: DOUGLAS PARTNERS	DATE: 20 OCTOBER 2023	PROJECT MANAGER: ET
	TITLE: MUSWELLBROOK VSP - GEOPHYSICAL INVESTIGATION	SCALE: 1:2300	DRAWN: PW
		DRG No: GBGA2673_01	REV: FINAL

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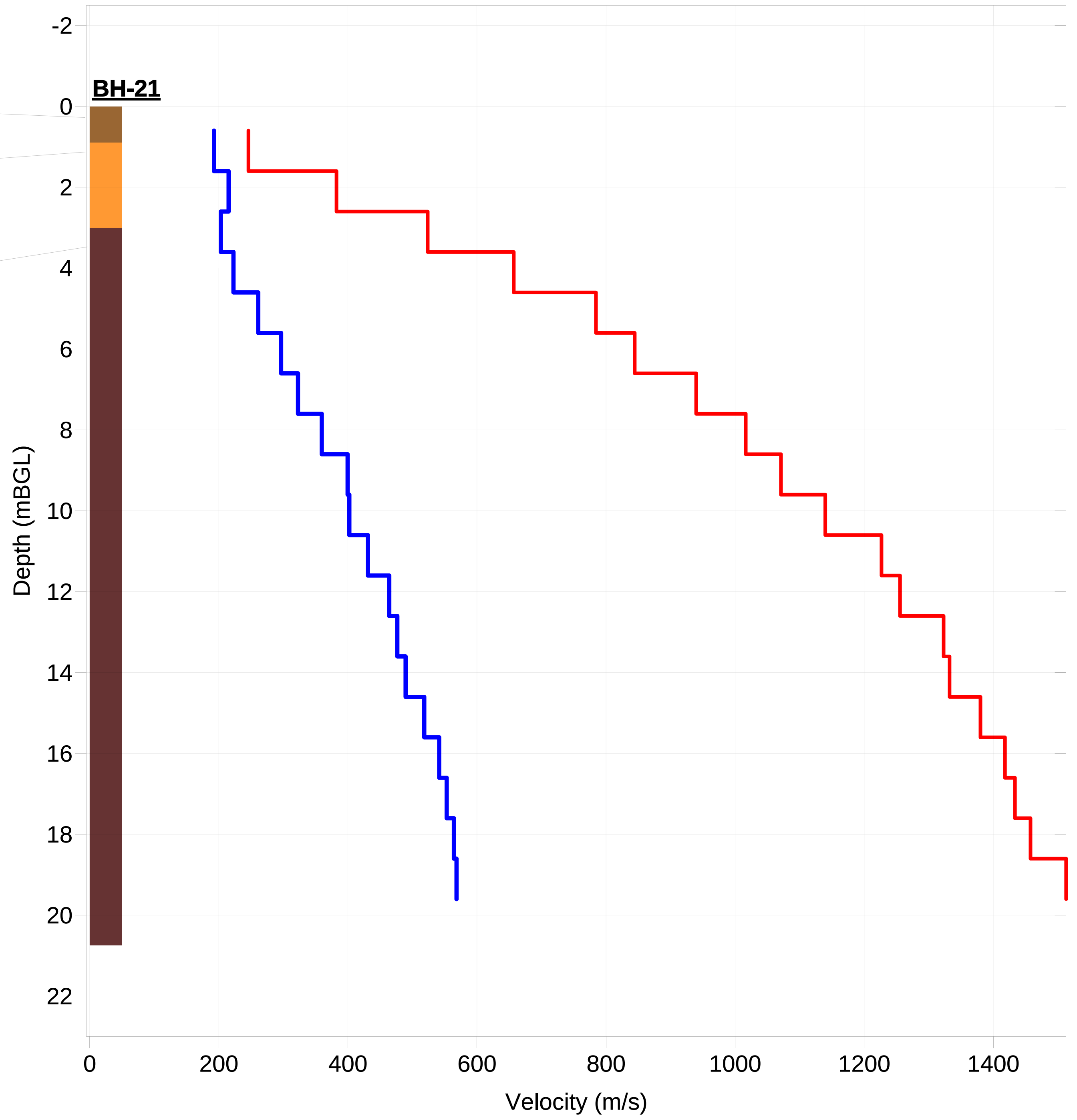
DOWNHOLE GEOPHYSICAL INVESTIGATION AT HEBDEN ROAD MUSWELLBROOK NSW
VERTICAL SEISMIC PROFILING
RESULTS AND BOREHOLE COMPARISON

SILTY CLAY
brown; medium plasticity.

SILTY CLAY
pale brown mottle grey and orange; medium plasticity

SILTSTONE
pale brown with orange brown iron staining. Highly weathered, becoming moderaly weathered at 6.05m.
Extremely weathere at 8.74 to 8.85m
Slightly weathered at 8.85 to 9.06
Fresh from 9.06 to termination depth.
Very low to low strength to 8.86m.
Medium to high strength from 8.96 to termination depth.

BH-21 AVERAGE SEISMIC VELOCITY PROFILES



LEGEND

S-Wave Velocity
P-Wave Velocity
Borehole Locations

BH-21

Average Dynamic Modulus								
True Depth (m)	P-wave Velocity Average (m/s)	S-wave Velocity Average (m/s)	Density	Vp/Vs	Shear Modulus	Bulk Modulus	Youngs Modulus	Poissons Ratio
0.60	245.93	192.60	1600.00	1.28	59.35	17.64	83.92	-0.29
1.60	382.38	215.22	1600.00	1.78	74.11	135.13	187.97	0.27
2.60	523.69	203.15	1600.00	2.58	66.03	350.76	186.40	0.41
3.60	657.02	222.75	2200.00	2.95	109.16	804.13	313.30	0.44
4.60	784.34	261.14	2200.00	3.00	150.03	1153.40	431.38	0.44
5.60	844.42	296.55	2200.00	2.85	193.48	1310.74	553.21	0.43
6.60	939.64	322.71	2200.00	2.91	229.11	1636.97	656.69	0.43
7.60	1016.44	359.50	2200.00	2.83	284.34	1893.80	812.35	0.43
8.60	1071.00	399.61	2200.00	2.68	351.32	2055.06	997.13	0.42
9.60	1139.69	402.26	2200.00	2.83	355.99	2382.89	1017.31	0.43
10.60	1226.77	431.08	2200.00	2.85	408.82	2765.85	1168.88	0.43
11.60	1255.47	464.11	2200.00	2.71	473.87	2835.82	1346.60	0.42
12.60	1322.99	476.61	2200.00	2.78	499.75	3184.35	1424.72	0.43
13.60	1332.20	489.46	2200.00	2.72	527.05	3201.75	1498.90	0.42
14.60	1380.11	518.33	2200.00	2.66	591.06	3402.25	1676.13	0.42
15.60	1418.05	541.54	2200.00	2.62	645.18	3563.65	1825.37	0.41
16.60	1433.50	553.09	2200.00	2.59	672.99	3623.50	1901.28	0.41
17.60	1457.64	564.23	2200.00	2.58	700.38	3740.56	1977.70	0.41
18.60	1512.84	568.34	2200.00	2.66	710.61	4087.64	2015.06	0.42

Note:

TITLE: DOWNHOLE GEOPHYSICAL INVESTIGATION AT HEBDEN ROAD MUSWELLBROOK NSW	
CLIENT: DOUGLAS PARTNERS	DATE: 19 OCTOBER 2023
SCALE: N/A / REV: FINAL	DATUM: GDA2020 MGA 56
P M: ET / DRAWN: PW, ET	DRG No: GBGA2673_02

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DOWNHOLE GEOPHYSICAL INVESTIGATION AT HEBDEN ROAD MUSWELLBROOK NSW
VERTICAL SEISMIC PROFILING
RESULTS AND BOREHOLE COMPARISON

SILTY CLAY
trace sand: brown; high plasticity; fine to coarse sand.

SILTY CLAY
trace sand: pale brown mottled orange grey: medium to high plasticity; fine to medium sand

SILTY CLAY
grey orange; medium plasticityl fine to medium sand.

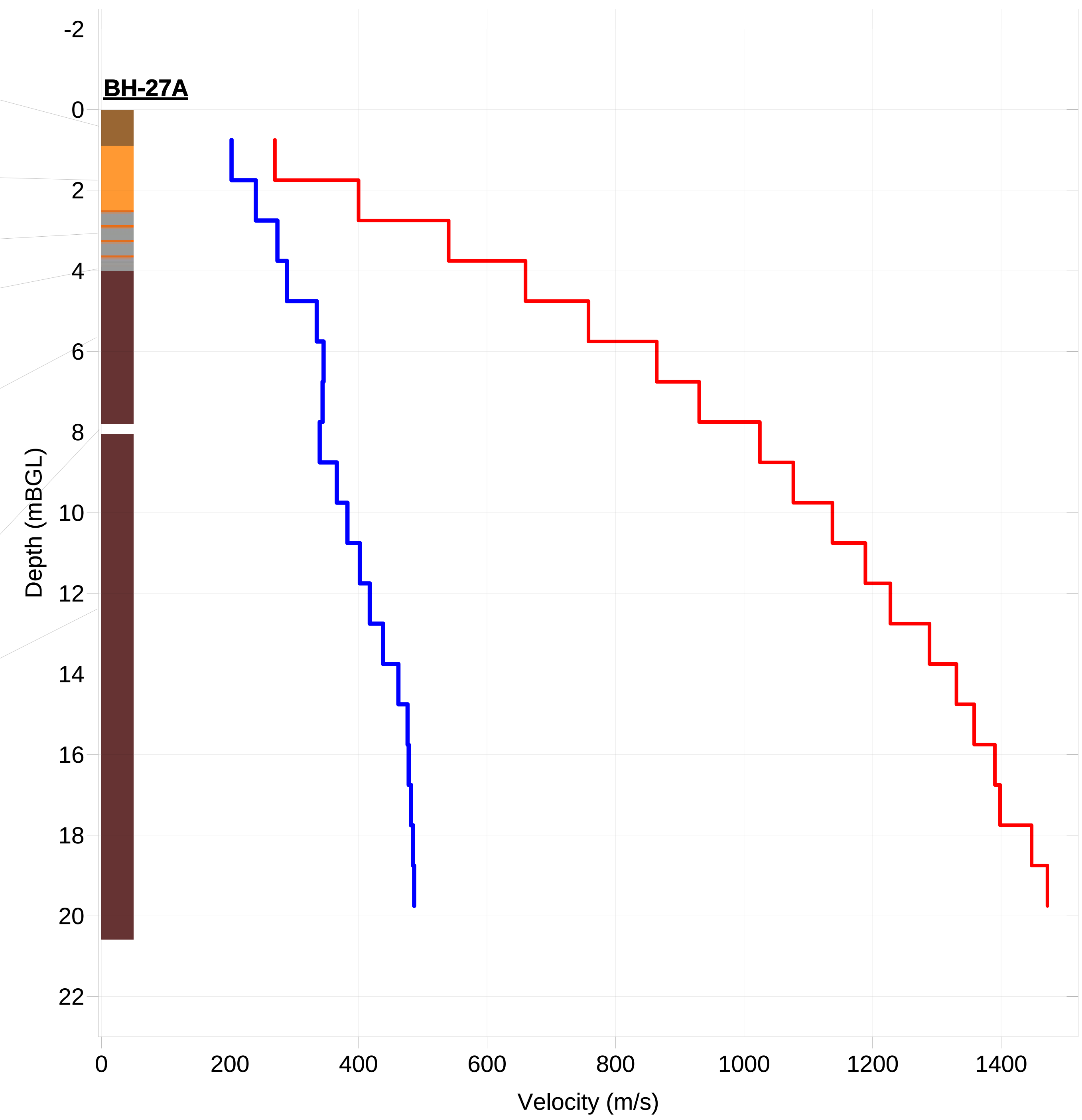
SILTY CLAY
grey mottled orange; medium plasticity fine to medium sand.

SILTSTONE
alternating exteremely to moderately weathred from 4.70m to 8.34m.
Exteremely to Moderate to slightly weathred from 8.34 to 9.43m.
Slightly weathered to fresh at 9.43m to 10.65.
Generally all Very Low to Low Strength

CORE LOSS
No Recovery from 10.87 to 11.00m

SILSTONE
grey fresh from 11.17m to 15.80m;
dark grey from 15.80m to terminantion;
Medium to high strength

BH-27A AVERAGE SEISMIC VELOCITY PROFILES



LEGEND

- S-Wave Velocity
- P-Wave Velocity
- Borehole Locations

BH-27A

Average Dynamic Modulus								
True Depth (m)	P-wave Velocity Average (m/s)	S-wave Velocity Average (m/s)	Density	Vp/Vs	Shear Modulus	Bulk Modulus	Youngs Modulus	Poissons Ratio
0.75	270.00	202.53	1600.00	1.33	65.63	29.13	112.44	-0.14
1.75	400.15	240.25	1600.00	1.67	92.35	133.05	225.00	0.22
2.75	540.35	273.92	1600.00	1.97	120.05	307.10	318.63	0.33
3.75	659.94	288.64	1600.00	2.29	133.30	519.09	368.38	0.38
4.75	757.90	335.09	2200.00	2.26	247.03	934.34	681.06	0.38
5.75	864.14	345.76	2200.00	2.50	263.01	1292.14	738.89	0.40
6.75	930.18	344.14	2200.00	2.70	260.54	1556.12	740.31	0.42
7.75	1024.57	339.70	2200.00	3.02	253.87	1970.94	734.16	0.44
8.75	1076.68	366.37	2200.00	2.94	295.30	2156.59	847.23	0.43
9.75	1137.52	382.88	2200.00	2.97	322.51	2416.69	926.32	0.44
10.75	1188.79	402.12	2200.00	2.96	355.75	2634.78	1021.28	0.44
11.75	1227.67	417.58	2200.00	2.94	383.62	2804.27	1100.67	0.43
12.75	1288.49	438.36	2200.00	2.94	422.75	3088.79	1212.92	0.43
13.75	1330.45	462.16	2200.00	2.88	469.90	3267.66	1345.21	0.43
14.75	1358.07	476.43	2200.00	2.85	499.36	3391.75	1428.00	0.43
15.75	1390.27	478.14	2200.00	2.91	502.95	3581.67	1441.39	0.43
16.75	1398.32	481.70	2200.00	2.90	510.47	3621.02	1462.67	0.43
17.75	1447.41	484.89	2200.00	2.99	517.26	3919.33	1486.38	0.44
18.75	1472.05	486.67	2200.00	3.02	521.07	4072.45	1499.28	0.44

Note:

TITLE: DOWNHOLE GEOPHYSICAL INVESTIGATION AT HEBDEN ROAD MUSWELLBROOK NSW		
CLIENT: DOUGLAS PARTNERS		DATE: 19 OCTOBER 2023
SCALE: N/A	REV: FINAL	DATUM: GDA2020 MGA 56
P M: ET	DRAWN: PW, ET	DRG No: GBGA2673_03

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BH-21

BH-21 Interval Dynamic Modulus								
True Depth (m)	P-wave Velocity (m/s)	S-wave Velocity (m/s)	Density	Vp/Vs	Shear Modulus	Bulk Modulus	Youngs Modulus	Poissons Ratio
0.60			1600.00					
	3743.87	376.45		9.95	226.75	22124.22	677.92	0.49
1.60			1600.00					
	2335.05	172.58		13.53	47.65	8660.38	142.70	0.50
2.60			1600.00					
	2587.07	343.45		7.53	259.51	14378.48	773.88	0.49
3.60			2200.00					
	3083.34	1067.08		2.89	2505.05	17575.33	7174.30	0.43
4.60			2200.00					
	1335.06	1018.30		1.31	2281.26	879.55	3670.46	-0.20
5.60			2200.00					
	2685.35	701.53		3.83	1082.72	14420.80	3168.87	0.46
6.60			2200.00					
	2263.55	1831.39		1.24	7378.80	1433.61	8151.38	-0.45
7.60			2200.00					
	1829.61	3688.35		0.50	29928.67	-32540.49	129482.67	1.16
8.60			2200.00					
	2582.14	427.64		6.04	402.33	14131.90	1195.64	0.49
9.60			2200.00					
	4739.29	1487.69		3.19	4869.06	42921.79	14074.97	0.45
10.60			2200.00					
	1674.09	2796.70		0.60	17207.35	-16777.48	78437.95	1.28
11.60			2200.00					
	3559.72	700.57		5.08	1079.76	26437.82	3195.79	0.48
12.60			2200.00					
	1461.13	748.45		1.95	1232.38	3053.59	3258.74	0.32
13.60			2200.00					
	2714.60	2810.17		0.97	17373.50	-6952.73	311976.12	7.98
14.60			2200.00					
	2376.04	1607.43		1.48	5684.42	4841.04	12256.15	0.08
15.60			2200.00					
	1728.48	834.17		2.07	1530.85	4531.70	4127.76	0.35
16.60			2200.00					
	2026.17	852.43		2.38	1598.59	6900.33	4451.98	0.39
17.60			2200.00					
	4564.46	652.79		6.99	937.50	44585.49	2792.93	0.49
18.60			2200.00					

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BH-27A

BH-27A Interval Dynamic Modulus								
True Depth (m)	P-wave Velocity (m/s)	S-wave Velocity (m/s)	Density	Vp/Vs	Shear Modulus	Bulk Modulus	Youngs Modulus	Poissons Ratio
0.75			1600.00					
	1879.21	661.87		2.84	700.92	4715.71	2003.50	0.43
1.75			1600.00					
	2407.19	496.89		4.84	395.04	8744.62	1167.55	0.48
2.75			1600.00					
	2050.91	361.35		5.68	208.91	6451.39	620.05	0.48
3.75			1600.00					
	1857.79	1217.53		1.53	3261.26	3244.69	7328.47	0.12
4.75			2200.00					
	2812.77	416.90		6.75	382.37	16895.91	1138.51	0.49
5.75			2200.00					
	1696.56	334.31		5.07	245.88	6004.43	727.69	0.48
6.75			2200.00					
	3404.16	309.83		10.99	211.19	25212.76	631.79	0.50
7.75			2200.00					
	1795.51	1025.47		1.75	2313.51	4007.83	5820.57	0.26
8.75			2200.00					
	2277.72	648.66		3.51	925.66	10179.40	2695.28	0.46
9.75			2200.00					
	2137.67	813.53		2.63	1456.04	8111.78	4121.52	0.42
10.75			2200.00					
	1901.67	724.95		2.62	1156.23	6414.37	3272.07	0.41
11.75			2200.00					
	3113.76	1089.52		2.86	2611.53	17848.01	7470.24	0.43
12.75			2200.00					
	2284.52	1567.41		1.46	5404.92	4275.29	11407.54	0.06
13.75			2200.00					
	1904.50	837.89		2.27	1544.55	5920.28	4262.93	0.38
14.75			2200.00					
	2143.23	505.28		4.24	561.67	9356.68	1651.97	0.47
15.75			2200.00					
	1539.21	546.56		2.82	657.19	4335.88	1876.75	0.43
16.75			2200.00					
	3531.25	546.17		6.47	656.27	26558.34	1952.71	0.49
17.75			2200.00					
	2112.03	521.09		4.05	597.37	9017.00	1753.38	0.47
18.75			2200.00					

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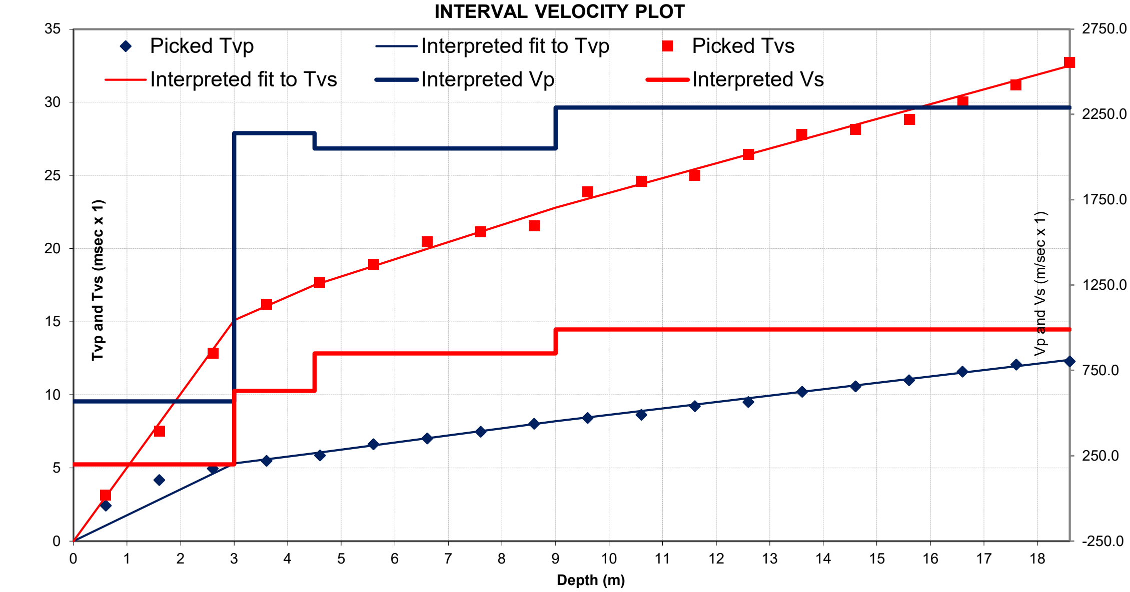
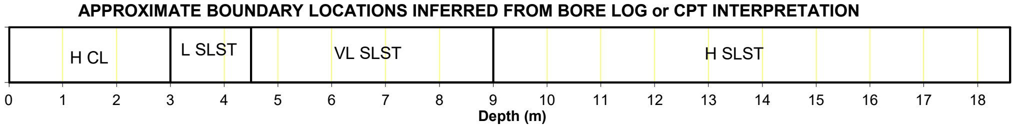
Appendix E

Interpreted Downhole P and S Wave Logs

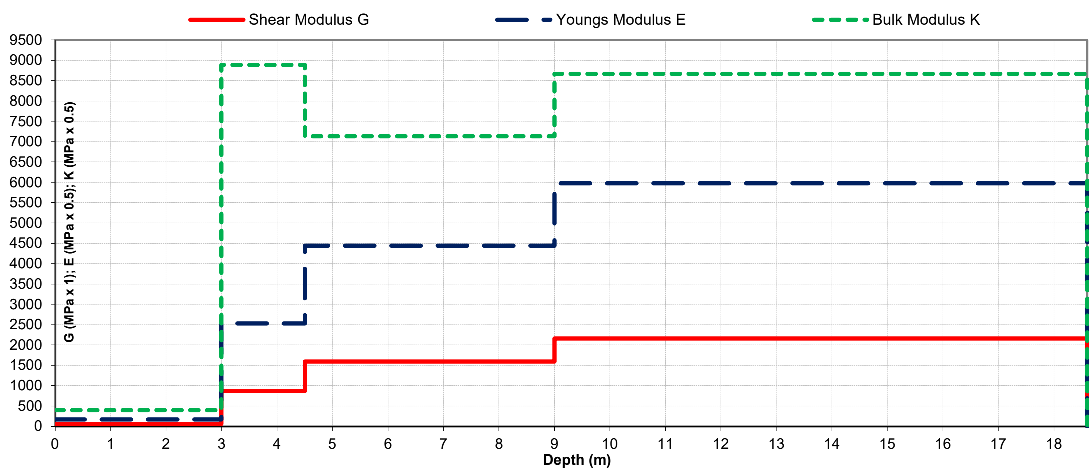
INTERVAL VELOCITY PLOT



APPROXIMATE BOUNDARY LOCATIONS INFERRED FROM BORE LOG or CPT INTERPRETATION



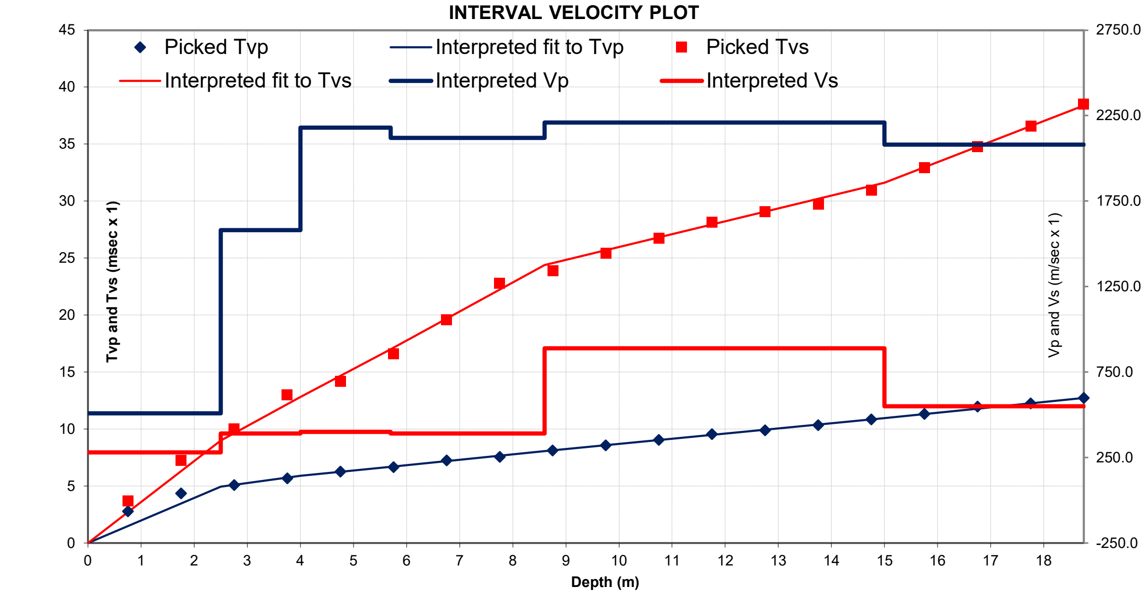
DYNAMIC ELASTIC MODULI

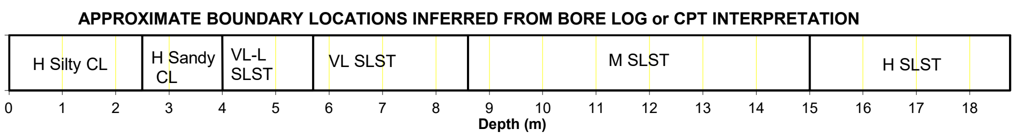


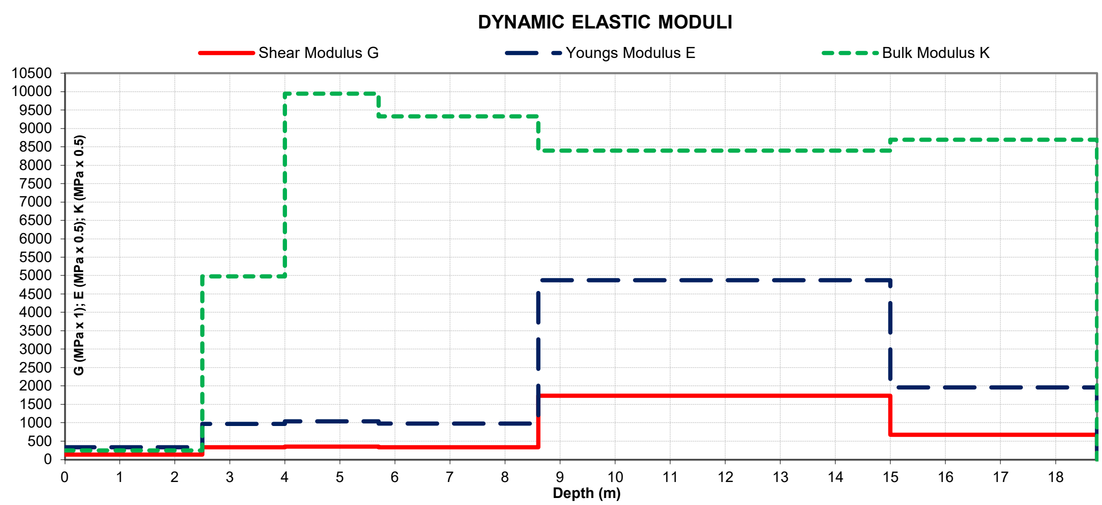
SUMMARY OF P & S WAVE INTERPRETATION

Depth Zone		Velocities		Poisson's	Bulk	Dynamic Elastic Moduli		
From	To	Vp	Vs	Ratio (r)	Density	Shear	Young's	Bulk
(m)	(m)	(m/sec)	(m/sec)	(calculated)	(t/m3)	(MPa)	(MPa)	(MPa)
0.00	3.00	570	200	0.43	1.60	60	170	400
3.00	4.50	2140	630	0.45	2.20	870	2530	8890
4.50	9.00	2050	850	0.40	2.20	1590	4440	7130
9.00	18.60	2290	990	0.39	2.20	2160	5980	8670
Weighted averages:		1940	790	0.40	2.10	1570	4390	6980

Douglas Partners	P&S Log: BH21	PROJECT: 224764.00
Geotechnics / Environment / Groundwater	CLIENT: Ausgrid	DATE: 15-Nov-23







SUMMARY OF P & S WAVE INTERPRETATION

Depth Zone		Velocities		Poisson's	Bulk	Dynamic Elastic Moduli		
From	To	Vp	Vs	Ratio (r)	Density	Shear	Young's	Bulk
(m)	(m)	(m/sec)	(m/sec)	(calculated)	(t/m3)	(MPa)	(MPa)	(MPa)
0.00	2.50	510	280	0.28	1.60	130	330	250
2.50	4.00	1580	390	0.47	2.20	330	970	4980
4.00	5.70	2180	400	0.48	2.20	350	1040	9950
5.70	8.60	2120	390	0.48	2.20	330	980	9330
8.60	15.00	2210	890	0.40	2.20	1740	4880	8400
15.00	18.75	2080	550	0.46	2.20	670	1960	8690
18.75								
Weighted averages:		1890	570	0.42	2.12	850	2420	7380

Douglas Partners
Geotechnics | Environment | Groundwater

P&S Log:	BH27A	PROJECT:	224764.00
CLIENT:	Ausgrid	DATE:	15-Nov-23

Douglas Partners

Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on Geotechnical Investigation

Proposed Muswellbrook Substation
20 Sandy Creek Road, Muswellbrook

Prepared for
Ausgrid

Project 224763.00
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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

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1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed new substation adjacent to the existing Muswellbrook substation at 20 Sandy Creek Road, Muswellbrook. The investigation was commissioned in an email dated 8 September 2023 by Paul Hurst / Sulev Kalamae of Ausgrid and was undertaken in accordance with Douglas Partners Pty Ltd proposal 224763.00 dated 22 August 2023 .

It is understood that the proposed development of the site includes a new 132 kV Sub-Transmission Substation. The proposed development is outlined in Section 2 of this report.

The purpose of the investigation was to provide information and comments on the following:

- A summary of investigation methods;
- Borehole logs and core photos (if required) as well as test location plan;
- Test Pit / Costean (Trench) Pit logs;
- Summarised subsurface conditions, noting rock and groundwater depths, if encountered;
- Soil aggressivity of buried structural elements with reference to AS 2159 (2009);
- Soil erosion and dispersion characteristics, as well as methods to deal with problem soils and suitable construction methods;
- Excavation conditions (to the depth of investigation);
- Safe batter slopes and temporary support for excavations;
- Geotechnical suitability of excavated material for re-use as filling;
- Site classification with reference to AS 2870 (2011) and characteristic surface movement (y_s);
- Shallow (pads / strips) and reinforced slab foundation options if suitable, including founding depths and design parameters (e.g. allowable bearing pressures);
- Bored pile founding depths and end bearing capacity design parameters;
- Retaining wall design parameters (Bulk density, Ka, Ko and Kp values);
- Design subgrade California Bearing ratio (CBR);
- Flexible and rigid pavement thickness design in accordance with relevant Austroads guidelines for the proposed transformer driveway;
- Earthworks preparation measures (fill layer thickness and compaction requirements); and
- Identification of the location of underground mines, and mine subsidence restrictions imposed by Subsidence Advisory NSW (SA NSW), if present.

The investigation included the drilling of 17 boreholes, the excavation of two costeans which comprised logging of up to 18 test pits within the costeans, and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the items listed above.

DP has undertaken a preliminary contamination and waste classification assessment (DP 2023) in conjunction with the geotechnical report, which is reported separately to this report. DP (2023) indicates the presence of contamination within the filling, and should be read in-conjunction with this report. The results of the test pits logs within the costeans are presented in this report for information purposes.

2. Site Description

The site located at 20 Sandy Creek Road, Muswellbrook. The overall lot contains grassed paddocks and an existing Ausgrid substation.

This proposed development site as defined by DP is termed 'the site' for the purpose of this report and is shown in Test Location Plan, Drawing 1, within Appendix C. Site identification details are outlined in Table 1 below.

Table 1: Site Identification

Item	Details
Allotment Identification	Part Lot 12 Deposited Plan 839233
Street Address	20 Sandy Creek Road
Locality	Muswellbrook
Site Area	3.8 ha
Local Government Area	Muswellbrook Shire Council
Current Land Use	Existing Substation

The site is located to the south of the existing substation. The northern part the site was formerly occupied by Muswellbrook Power Station which is understood to have been demolished in the mid to late 1990s. The northern part of the site, in the area where the former Power Station was located, appears to be filled. It appears the Power Station area was terraced to allow construction of the Power Station, then backfilled to 'cap' demolish waste associated with the removal of the Power Station. The southern part of the site surface appears to have been disturbed and is likely to have had topsoil and near surface soils stripped.

The site typically slopes from the south (RL 196 AHD) to the north (RL 176 AHD) with localised disturbance in the northern part of the site.

Observed surface features include earth mounded drainage bunds, disturbed areas in the northern part of the site, and localised fibro materials, as presented on Drawing 1, which is attached within Appendix C. Site vegetation comprised sparse semi-mature trees and limited grass cover.

3. Published Data

NSW Hunter Coalfield Regional geology 1:100,000 plan indicates that the site is underlain by the Branxton Formation, which is part of the Permian aged Maitland Group, comprising, conglomerate, sandstone and siltstone.

Reference to published mapping indicates that the site outside mapped acid sulfate soil (ASS) areas.

The site is located within a proclaimed mine subsidence district.

4. Proposed Development

Based on conversations with Ausgrid it is understood that the proposed new works are to be located to the south of, and outside of, the existing substation. The proposed development is further understood to comprise:

- An outdoor switch yard;
- Prefabricated single storey metal clad and steel framed building;
- Mobile Equipment Room or 'MER' to be installed on top of foundations;
- Associated electrical infrastructure works may include either a new or a modified concrete slab, some steelwork, framed cable support structures and a number of in-ground conduit banks and possibly concrete cable jointing pits;
- Retaining walls up to 2 m in height;
- Buried pipes and electrical services;
- Hardstand pavement across switch yard;
- Associated exit/entry pavement.

The client provided a typical design drawing of a substation switchgear replacement, which is proposed at the site, and which is titled "ZN 228 Stockton – 33/11kV Substation 11 kV Switchgear Replacement Civil & Structural Works Transportable 11 kV Switch Building Support Structure Details – Sheet 1", and the drawing has been attached for information within Appendix C.

No structural loads were provided to DP at the time of this report.

The preferred location for the development within the site is understood to be in the northern part of the site adjacent to the existing substation. It is noted, however, that the southern part of the site is also a possible location for the development. Both parts of the site are understood to be under consideration.

5. Field Work

5.1 Field Work Methods

Field work for the investigation was undertaken in the period of the 18 to 25 September 2023 and comprised the following:

- A site walkover by geotechnical engineer to set out test locations in areas accessible and free from buried services. The test locations were nominated by the client and DP;
- Excavation of Costean 101 and Costean 102, which were excavated using a 20 tonne excavator fitted with a 450 mm wide bucket. The Costeans were excavated up to 2 m depth for the purpose of assessing contamination in the filling and were aligned as follows:
    - Costean 101 was excavated in the north-south alignment and was approximately 50 m in length. Pits 101-1 to 101-6 were recorded within Costean 1; and
    - Costean 102 was excavated in the east-west alignment and was approximately 100 m in length. Pits 102-1 to 102-12 within Costean 2.
- Drilling of 17 bores (Bores 1 to 17) using a purpose built geotechnical drilling rig. The bores were drilled to depths ranging from 1.12 m to 10 m depth, using solid flight auger, rotary and NMLC coring methods;
- Installation of two piezometers (Bores 4 and 6) up to 10 m depth for the purpose of enabling groundwater level measurement;
    - Screens were installed at depths from 1.6 m to 4.6 m and 7 m to 10 m, in Bores 4 and 6 respectively;
    - The piezometers were purged after installation and groundwater readings conducted on 27 September 2023.
- Thermal resistivity in-situ testing and laboratory testing was undertaken at selected depths and test locations. Further methods on field testing and laboratory testing is outlined in Section 7.11 of this report;
- The test locations were set out by a geotechnical engineer from DP who also logged the subsurface profile at each test location and collected samples for identification and laboratory testing purposes. In-situ testing in the soil profile comprised pocket penetrometer testing at selected locations;
- The test locations were recorded using a differential GPS and are considered accurate to ±0.10 m, depending on satellite coverage, and the results are documented on the Test Pit and Borehole Logs attached. The location of the tests are shown on Drawing 1 in Appendix C.

5.2 Field Work Results

The subsurface conditions encountered at the test locations are presented in detail in the Test Pit logs and Borehole logs included in Appendix A. These should be read in conjunction with the general notes preceding them, which explain the descriptive terms and classification methods used in the reports.

The subsurface conditions encountered within the test locations have been categorised into broad geotechnical units according to their inferred geological origin, as follows:

- Unit 1 - Fill; The fill generally comprised gravelly sand/sandy gravel/sandy clay fill with various inclusions such as concrete and brick and brick fragments, metal bars, concrete reinforcement, wire, tiles, ceramic, concrete pipes, timber, metal plates, metal sheeting, steel beams, rubber, rubber hoses (with possible asbestos containing material inserts), cables, and fibre cement sheeting fragments (possible asbestos containing material);
- Unit 1A – Fill/Old Footings: Old concrete footings and possible slab foundations were encountered at the base of filling. The dimensions and full extent of footings are unknown;
- Unit 2 - Topsoil (organics and silts):
- Unit 3: Residual soils;
    - Unit 3A (Silty Clay or Sandy Clay): Typically very stiff to hard in consistency;
    - Unit 3B (Sand): Typically dense sand, likely originated from extremely weathered sandstone;
- Unit 4 Rock: Sandstone and Siltstone:
    - Unit 4A - Extremely weathered material (soil like properties);
    - Unit 4B - Very low strength;
    - Unit 4C - Low and Medium strength;
    - Unit 4D – High and Very High strength.

The predominant subsurface conditions encountered within the bores are summarised in Table 2 below, and the results of the pits are also summarised below:

Table 2 - Summary of Boreholes

Borehole		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
RL (AHD)		175.8	174.5	175	176.5	178.7	179.6	178	179.5	183	183.7	183.7	183.3	185.1	188.2	188.5	183	181.7
Material Description	Unit	Depth Range (m)																
Fill	1	NE	NE	0.0 - 1.10	NE	NE	NE	0.0 - 3.2	0.0 - 0.5	NE	NE	NE	0.0-0.55	NE	NE	NE	0.0 - 1.1	0.0 - 1.0
Fill/Old Footings	1A	NE	NE	1.10 - 1.12	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Topsoil (organics and silt)	2	0.0 - 0.03	0.0 - 0.03	NE	0.0 - 0.03	0.0 - 0.03	0.0 - 0.03	NE	NE	0.0 - 0.03	0.0 - 0.03	0.0 - 0.03	NE	0.0 - 0.03	0.0 - 0.03	0.0 - 0.03	NE	NE
Sandy Clay – Typically VST to H	3A	0.03 - 3.45	0.03 - 2.05	NE	0.03 - 4.66	0.03 - 2.05	0.03 - 3.8	NE	0.5 - 3.45	0.03 - 2.3	0.03 - 1.85	0.03 - 2.16	0.55 - 3.9	0.03 - 3.5	0.03 - 2.66	0.03 - 1.0	1.1 - 2.78	1.0 - 2.64
Clayey Sand / Sand with Clay (Typically D to VD)	3B	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Sandstone (Pebbly) (Extremely Weathered Material)	4A	NE	2.05 - 2.12	NE	NE	NE	3.8 - 4.02	3.2 - 3.45	3.45 - 3.5	2.3 - 2.4	1.85-3.42[c]	NE	NE	3.5 - 4.3	NE	1.0 - 2.57	NE	NE
Sandstone (Pebbly) (Typically VLS to LS)	4B	7.0 - 7.74	NE	NE	NE	2.05 - 2.72	4.02 - 4.33	3.45 - 4.01	NE	NE	3.42 - 4.8[a]	2.16 - 4.32	3.9 - 4.22	4.30 - 6.92[a]	2.66 - 3.15[a]	2.57 - 5.25[a]	NE	NE
Sandstone (Pebbly) (Typically LS to MS)	4C	3.45 - 7.0 7.74 - 8.25	2.12 - 8.55[a]	NE	8.29 -10.0	NE	4.33 - 10.0[a]	NE	NE	NE	4.8 - 10.0	4.32 - 6.35[d]	NE	6.92 - 10.0	3.15 - 10.0[d]	5.25 - 10.0	NE	NE
Sandstone (Pebbly) (Typically HS to VHS)	4D	8.25 - 10.0	8.55 - 10.0	NE	4.66 - 8.29[b]	NE	NE	NE	NE	NE	NE	6.35 - 10.0	NE	NE	NE	NE	NE	NE

Notes to Table:

NE – Not encountered

NFGWO – No free groundwater observed

a – with some weak zones; b – with some core loss and low strength seams; c – with some very Low strength seams; d - with some high strength seams

The costeans recorded the following general sub-surface profile:

Fill (Unit 1 / 1A)	Generally comprising gravelly sand/sandy gravel/sandy clay fill with various inclusions such as concrete and brick and brick fragments, concrete footings / slabs, metal bars, concrete reinforcement, wire, tiles, ceramic, concrete pipes, timber, metal plates, metal sheeting, steel beams, rubber, rubber hoses (with possible asbestos containing material inserts), cables, concrete slabs and fibre cement sheeting fragments (possible asbestos containing material). Fill was encountered along the entire length of Costeans. Costean 101 encountered filling from GL (0.0 m) to depths ranging from 0.9 m to 2.0 m, noting Pit 101-1 was terminated in fill at 2.0 m depth. Footings / concrete (Unit 1A) were encountered in Pits 101-11 (1.3 m), 101-2 (1.3 m), and 101-3 (1.2 m). Costean 102 encountered fill from GL (0.0 m) to depths ranging from 0.85 m to 1.9 m. Footings / concrete were encountered in Pits 102-7 (1.0 m), 102-9 (1.0 m) and 102-11 (0.9 m).
Sandy Clay/Clayey Sand (Unit 3):	Encountered at various locations along each costean from depths of 0.8 m / 1.9 m to depths of 1.2 m to 2.2 m, and below Unit 1/1A.
Sandstone (Unit 4):	Encountered at various locations within Costean 102 (102-1, 102-2, 102-3, 102-8, 102-10 and 102-12) at depths of 1.2 m to 2.1 m below ground level to termination.

5.3 Groundwater

No free groundwater was observed during the period the pits remained opened. Similarly, no free groundwater was observed during the auger drilling of the bores. Both piezometers did not contain groundwater upon initial groundwater measurement on 27 September 2023.

It should be noted that groundwater levels are affected by factors such as climatic conditions and soil permeability and will therefore vary with time.

6. Laboratory Testing

6.1 Geotechnical Laboratory Testing

The detailed geotechnical laboratory testing results are attached within Appendix B, and a summary of tests undertaken are summarised below.

Table 3: Shrink Swell and Atterberg Limits

Bore	Depth (m)	Description	FMC (%)	LL (%)	PL (%)	PI (%)	Shrink (%)	Swell (%)	I_{SS} (% per ΔpF)	PP before soaking (kPa)	PP after soaking (kPa)
1	0.5 - 0.85	Sandy Clay	11.4	-	-	-	1.2	4.7	2.0	>600	310
5	0.5 - 0.86	Sandy Clay	16.9	-	-	-	2.5	6.9	3.3	>600	230
14	0.5 - 0.81	Sandy Clay	-	46	21	25	-	-	-	-	-
16	1.5 - 1.73	Sandy Clay	10.9	-	-	-	0.9	5.3	2.0	>600	340

Notes to table:
FMC – Field Moisture Content
LL – Liquid Limit
PL – Plastic Limit
I_{SS} – Shrink Swell Index
PP – Pocket Penetrometer Reading

Table 4: Moisture Content Determination and California Bearing Ratio

Bore	Depth (m)	Description	FMC (%)	MDD (t/m^3)	OMC (%)	CBR (%)	Swell (%)
1	0.0 - 0.5	Sandy CLAY	13.3	1.63	19.5	4.0	1.5
5	0.0 - 0.5	Sandy CLAY	10.2	1.83	14.5	6	1.5
8	0.0 - 0.5	FILL: Clayey SILT with Sand and Gravel	9.0	1.81	13.5	6	0.5
9	0.0 - 0.5	Sandy CLAY	8.3	1.77	15.0	7	0.0
12	0.55 - 1.05	Sandy CLAY	7.8	1.85	13.5	8	0.0

Notes to table:
FMC – Field Moisture Content
MDD – Maximum Dry Density
OMC – Optimum Moisture Content
CBR – California Bearing Ratio

Table 5: Emerson Class Testing

Bore	Depth (m)	Description	Emerson Class
2	1.0 - 1.45	Sandy Clay	4*
5	1.1 - 1.55	Sandy Clay	4*
8	1.24 - 1.69	Sandy Clay	2
9	1.21 - 1.66	Sandy Clay	4*
14	1.0 - 1.45	Sandy Clay	4*

Notes to table:
Emmerson Class No. (AS 1289.3.2.1)

* Carbonate Present

6.2 Geo-chemical Laboratory Testing

Five samples were submitted to Envirolab Services Pty Ltd for analysis of pH, electrical conductivity (EC), soluble sulphate (SO_4) and soluble chloride (Cl), to assess soil aggressiveness. Detailed laboratory report sheets are provided in Appendix B, along with other chemical tests which have been reported within, and are summarised in Table 6 within Section 7.6.

6.3 Thermal Resistivity Testing

Thermal resistivity laboratory testing was performed on undisturbed samples (U70 tube samples) in accordance with ASTM D5534, and was undertaken on selected samples from the test locations (i.e. Bore 1, 5, 8, 9 and 12). The results were plotted in the form of a dry-out curve to determine the relationship between moisture content and thermal resistivity.

The field testing was undertaken by Geotherm Australia and comprised using a probe in accordance with ASTM D5334, within shallow test pits excavated over Bores 1, 5, 8, 9 and 12, and the field testing was undertaken at similar depths to the above mentioned laboratory test sample.

The results of the field and laboratory testing with dry out curve interpretations are contained within Appendix B.

7. Comments

7.1 Appreciation of Subsurface Conditions

The pertinent characteristics of the subsurface conditions are further summarised as follows:

- Unit 1 fill up to 3.2 m in thickness in the northern part of the site. The Unit 1 fill is considered to be uncontrolled, and contain deleterious materials;

- It should be noted that the Unit 1A fill contamination, including asbestos containing materials, asbestos fines in soil, and PFAS, has been identified visually and via laboratory testing within fill. It is noted that management will be required for the contaminated materials, including site-specific Work Health Management Plans and procedures to be implemented during construction for identified impact or potentially impacted areas;
- The Unit 1A old footings were present at the base of the fill at some locations. The footings were generally encountered at depths of 1.0 m to 1.3 m depth although the existing footing depth and extent is unknown at this stage;
- Unit 2: Topsoil up to 30 mm thickness in some bores;
- Unit 3: Residual sand and clay soils. Typically very stiff to hard clay or dense sand (extremely weathered rock) below fill / topsoil;
- Unit 4: Rock was encountered from depths ranging from 0.9 m to 3.0 m depth and continuing to 10.0 m depth in cored bores, and the rock was initially extremely weathered, and grades from very low strength through to very high strength.

The Unit 1 fill within the northern area of the site comprised various deleterious materials and Unit 1A old footings at the base of the fill, and this fill is associated with the former Power Station. The Unit 1 fill ranged from 0.9 m to 3.2 m in depth. The Unit 1 fill is considered to be non-engineered / uncontrolled filling and not suitable to support structural loads due to the high risk of differential settlements. Based on the available information it is not recommended footings be founded in such materials. Although technically feasible the use of lightly loaded shallow footings within fill has not been considered further in this report. If the client accepts the risk of differential settlement, which would increase the risk of tilting and cracking of structures / fill platforms and pavements, movement of buried service pipes, and increased maintenance, lightly loaded footings may be considered as a design option however further specific assessment and design would be required to evaluate such options.

Given the conditions encountered, and depending on the proposed cut / fill depths, the suggested options for construction are as follows:

- Option A - Construct Platform for Substation in northern part of the site:
    - Remove Unit 1 and Unit 1A fill and replace with engineered filling;
        - The disturbance and re-use of the existing Unit 1 fill would trigger specific Work Health & Safety (WHS) Plans for working with contaminated soils;
        - An alternative to re-using the existing fill, import filling or use of other site won fill such as Unit 3 clay and Unit 4 rock could be considered;
        - The existing fill is not considered suitable for re-used, without careful separation during excavation, and it would need to be stored on-site, or exported off site in accordance with EPA requirements.
    - Support footings within engineered filling for lightly loaded structures with heavily loaded footings founding within Unit 4 rock using piles.

- Option B - Construct Platform for Substation in southern part of the site:
  - Cut and fill to terrace an area for construction. Bulk excavation into Unit 3 soils and Unit 4 rock, and reuse site won Unit 3 and Unit 4 as engineered filling;
  - Found footings within Unit 3 and Unit 4 and or engineered filling and heavily loaded footings to be founded within Unit 4 rock using piles.

The Unit 3 very stiff to hard residual clay, where encountered, is suitable to support lightly loaded shallow footings, and heavily loaded structural loads should be supported on piles founded within rock (Unit 4).

The Unit 3 silty clay is of moderately to highly plasticity and moderately to highly reactive, and the upper clay soils near the site surface are prone to softening, particularly during extended periods of wet weather. Suitable site preparation measures will be required to facilitate construction of the pavements.

7.2 Site Classification

Site classification of foundation soil reactivity provides an indication of the propensity of the ground surface to move with seasonal variation in moisture. Based on procedures presented in AS 2870 (2011) and on results from this investigation the recommended site classification for the proposed development is presented below:

It should be noted that standard designs within AS 2870 (2011) for site classifications which are based on characteristic surface movements only apply to structures of similar size and flexibility to residential buildings and do not apply to industrial structures or buildings larger than two storeys. Similar principles in design for reactivity / movement, however, should be incorporated into design, construction and maintenance.

Due to the presence of uncontrolled filling to greater than 3.0 m depth in parts of the site, and the presence of old footings the site is technically Class P, as defined in AS 2870 (2011). AS 2870 (2011) does not provide standard footing options for such conditions. Accordingly, all footings should be designed in accordance with engineering principles.

To provide suitable founding conditions for shallow footings all uncontrolled fill should be removed and replaced with engineered filling or piles should be used to support structural loads. Founding shallow footings within existing uncontrolled filling is technically feasible, however, the client should accept the risk of differential settlements, which are difficult to predict and design for.

As a preliminary guide to reactive soil movements in the natural site soils, the soil profiles and the laboratory tests were used to estimate the characteristic surface movement (ys) value for normal seasonal moisture variations. Based on this local information it is anticipated that characteristic surface movements are likely to be in the order of 60 mm, i.e. commensurate with a ‘Class H1-D’ (extremely reactive) classification, where founded within the Unit 3 hard clays, for the site in its present state, without the placement of additional filling. If cut or fill occurs on the site, the site classification should be re-assessed, and possibly E-D site classifications may be applicable.

Design, construction and maintenance should take into account the need to achieve and preserve an equilibrium soil moisture regime beneath and around buildings. Such measures include paved areas around structures to fall away from the building, flexible plumbing connections and service trenches to be backfilled with compacted clay. These and other measures are described in AS 2870 (2011) and the attached (CSIRO, 2021).

Footings should not be founded in existing or proposed filling unless it has been placed and compacted under Level 1 earthworks inspection and testing requirements in accordance with the procedures outlined in AS 3798 (2007) or specifically assessed and designed for founding within uncontrolled filling.

Engineered filling requirements are outlined below in Section 7.12 of this report.

7.3 Footings

Shallow strip and pad footings for the proposed structures could be founded in Unit 3 clay of very stiff to hard consistency and or engineered filling may be proportioned for an allowable bearing pressures and designed for the preliminary settlement estimates listed in Table 3 below.

Table 6: Preliminary Settlement Estimates

Foundation Material	Founding Depth (m)	Footing Type and Dimension	Maximum Allowable Bearing Pressure (kPa)	Estimated Settlement (mm)
Unit 3 or Engineered Fill	1.0	Pad - 1.0 m x 1.0 m	150	10 - 15
		Pad – 2.0 m x 2.0 m		20 - 25
Unit 3 Very stiff to hard clay or dense residual sand	1.0	Pad - 1.0 m x 1.0 m	250	10 - 15
		Pad – 2.0 m x 2.0 m		20 - 25

Notes to table:

It should be noted that the estimated settlements in the above table assume surcharge is applied uniformly across the footing, and do not include allowances for fluctuations due to seasonal ground movements

Footings should be preferably founded within similar materials for individual buildings/structures to reduce the risk of differential settlement.

Footing inspections should be undertaken by a geotechnical engineer to confirm foundation conditions, if the parameters in this report are adopted for design.

7.4 Piles

Suitable pile footing types will need to consider several factors, including depth to rock, structural capacity of the pile, the presence of fill and obstructions in fill (i.e. old footings etc) and potential for hole collapse.

Bored piles are considered an appropriate pile type within the Unit 4 rock. However, conventional bored piles through Unit 1 and Unit 1A will require specialised piling contractors, with appropriate casing, core barrels and down hole hammers to allow penetration of deleterious materials, such as existing concrete footings. Piling within Unit 1 and Unit1A is considered to be problematic and specialised advice from piling contractors would be required to provide input on their ability to penetrate such conditions.

It is recommended that bored piles should be founded at least one pile diameter into Unit 4B rock, and should be designed based on the parameters outlined below, where required to support heavy structural loads (especially under columns).

Geotechnical Strength Reduction Factor (AS2159)

The design geotechnical strength of a pile ($R_{d,g}$) is the ultimate geotechnical strength ($R_{d,ug}$) multiplied by the geotechnical strength reduction factor (ϕ_g), such that:

$$R_{d,g} = \phi_g \, . \, R_{d,ug}$$

The calculated value $R_{d,g}$ must equal or exceed the structural design action effect E_d. Selection of the geotechnical strength reduction factor (ϕ_g) is based on a series of individual risk ratings (IRR) which are weighted and lead to an average risk rating (ARR). The individual risk ratings and final value of ϕ_g depend on the following factors:

- Site: the type, quantity and quality of testing;
- Design: design methods and parameter selection;
- Installation: construction control and monitoring;
- Pile testing regime: testing benefit factor based on percentage of piles tested and the type of testing; and
- Redundancy: whether other piles can take up load if a given pile settles or fails.

It is anticipated that the pile configuration for the structure would be a low redundancy situation, and hence the appropriate basic geotechnical strength reduction factor is likely to be 0.52. The redundancy category should be confirmed by the designer.

Table 8.2.4(B) of AS 2159 (2009) requires that 5% to 15% of piles should be subject to integrity testing if the adopted ϕ_g exceeds 0.4. Higher values of ϕ_g can be justified by more comprehensive static or dynamic load testing. Similarly, where the basic geotechnical strength reduction factor of greater than 0.4 is to be used, serviceability (load) testing must be performed for all foundations with an average risk rating of 2.5 or greater.

Bored Pile Design Parameters

The design of bored concrete piles may be based either on limit state design methods or a 'working stress' approach. The vertical Young's modulus (E_v) values and the ultimate limiting (end bearing and shaft adhesion) pressures given in Table 7 may be used to assess the limiting states for pile design purposes in accordance with AS 2159 (2009).

Alternatively the piles may be proportioned on the basis of the 'allowable pressures or serviceability' given in Table 7. The settlement of piles subjected to vertical loads will vary depending on the ('serviceability' or working) loads applied and the foundation conditions below the pile toe.

Table 7: Geotechnical Parameters for Pile Design in Rock

Geotechnical Unit	Strata Depth (m) of Foundation Material				Vertical Young's Modulus, E_v (6) (MPa)	Ultimate Strength		Serviceability / Maximum Allowable End Bearing Pressure (3),(5) (kPa)
	Bore 2	Bore 6	Bore 10	Bore 14		End Bearing (3),(4) (kPa)	Shaft Adhesion (1),(2) (kPa)	
Unit 4B	2.05-2.55	4.0 – 4.33	1.85-5.0	2.66-3.15	50	3,000	100	700
Unit 4C	2.55-8.55	4.33 – 10.0	5.0-10.0	3.15 – 10.0-	100-200	10,000(7)	700	3,000
Unit 4D	8.55-10.0	-	-	-	350-500	50,000	1,400	8,000

Notes to table:

All pile end bearing parameters are based on pile penetration of at least four pile diameters below the ground surface;

1 Shaft adhesion parameters are only applicable where adequate socket roughness (roughness category "R2" or greater) is achieved. Roughness categories are defined in (Pells, Mostyn, & Walker, 1998)

2 For calculation of tension or uplift capacity the shaft adhesion should be taken as 70% of the above shaft adhesion parameters also assessed using the inverted cone method.

3 Bearing pressure values assume a minimum embedment of one pile diameter into the relevant bearing stratum.

4 Ultimate end bearing parameters mobilised at large settlements (i.e. > 5% of pile diameter).

5 Allowable end bearing parameters could experience settlements of less than 1% of the pile diameter.

6 A range of values has been given for vertical Young's Modulus (E_v) based on typical published correlations.

7 Lower end values have been given for ultimate end bearing owing to the presence of weaker seams within the rock mass. Care should be taken to ensure that the piles are not founded within these lower strength seams.

It is suggested that (Pells P. J., 1999) is used for the evaluation of the geotechnical strength and serviceability of piles designed to the parameters listed above.

The design of piles required to resist uplift or tension loads should be checked against the 'cone-pullout' failure mode as well as the shaft (i.e. 'piston pull-out') capacity of the pile. It is suggested that an inverted 60° cone from the base of the pile be used for calculation of uplift capacity.

Bored piles should have bases and sockets cleaned and free of debris and water at the time of concrete placement. Cleaning buckets should be used during pile installation to provide a suitably clean base which is at least 90% clean of drill cuttings. A roughening tool should be used to roughen sidewalls and remove clay smear during pile installation.

It is also recommended that geotechnical inspections and monitoring be undertaken during the installation of piles to confirm socket roughness and design parameters.

Notwithstanding the above, piling contractors should be responsible for selecting an appropriate piling method with reference to the ground conditions, and the pile capacities required for design.

7.5 Excavatability

The proposed depth of excavation is unknown at this stage. However for preliminary purposes, it is anticipated that excavations will be less than 3 m below current site levels in the northern area of the site and consequently predominantly within Unit 1 and Unit 1A materials, and possibly up to 5 m of cut will be required to terrace the southern part of the site.

It is anticipated that bulk excavation will generally be achievable using conventional hydraulic equipment for the Unit 1, Unit 2 and Unit 3 soils and fill, which were generally encountered at depth of between 0.5 m to 2 m. It is noted that the 21 tonne excavator used for the field work encountered refusal at depths of 1.6 m (Pit 102-10), 1.9 m (Pit 102-12) within sandstone 2.0 m (Pit 102-2), 2.1 m (Pit 102-3) 1.3m (Pit 102-8). Hence medium sized excavators (20 tonne or greater) may be required for bulk excavation within the Unit 1, Unit 2 and Unit 3 soils.

It is likely that a large excavator fitted with a rock hammer will be required to break up concrete footings (Unit 1A) and aid the excavation and removal process where required.

It is important to note that excavatability of rock is dependent not only on rock strength, but also on the presence, orientation and extent of discontinuities such as jointing and fracturing and other factors. For example, low strength rock with few discontinuities can be more difficult to excavate than highly fractured high strength rock.

Confined and detailed excavations in medium strength and high strength rock, will likely require the use of excavators fitted with rippers, rock hammers and/or rock sawing.

Selection of excavation methods and equipment should take into account the particle size distribution of excavated material which is intended for re-use as engineered fill.

The abbreviations shown below are used in Table 5 together with graduated shading to indicate possible characteristics of excavatability for each interpreted layer.

Probable Excavation Methods

Excavatable using excavators, elevating scrapers and light ripping (e.g. D8)
Probably excavatable by medium ripping
Probably excavatable by heavy ripping
Blasting to loosen/fracture

Interpretation of Test Pits and Boreholes

Based on the results obtained from the cored boreholes, assessments have been made regarding the potential rippability / excavatability of the materials encountered. Estimates of rock rippability / excavatability were made using a combination of company experience and with reference to Figure 34 from (Braybrooke, 1988). A reproduction of this interpretative chart is presented below.

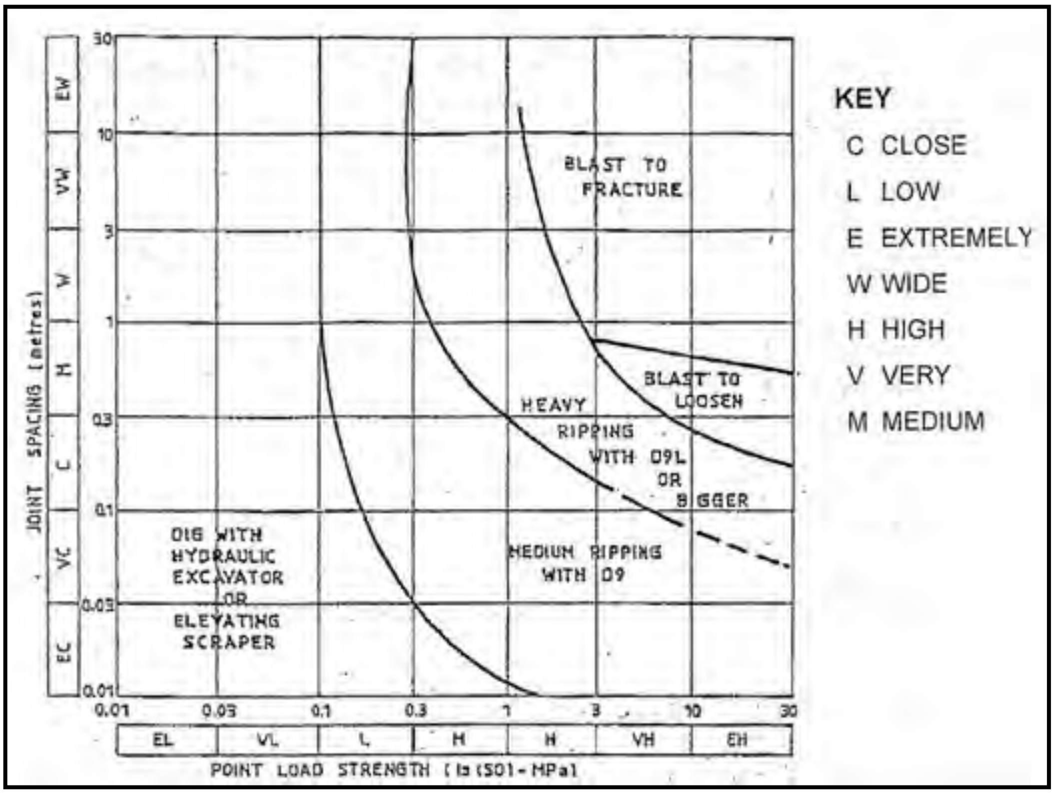

Figure 1 – Rippability Estimate from Strength and Joint Spacing (Braybrooke, 1988)

Table 8 below summarises the interpreted excavation conditions for each of the cored boreholes with reference to Figure 1.

Table 8: Interpreted Excavation Conditions at Bore Locations

Interpreted Excavation Method	Interpreted Depth Range for Probable Method of Excavation (m)								
Bore Location	1	2	4	6	10	11	13	14	15
Hydraulic excavator, elevating scrapers and light ripping, eg using D8.	0 - 3.5	0 -2.1	0-4.7	0 - 4.33	0 - 3.7	0 - 2.8	0 - 5.4	0 - 3.1	0 - 4.3
Medium Ripping, eg using D9	3.5-8.1	2.1 - 2.80	4.7 - 6.2	4.33 - 7.00	3.7 - 5.0	2.8 - 4.3	5.4 - 10.00	3.1- 5.8	4.3 - 5.3
Heavy ripping with D9L or D10 or bigger.	8.1-10	2.80 - 10.00	6.2-10.0	7.00 - 10.00	5.0 - 10.0	4.3 - 6.3	NE	5.8 - 7.4	5.3 - 10.00
Blasting to loosen / fracture	NE	NE	NE	NE	NE	6.3 - 10.00	NE	7.4 - 10	NE
Bore Termination Depth	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Notes to table:

(1) - Blasting likely required below nominated depth, although some bands may be rippable

NE - Not Encountered

Strength and joint spacing based on individual borehole locations

7.5.1 Geotechnical Re-use of Excavated Materials

The majority of Unit 3 soils and/or Unit 4 rock encountered on site will likely be suitable for use as engineered fill beneath pavement, hardstand and structural areas, however the suitability of the Unit 4 material will be dependent on the ability to create a suitable particle size distribution, and may require additional processing such as crushing and blending.

The reactivity of the clay should be considered and the use of site won clay soils will negatively impact characteristic surface movements (possibly commensurate with Class E-D classification). Laboratory test results also indicated that some of the clays are of high plasticity and hence consideration could be given to blending the clay with the weathered bedrock material, which was encountered at greater depth, to reduce the plasticity and improve the shrink-swell characteristics and strength of the clay soils, or capping of clay fill with at least 0.6 m of non-reactive filling will reduce overall characteristic surface movements.

The Unit 4 rock would be a suitable engineering fill material provided the material can be produced to generate a well graded material. This may require using hammers or possibly cross-ripping the rock with tynes. The finer material is likely to require segregation from the oversize material (say >200 mm), with the coarser material requiring further processing such as crushing or additional hammering to produce a material suitable for engineered fill.

Unit 1 material and soils with deleterious materials (such as organics, building demolition material, etc.) are not considered suitable for re-use as engineered fill, without removal of the majority of deleterious materials, as well as removal of oversized particles, where encountered. As stated above specific management plans would be required when working with Unit 1 filling. It is considered that removal of such materials is likely to be too high of a risk in regards to workers WHS and is therefore not recommended.

Moisture conditioning by adding water would be required for site won filling.

In accordance with the NSW POEO Act, all material that will be removed from site must be subject to a waste classification assessment in accordance with NSW EPA waste classification guidelines to facilitate off-site disposal to an appropriately licensed landfill / waste management facility, or appropriately assessed for its potential reuse on another site as either Virgin Excavated Natural Material (VENM) or an appropriate resource recovery exempt material (e.g. Excavated Natural Material (ENM)) in accordance with the appropriate NSW EPA resource recovery order (RRO). DP can assist with classification and assessment of materials to be removed from site, if required.

7.6 Excavation Batters

The following batters are recommended for slopes with a total height of up to 5.0 m.

Table 9: Recommended Temporary Batter Slopes

Strata	Temporary Maximum Slope (H:V)	Long Term Maximum Slope (H:V)
Unit 1 – Fill	2H:1V (Less than 1.0 m depth)	3H:1V
Unit 3 – clay	1H:1V	3H:1V
Unit 4A / 4B- Very Low to Low Strength Rock	0.75H:1V	1H:1V
Unit 4C – Low to medium strength	0.5H:1V	0.25H:1V
Unit 4D – High strength or stronger	0.5H:1V	0.25H:1V

Notes to table:
Batter slopes within fill and rock are subject to geotechnical inspection during construction; dependent on jointing

Rock cuttings should be inspected by a suitably qualified engineering geologist / geotechnical engineer, during excavation / trimming, to confirm the above batter slopes and identify the need or otherwise for bolting or other temporary support measures.

All batter slopes should be protected from erosion. Surface water should be diverted away from slopes by installation of a dish drain at the crest of slopes.

7.7 Retaining Walls

Where support is to be provided to adjoining structures or services, the use of retaining walls up to 2 m in height is recommended. Design parameters for estimating long-term earth pressures on retaining walls with level back fill (i.e. no slopes) are presented in Table 10. These values are unfactored hence a suitable factor of safety should be used in design.

Table 10: Design Parameters for Retaining Structures (Unfactored)

Unit	Material	γ_b (kN/m^3)	Ka	Ko	Kp
-	Engineered fill	20	0.41	0.58	2.5
3A	Very stiff to hard residual clay	20	0.36	0.53	2.8
3B	Dense residual clayey sand	20	0.29	0.46	3.4

Notes to table:
γb - bulk density
Ka - coefficient of active earth pressure
Ko - coefficient of ‘at-rest’ earth pressure
Kp - coefficient of passive earth pressure

7.8 Soil Aggressivity to Buried Structures

Table 11: Soil Aggressivity

Bore	Depth (m)	Description	Soil Condition	pH (concrete)	pH (steel)	Resistivity(1) (Ω.cm) (steel)	SO_4 (ppm) (concrete)	Cl (ppm) (steel)
1	2.5 - 2.92	Sandy CLAY	B	9.5	9.5	4545	20	21
4	1.0 - 1.35	Sandy CLAY	B	7.8	7.8	2326	260	330
12	2.5 - 2.95	Sandy CLAY	B	8.8	8.8	2174	49	350
13	1.0 - 1.45	Sandy CLAY	B	8.6	8.6	1042	570	780
16	1.1 - 1.45	Sandy CLAY	B	3.7	3.7	588	4100	37

Notes to Table:

Non-aggressive
Mildly aggressive
Moderately aggressive
Severely Aggressive
Very Severe

NT Not Tested

1 Resistivity calculated based on inverse of conductivity in aqueous solution results

Scale of aggressivity based on threshold values given in AS 2159 – 2009: Piling – Design and Installation.

Reference should be made to Tables 6.4.3 of (AS 2159, 2009) to determine the minimum concrete cover to reinforcement required (for concrete piles), based on this exposure classification and the minimum concrete strength appropriate for the indicated site conditions.

7.9 Earthquake Design Parameters (Site Sub-Soil Class)

Sections 3 and 4 of AS 1170.4 (2007) provides details regarding hazard factors and site sub-soil classes.

Reference to Figure 3.2(G) of AS 1170.4 (2007) indicates that a hazard factor, Z, of 0.12 would be applicable for earthquake design at this site.

Conditions encountered during the investigation are summarised as fill up to about 3 m depth, overlying typically stiff to hard or dense to very dense residual soils, extremely weathered material grading to low strength and increasing up to very high strength rock. Based on these conditions, Section 4 of AS 1170.4 (2007) indicates that the site would be classed as a “shallow soil site”, for which a sub-soil ‘Class C_e’ would apply.

7.10 Soil Erosion and Dispersion Potential

To minimise impacts of erosion and or dispersion the following measures may decrease the likelihood:

- Compaction of any proposed fill in accordance with Section 7.12 of this report;
- Permanent batter slopes should be vegetated as soon as possible, to reduce the risk of significant soil erosion occurring;
- Topsoil (with minimum thickness of 100 mm and a maximum of 200 mm thickness) and vegetation on exposed batters or cuts. Hydro-mulching could be considered to promote growth;
- Adequate surface drainage is provided to reduce surface and seepage water flows;
- Contour drains along the crest of both cut and fill batters should be provided to reduce the potential for erosion. Such drains should be vegetated or gravel-lined, as appropriate for the expected flows;
- Short term erosion measures such as silt fencing, hay bales etc., where required during construction; and
- Drains should be vegetated or concrete-lined, as appropriate for the expected flows. The use of rip-rap (rockfill) blankets or extensive re-vegetation may be required to dissipate stormwater flows at the location of drain outlets or previously eroded areas if encountered.

7.11 Thermal Resistivity Testing

Thermal resistivity laboratory testing was performed on undisturbed samples (U70 tube samples) in accordance with ASTM D5534, and was undertaken on selected samples from the test locations (i.e. Bore 1, 5, 8, 9 and 12). The results were plotted in the form of a dry-out curve to determine the relationship between moisture content and thermal resistivity.

The field testing was undertaken by Geotherm Australia and comprised using a probe in accordance with ASTM D5334, within the test pits excavated over Bores 1, 5, 8, 9 and 12, and the field testing was undertaken at similar depths to the above mentioned laboratory test sample.

The results of the field and laboratory testing with dry out curve interpretations are contained within Appendix B.

7.12 Pavement Thickness Design

The pavement thickness designs presented in this report is considered preliminary only and is based on assumed traffic loading data, and it is further understood that for specific pavements which may be traffic by forklifts / cranes or where stacking or structural point loads occur that Ausgrid will undertake specific pavement thickness designs.

7.12.1 Design Traffic Loading

It is understood that majority of traffic will comprise light vehicles and light trucks during the operation of the substation. The construction period is likely to constitute the highest volume of road register trucks. No specific traffic volume data has been provided, whoever for the purpose of these preliminary pavement designs the design traffic loadings adopted for pavement thickness design has been provided within Table 12 below.

Table 12: Summary of Design Traffic Loading Adopted

<table>
<tr><th>Pavement</th><th>Pavement Type</th><th>Design Traffic Loading (ESA's)</th><th>Average ESA / HVAG</th><th>Design Traffic Loading HVAG</th></tr>
<tr><td>Access Road</td><td>Flexible</td><td rowspan="2">8 x 10⁴</td><td rowspan="3">0.8</td><td>-</td></tr>
<tr><td rowspan="2">Substation Platform</td><td>Flexible</td><td>-</td></tr>
<tr><td>Rigid - concrete</td><td>-</td><td>1 x 10⁵</td></tr>
</table>

7.12.2 Design Subgrade CBR

The expected subgrade conditions for the access road pavements generally comprise natural silty clay Unit 2. Similarly, subgrade conditions for the substation platform will comprise Unit 2 materials given earthworks are likely to be required for regrading of the area.

Based on the results of the laboratory testing (CBR 4% to 8%) and experience with similar soils in the area a subgrade CBR of 3% has been adopted. Given the low CBR subgrade soils and their risk to swell and soften with increase in moisture content a select subgrade layer is recommended to allow construction of overlying pavements and fill within the fill platform.

An effective CBR of 4% being adopted for platform pavement thickness design purposes, given that a 500 mm thick select subgrade layer (at least CBR 10%) is to be used.

A design CBR of 7% should be adopted for platform pavement thickness design purposes, where Unit 4 rock is exposed. As outlined above design CBR of 3% should be adopted for access road pavement thickness design purposes, where Unit 3 clay soils are encountered at subgrade level and no select material is to be used.

It is noted that clay can be susceptible to softening upon inundation or exposure to moisture, hence care should be taken to protect excavations / subgrades against inclement weather or prolonged exposure to the elements.

7.12.3 Flexible Pavement Thickness Design

The flexible pavement thickness design was undertaken in accordance with the Austroads guideline for design of pavements (Austroads, 2017). The results are presented in below in Table 13.

Table 13: Flexible Pavement Thickness

Traffic Load	8×10^4 ESA		
Effective Design Subgrade CBR	3% Clay subgrade with no select	4% Clay subgrade with 500 mm of select material of CBR 10%	7% Rock subgrades
Design Life (years)	20		
Pavement Layer	Layer Thickness (mm)	Layer Thickness (mm)	Layer Thickness (mm)
Asphalt	50 AC10 and Primer seal [1]	50 AC10 and Primer seal [1]	50 AC10 and Primer seal [1]
Basecourse	100	100	100[3]
Subbase	230	170	100[3]
Total Pavement Thickness (including AC wearing course)	380	320 + Select	250 + Select

Notes to Table:

(1) A 7 mm - 10 mm prime seal should be placed over the basecourse.

(2) Incorporation of a select layer is recommended owing to the presence of expansive clay subgrade and has been considered in determining the design subgrade CBR (refer Section 7.12.2). Additional select material may be required to allow for compaction of overlying pavement layers depending on the moisture condition of the clay subgrade at the time of construction.

(3) A single 200 mm layer of basecourse material could be used with the omission of the subbase layer, to assist with placement and compaction

It is expected that there may be a requirement for increased maintenance in areas of tightly turning trucks due to high shear / torsional stresses applied to the pavement surface. The use of a stiffer binder (i.e. Class 450 or Class 600 PMB bitumen) in the asphalt (if used) would be expected to reduce the damage to the asphalt surface in areas of tightly turning heavy vehicles.

It is recommended that where any new pavements abuts an existing pavement, it should be benched / keyed in a minimum width of 0.3 m. Vertical interface / joints between the new and existing sections of pavements should not be located within wheel paths.

7.12.4 Rigid Pavement Thickness Design

Based on the procedures outlined in (Austroads, 2017) the following rigid pavement thickness design, shown in Table 14, is suggested.

Table 14: Rigid Pavement Thickness Design

Traffic Load	1 x 10^5 HVAGs	
Design Subgrade CBR	4% Clay subgrade with 500 mm select material of CBR 10%	7% Rock subgrades
Design Life (years)	20	
Load Safey Factor	1.2	
Pavement Layer	**Layer Thickness (mm)**	
Concrete Base	165	160
Subbase	100	100
Select Subgrade[(1)]	500	500
Total Pavement Thickness	265 + Select	260 + Select

Notes to Table:

This pavement thickness design is based on the use of concrete shoulders, a concrete flexural strength of at least 4 MPa and a design project load safety factor of 1.2.

[1] Incorporation of a select layer is recommended owing to the presence of expansive clay subgrade and has been considered in determining the design subgrade CBR (refer Section 7.12.2). Additional select material may be required to allow for compaction of overlying pavement layers depending on the moisture condition of the clay subgrade at the time of construction.

The rigid pavement thickness given in Table 14 is based on a 28-day compressive strength of at least 32 MPa. Steel reinforcing and joint detail for the concrete pavement should be designed by the civil engineer for the project based on the procedures in Austroads.

7.13 Material Quality and Compaction Requirements

Recommended pavement material quality and compaction requirements are presented in below.

Table 15: Material Quality and Compaction Requirements

Pavement Layer	Material Quality	Compaction
Asphalt	Conform to local Council requirements or TfNSW R116	NCC requirements or TfNSW R116
Unbound Basecourse	CBR > 80%, PI ≤ 6%, Grading in accordance with Council requirements	Compact to at least 98% dry density ratio Modified (AS 1289.5.2.1)
Subbase	CBR > 30%, PI ≤ 12%, Grading in accordance with Council requirements	Compact to at least 95% dry density ratio Modified (AS 1289.5.2.1)
Select Subgrade	Access Road - CBR>30%, as per subbase (minimum 300 mm thick) Platform - CBR ≥ 10% with no particles greater than 200 mm (minimum 500 mm thick)	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)

Table 16: Material Quality and Compaction Requirements – Concrete Pavement

Layer	Material Quality	Compaction
Concrete Base	Minimum 32 MPa 28 day compressive strength Flexural Strength of 4.0 MPa	-
Subbase	CBR > 30%, PI ≤ 12%, Grading in accordance with Council requirements	Compact to at least 95% dry density ratio Modified (AS 1289.5.2.1)
Select Subgrade	Access Road - CBR>30%, as per subbase (minimum 300 mm thick) Platform - CBR ≥ 10% with no particles greater than 200 mm (minimum 500 mm thick)	Compact to at least 100% dry density ratio Standard (AS 1289.5.1.1)

7.13.1 Pavement Drainage

The vehicular pavement designs provided above depend on the provision of adequate surface and subsoil drainage to maintain the subgrade as close to the optimum moisture content as possible and to ensure that the pavement layers do not become saturated.

Normally, subsoil drainage should be installed at least 0.5 m below subgrade level adjacent to pavements. Preparation of subgrade surfaces should be such that adequate crossfalls for surface drainage are achieved across the final pavement.

In the case where new pavement abuts existing pavement a subsoil drain should be installed at the interface. This drain should comprise a narrow trench backfilled with either 'no-fines' concrete or 14 mm aggregate and 100 mm diameter 'Ag' pipe wrapped in a geotextile. The drain should extend from the top of the subbase layer to within the subgrade and be connected to the subsurface drainage system, to ensure the release of any moisture trapped between the existing and new pavement materials.

7.14 Earthworks Preparation Measures

The recommended earthworks preparation measures are provided in the following sections.

Geotechnical inspection, compaction testing and proof rolling of all engineered fill is recommended. Subgrade inspections are also recommended. Earthworks construction procedures should be in accordance with AS 3798 (2007).

7.14.1 Substation Platform Fill

The construction of a filling under buildings should be carried out in accordance with Level 1 testing, as defined in AS 3798 (2007) and should include the following:

- Remove topsoil (Unit 2), uncontrolled fill (Unit 1 / 1A) and unsuitable materials to expose a stiff or stronger clay soils (Unit 3) and/or rock (Unit 4), noting that disturbance of the existing fill would trigger specific Work Health & Safety (WHS) Plans for working with contaminated soils;
- Removal of tree root zone;
- Test roll and inspect the exposed subgrade and remove soft / weak material. Unsuitable material should be replaced with engineered fill;
- Compact the subgrade to at least 95% Standard dry density ratio, as measured by AS 1289.5.1.1, at a moisture content within the range from -2% OMC to OMC, where OMC is the optimum moisture content as measured by AS 1289.5.1.1;
- Place and compact the engineered fill (clay materials) within the range of 98% to 102% Standard dry density ratio, at a moisture content within the range ± 2% of OMC. The use of clay fill should only be undertaken when it is located at least 0.6 m below finished level;
- Place and compact the engineered fill (non-reactive materials) to at least 98% Standard dry density ratio, at a moisture content within the range ± 2% of OMC. Non-reactive fill should be used within the upper 0.5 m of fill profile. Specific assessment of non-reactive fill thickness should be undertaken prior to construction to confirm these requirements and the impact on site classification;
- The 'non-reactive' fill material should be a low permeability crushed siltstone/sandstone or ridge gravel placed as engineered fill (Level 1 testing) in accordance with AS 3798 (2007), with shrink-swell index of less than 1%, and a soaked CBR value of 15% or greater;
- Engineered fill placed as above should surround structures / building footprint by at least a 2 m horizontal distance.

At the completion of earthworks, the surface heave movements and re-classification of the site should be confirmed by site specific laboratory testing and engineering assessment by this Office.

7.14.2 Pavement Subgrade

A site entry pavement as well as pavements on the substation fill platform are anticipated. Pavement subgrade preparation should be as follows:

- Excavate to design subgrade level, incorporating the select layer, noting that disturbance of the existing fill would trigger specific WHS Plans for working with contaminated soils. The surface should be sloped to ensure water does not pond over the materials;
- Strip all vegetation and topsoil (Unit 2) which contains organic matter (up to 0.03 m encountered during this investigation) and grub out all significant roots;
- The exposed subgrade material surface should be inspected by a geotechnical engineer to check for excessively wet areas or weak zones, and assess if pavement should be constructed over natural subgrade or of subgrade treatment such as drying back, removal and replacement, select and/or bridging layer if required;
- Where suitable subgrades are encountered, the subgrade should be compacted to at least 100% Standard dry density ratio, as measured by AS 1289.5.1.1, at a moisture content within the range from -4% OMC to OMC, where OMC is the optimum moisture content as measured by AS 1289.5.1.1;
- If rock is encountered at subgrade level, it should be ripped to a depth of at least 100 mm and recompacted prior to placement of pavement layers, subject to assessment by the geotechnical engineer; The ripped rock should be compact to at least 100% Standard dry density ratio, as measured by AS 1289.5.1.1, at a moisture content within the range from -4% OMC to OMC, where OMC is the optimum moisture content as measured by AS 1289.5.1.1;
- Placement of pavement as required in accordance with requirements outlined above.

Earthworks construction procedures for pavement subgrade preparation should be subject to Level 2 geotechnical inspections and testing as detailed in AS 3798 (2007), which requires at least one field density test per layer of filling per 50 m lineal distance placed.

7.14.3 General

- Engineered fill should be placed in near horizontal layers not exceeding 300 mm loose thickness, and with a maximum particle size not exceeding two-thirds of the compacted layer thickness;
- The fill layers should be keyed or benched at least 0.3 m into batter slopes;
- Adequate surface drainage should be provided to direct surface water away from engineered filling;
- Excavations should be wide enough to allow access for adequately sized compaction equipment;
- Embankments should be over-filled at the batters and trimmed back to the design batter angle to ensure the filling is compacted for the full design width.

7.15 Mine Subsidence

Correspondence with Mr Paul Grey (SA NSW Senior Risk Officer) of SA NSW on 11 May 2023 indicated the following:

- The site is in a proclaimed mine subsidence district;
- The site is not undermined and is unlikely to ever be mined;
- SA NSW confirmed that the subject site is currently assigned **Guideline 8**, and as such, the property is assessed by SA NSW as not being at risk of mine subsidence and no mine subsidence related restrictions apply to the site;
- Any development on the site is exempt from requiring Subsidence Advisory approval, and should be confirmed by the client with SA NSW prior to construction during the early planning phases of the project.

8. References

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9. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at 20 Sandy Creek Road, Muswellbrook in accordance with DP's proposal dated 22 August 2023 and acceptance received from Paul Hurst / Sulev Kalamae dated 8 September 2023. The work was carried out under period contract terms between DP and Ausgrid. This report is provided for the exclusive use of Ausgrid for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

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

Douglas Partners Pty Ltd

Appendix A

About this Report
Terminology, Symbols and Abbreviations
Soil Descriptions
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Sampling, Testing and Excavation Methodology
CSIRO 2021
Borehole Logs 1 to 17
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About this Report

November 2020

Introduction

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

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

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

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

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

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

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Site Anomalies
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes
Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection
The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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Terminology, Symbols and Abbreviations

Introduction to Terminology, Symbols and Abbreviations

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

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

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

Abbreviation Codes

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

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

Data Integrity Codes

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

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

Graphic Symbols

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

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Introduction

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

classification | name | detailed description

(SC) Clayey SAND, trace silt; grey, fine to medium grained

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

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

Particle size designation and Behaviour Model

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

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

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

[1] – refer grain size subdivision descriptions below

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

Component proportions

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

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

[1] As defined in AS1726-2017 6.1.4.4

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

Composite Materials

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

Classification

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

Soil Name

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

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

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

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

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

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

Identification of minor components

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

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

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

Soil Composition

Plasticity

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

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

Grain Size

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

Grading

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

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

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Soil Condition

Moisture

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

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

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

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

Consistency/Density/Compaction/Cementation/Extremely Weathered Material

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

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

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

<u>Consistency (fine grained soils)</u>

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

<u>Relative Density (coarse grained soils)</u>

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

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

Compaction (anthropogenically modified soil)

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

Cementation (natural and anthropogenic)

Cementation Term	Abbreviation Code
Moderately cemented	MOD
Weakly cemented	WEK

Extremely Weathered Material

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

Soil Origin

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

Cobbles and Boulders

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

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

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Rock Strength

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

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

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

[1] Rock strength classification is based on UCS. The UCS to $I_{s(50)}$ ratio varies significantly for different rock types and specific ratios may be required for each site. The point load Index ranges shown above are as suggested in AS1726 and should not be relied upon without supporting evidence.

The following abbreviation codes are used for soil layers or seams of material "within rock" but for which the equivalent UCS strength is less than 0.6 MPa.

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

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

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

Degree of Alteration

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

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

Degree of Fracturing

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

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

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Defect Descriptions

Defect Type

Term	Abbreviation Code
Bedding plane	B
Infilled seam	IS
Cleavage	CV
Crushed zone	CZ
Decomposed seam	DS
Fault	F
Joint	JT
Lamination	LAM
Parting	P
Shear zone	SZ
Vein	VN
Drilling/handling break	DB , HB
Fracture	FC

Rock Defect Orientation

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

Rock Defect Coating

Term	Abbreviation Code
Clean	CN
Coating	CT
Healed	HE
Infilled	INF
Stained	SN
Tight	TI
Veneer	VNR

Rock Defect Infill

Term	Abbreviation Code
Calcite	CA
Carbonaceous	CBS
Clay	CLAY
Iron oxide	FE
Manganese	MN

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Rock Defect Shape/Planarity

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

Rock Defect Roughness

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

Defect Orientation

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

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Sampling and Testing

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

SAMPLE			DEPTH (m)	TESTING	
SAMPLE REMARKS	TYPE	INTERVAL		TEST TYPE	RESULTS AND REMARKS
	SPT		1.0 1.45	SPT	4,9,11 N=20

Sampling

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

Sample Type	Code
Auger sample	A
Bulk sample	B
Core sample	C
Disturbed sample	D
Sample from SPT test	SPT
Environmental sample	ES
Gas sample	G
Undisturbed tube sample	U[1]
Water sample	W
Piston sample	P
Core sample for unconfined compressive strength testing	UCS
Material Sample	MT

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

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

Field and Laboratory Testing

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

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

Field and laboratory testing (continued)

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

Groundwater Observations

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

Drilling or Excavation Methods/Tools

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

Method	Abbreviation Code
Toothed bucket	TB[1]
Mud/blade bucket	MB[1]
Ripping tyne/ripper	R
Rock breaker/hydraulic hammer	RB
Hand auger	HA[1]
NMLC series coring	NMLC
HMLC series coring	HMLC
NQ coring	NQ3
HQ coring	HQ3
PQ coring	PQ3
Push tube	PT[1]
Rock roller	RR[1]
Solid flight auger. Suffixes: /T = tungsten carbide tip, /V = v-shaped tip	AD[1]
Sonic drilling	SON[1]
Vibrocore	VC[1]
Wash bore (unspecified bit type)	WB[1]
Existing exposure	X
Hand tools (unspecified)	HAND
Predrilled	PD
Diatube	DT[1]
Hollow flight auger	HSA[1]
Vacuum excavation	VE

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

FOUNDATION MAINTENANCE AND FOOTING PERFORMANCE

Understanding and preventing soil-related building movement

This Building Technology Resource is designed to identify causes of soi -related building movement, and to suggest methods of prevention of resultant cracking.

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the home owner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

SOIL TYPES

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. Table 1 below is a reproduction of Table 2.1 from Australian Standard AS 2870-2011, Residential slabs and footings.

CAUSES OF MOVEMENT

SETTLEMENT DUE TO CONSTRUCTION

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction but has been known to take many years in exceptional cases.

These problems may be the province of the builder and should be taken into consideration as part of the preparation of the site for construction.

EROSION

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

SATURATION

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

SEASONAL SWELLING AND SHRINKAGE OF SOIL

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below, from AS 2870). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

SHEAR FAILURE

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

TREE ROOT GROWTH

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.

TABLE 1. GENERAL DEFINITIONS OF SITE CLASSES.

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

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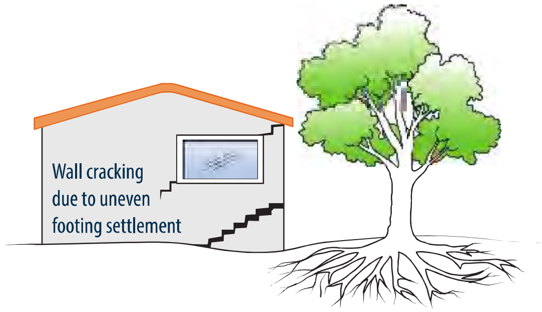

FIGURE 1 Trees can cause shrinkage and damage.

- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

UNEVENNESS OF MOVEMENT

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior through absorption. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Shrinkage usually begins on the side of the building where the sun's heat is greatest.

EFFECTS OF UNEVEN SOIL MOVEMENT ON STRUCTURES

EROSION AND SATURATION

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

SEASONAL SWELLING/SHRINKAGE IN CLAY

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated, and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry, and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

MOVEMENT CAUSED BY TREE ROOTS

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

COMPLICATIONS CAUSED BY THE STRUCTURE ITSELF

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

EFFECTS ON FULL MASONRY STRUCTURES

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

EFFECTS ON FRAMED STRUCTURES

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

EFFECTS ON BRICK VENEER STRUCTURES

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

WATER SERVICE AND DRAINAGE

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

SERIOUSNESS OF CRACKING

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. Table 2 below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

PREVENTION AND CURE

PLUMBING

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

GROUND DRAINAGE

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject may be regarded as an area for an expert consultant.

PROTECTION OF THE BUILDING PERIMETER

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill.

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

CONDENSATION

In buildings with a subfloor void, such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

TABLE 2. CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS.

Description of typical damage and required repair	Approximate crack width limit	Damage category
Hairline cracks	<0.1 mm	0 – Negligible
Fine cracks which do not need repair	<1 mm	1 – Very Slight
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2 – Slight
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3 – Moderate
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4 – Severe

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Warning: Although this Building Technology Resource deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders, and mould.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

THE GARDEN

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

EXISTING TREES

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

INFORMATION ON TREES, PLANTS AND SHRUBS

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information.

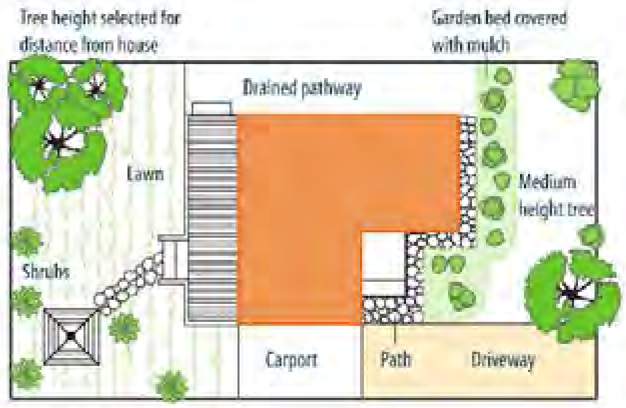

FIGURE 2 Gardens for a reactive site.

EXCAVATION

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

REMEDIATION

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the home owner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 175.8 AHD
COORDINATE: E:303147.5, N:6430358.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 1
PROJECT No: 224763.00
DATE: 18/09/23
SHEET: 1 of 2

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	ROCK DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.03	TOPSOIL, silt and organics, dry													
		Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse, rounded to sub-rounded gravel.	RS	H	w<PL							B	0.50		
												U50	0.50–0.85	PP (0.85)	400kPa
												U75	0.85–1.20		
												SPT	1.20–1.65	SPT	3,10,14 N=24
												SPT	2.50–2.92	SPT	10,23,25/120
	3.45	Pebbly SANDSTONE: brown, highly weathered		NA	NA							SPT	3.45–3.52	SPT	25/70
	3.52	SANDSTONE: pale brown; with orange brown iron staining				HW	3.52	L							
						XW	3.56–3.58	SEAM			3.56-3.58m: CS				
						HW	3.58–4.04	L	100	59	3.68-3.80m: FC; 3.93m: JT/55°, PR, Fe, RF; 4.02m: P			PLT / PLT	PL(A)=0.27MPa / PL(D)=0.2MPa
						HW	4.04–4.44	L to M			4.20m: JT, 80°/85°, PR, RF; 4.26m: JT/10°, Fe, Clay; 4.36m: JT/45°, PR, TI Fe, RF			PLT / PLT	PL(A)=0.29MPa / PL(D)=0.32MPa
						XW	4.44–4.48	SEAM			4.44-4.48m: CS				
						HW	4.48–	L to M	100	82	4.71m: JT/10°, PR, RF; 4.75m: JT/45°, PR, RF; 4.92m: JT/10°, PR, TI, RF; 4.96m: JT/10°, PR, TI, RF; 5.11m: JT/45°, PR, TI, RF; 5.50m: JT/50°, PR,	UCS	5.14–5.42	PLT / PLT / PLT / PLT	PL(A)=0.28MPa / PL(D)=0.25MPa / PL(D)=0.28MPa / PL(A)=0.31MPa

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger to 3.45m, then NMLC coring to 10m depth
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 3.5m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

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LOCATION ID: 1
PROJECT No: 224763.00
DATE: 18/09/23
SHEET: 2 of 2

CONDITIONS ENCOUNTERED						SAMPLE				TESTING	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL: ORIGIN(#), CONSIS.(*) DENSITY.(*), MOISTURE	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	170, 169, 168, 167, 166	6, 7, 8, 9	[CONT] SANDSTONE: pale brown; with orange brown iron staining				UCS	8.68–8.91	6, 7, 8, 8.68, 8.91, 9		
		10.00	Borehole discontinued at 10.00m depth. Limit of investigation.						10		

ROCK

WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)
HW	– 5.76	VL to L
XW	5.76 – 5.82	SEAM
HW	5.82 – 7.37	L to M (to 7.00)
HW	7.00 – 7.37	VL
XW	7.37 – 7.43	SEAM
HW	7.43 – 7.62	VL
XW	7.62 – 7.74	SEAM
MW	7.74 – 8.10	M (to 8.25)
SW	8.10 – 8.31	H (from 8.25)
FR	8.31 – 10.00	H

RECOVERY (%)	RQD
100	82
100	28
100	41
100	100

FRACTURE SPACING (m): 0.05 0.10 0.25 0.50 1.00 5.00

DEFECTS & REMARKS

- Clay, RF
- 5.54m: JT/50°, PR, Clay, RF
- 5.76-5.82m: CS
- 5.95-6.15m: FC
- 6.31m: JT, 50° /55°, PR, Fe, RF
- 6.33m: JT, 50° /55°, PR, Fe, RF
- 6.37m: P, SH, PR, Clay, RF
- 6.40m: P, SH, PR, Fe, RF
- 6.54m: JT/10°, UN, Fe, RF
- 6.60m: JT, 70° /75°, UN, Fe, RF
- 6.67m: JT/45°, PR, Fe, RF
- 6.74-7.00m: FC
- 7.07m: P, SH, PR, RF
- 7.20m: JT/45°, PR, Clay, RF
- 7.28m: JT/45°, PR, RF
- 7.32m: JT/30°, PR, RF
- 7.37-7.43m: CS
- 7.48m: JT/50°, PR, RF
- 7.49m: JT/50°, PR, RF
- 7.62-7.74m: CS
- 8.00m: JT/10°
- 8.12m: P, SH, PR, RF

TESTING

TEST TYPE	RESULTS AND REMARKS
PLT	PL(D)=0.16MPa
PLT	PL(A)=0.19MPa
PLT	PL(A)=0.39MPa
PLT	PL(D)=0.33MPa
PLT	PL(A)=0.16MPa
PLT	PL(D)=0.11MPa
PLT	PL(D)=0.32MPa
PLT	PL(A)=0.32MPa
PLT	PL(A)=0.47MPa
PLT	PL(D)=0.26MPa
PLT	PL(D)=1.4MPa
PLT	PL(A)=1.6MPa

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

PLANT: Truck Mounted Drill Rig
OPERATOR: Ground Test
LOGGED: Chaplin
METHOD: Solid flight auger to 3.45m, then NMLC coring to 10m depth
CASING: HQ to 3.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 174.5 AHD
COORDINATE: E:303202.2, N:6430360.5
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 2
PROJECT No: 224763.00
DATE: 21/09/23
SHEET: 1 of 2

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks	Sample Type / Interval	Test Type	Results and Remarks
0.03	TOPSOIL, silt and organics, dry											
0.03–2.05	Sandy CLAY (CI), with gravel: orange brown mottled grey; medium plasticity; fine to medium sand; fine to coarse, angular to sub-angular gravel. 1.93m: increase in drill resistance indicative of rock	RS possibly XWM	H to Fr	w<PL						U50 (0.50–0.75)	PP (0.75)	>400kPa
										SPT (1.00–1.45)	SPT	9,12,19 N=31
											PP (1.45)	>400kPa
2.05–2.10	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly				HW				2.08m: JT/45°, PR, Fe, RF; 2.10-2.12m: CS			
2.12–2.49					HW	L to M			2.20m: P, SH, PR, Fe, RF; 2.30m: P, SH, PR, Fe, RF; 2.35-2.38m: FC; 2.41m: P, SH, PR, Fe, RF		PLT / PLT	PL(A)=0.18MPa / PL(D)=0.61MPa
2.49–2.55					XW	SEAM			2.49-2.55m: CS			
2.55–2.80					HW	L to M			2.80m: P, SH, PR, TI Fe, RF		PLT / PLT	PL(D)=0.26MPa / PL(A)=0.44MPa
2.80–					HW to MW	M	100	67	3.22m: P, SH, PR, Fe, RF		PLT / PLT	PL(D)=0.46MPa / PL(A)=0.75MPa
									3.71m: P, SH, PR, TI Fe, RF; 3.76m: P, SH, PR, TI Fe, RF	UCS (3.41–3.71)		
									4.08m: P, SH, PR, Fe, RF		PLT / PLT	PL(D)=0.34MPa / PL(A)=0.64MPa
									4.54m: JT/10°, PR, Fe, RF; 4.72m: JT/10°, PR, Fe, RF		PLT / PLT	PL(A)=1.2MPa / PL(D)=0.85MPa
							100	97			PLT / PLT	PL(A)=0.89MPa / PL(D)=1.1MPa

Groundwater: No free groundwater observed

RL (m): 174, 173, 172, 171, 170

Weath. depths: 2.05, 2.10, 2.12, 2.49, 2.55, 2.66, 2.80

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

PLANT: Truck Mounted Drill Rig
OPERATOR: Ground Test
LOGGED: Chaplin
METHOD: Solid flight auger to 2.05m, then NMLC coring to 10m depth
CASING: HQ to 2m
REMARKS:

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 174.5 AHD
COORDINATE: E:303202.2, N:6430360.5
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 2
PROJECT No: 224763.00
DATE: 21/09/23

RL (m)	Depth (m)	Description of Strata	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks	Sample Type	Sample Interval	Depth (m)	Test Type	Results and Remarks
169		[CONT] SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly		5.53									
				5.55				5.54m: P/10°, PR, RF					
			HW	5.67	L								
			XW	5.76	L			5.67-5.76m: CS					
			HW	5.81									
				5.83				5.86m: P, SH, PR, Fe, RF					
	6		MW	6.09				6.00m: P, SH, PR, RF			6		
		From 6.09m: becomes grey in colour	SW	6.29				6.29m: P, SH, PR, RF				PLT PLT	PL(D)=0.84MPa PL(A)=0.94MPa
168						100	97	6.71m: P, SH, PR, RF					
	7				M			7.01m: JT/15°, PR, RF			7		
167								7.53m: JT/35°, PR, RF	UCS	7.52–7.87	7.52	PLT PLT	PL(D)=0.47MPa PL(A)=0.93MPa
	8		FR								7.87 8		
166				8.55								PLT PLT	PL(D)=0.29MPa PL(A)=0.87MPa
								8.61m: P, SH, PR, RF					
	9					100	100	8.91m: JT/20°, PR, SM			9		
165					H							PLT PLT	PL(D)=1.3MPa PL(A)=1.4MPa
	10.00	Borehole discontinued at 10.00m depth. Limit of investigation.									10		

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

PLANT: Truck Mounted Drill Rig
OPERATOR: Ground Test
LOGGED: Chaplin
METHOD: Solid flight auger to 2.05m, then NMLC coring to 10m depth
CASING: HQ to 2m
REMARKS:

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Refer to explanatory notes for symbol and abbreviation definitions

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 175.0 AHD
COORDINATE: E:303262.7, N:6430363.5
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 3
PROJECT No: 224763.00
DATE: 21/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed			FILL / Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse, angular to sub-angular gravel.		FILL	NA	w<PL		U50		0.50 – 0.72		
	174	0.75 / 1	FILL / Silty GRAVEL (GM): dark grey; fine to coarse, sub-angular to sub-rounded.		FILL	NA	D		D		0.75 – 0.85		
									SPT		1.00 – 1.10	SPT	25/100
		1.10	CONCRETE: grey.			NA	NA						
		1.12	Borehole discontinued at 1.12m depth. TC bit refusal, likely concrete.										
	173	2									2		
	172												

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger with TC bit to 1.12m
REMARKS:

OPERATOR: Ground Test
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 176.5 AHD
COORDINATE: E:303317.6, N:6430366.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 4
PROJECT No: 224763.00
DATE: 21/09/23
SHEET: 1 of 2

Groundwater: No free groundwater observed

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Strength	Recovery (%)	RQD	Defects & Remarks
0.03	TOPSOIL, silt and organics, dry								
	Sandy CLAY (CI), trace gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel. 4.60m: increase in drill resistance indicative of rock	RS	H	w<PL					
4.66	SANDSTONE: brown with orange brown iron staining, fine to coarse grained; pebbly				HW	VH	100	34	4.70-4.75m: FC; 4.81-4.88m: FC; 4.94-5.00m: FC; 5.21m: JT/15°, PR, Fe, RF
5.27	CORE LOSS						0	0	

RL (m): 176, 175, 174, 173, 172

Sample Type	Interval (m)	Test Type	Results and Remarks
U50	0.50 – 0.68	PP	>400kPa
SPT	1.00 – 1.45	SPT	16,23,23 N=46
		PP	>400kPa
SPT	2.50 – 2.95	SPT	16,23,24 N=47
		PP	>400kPa
SPT	4.00 – 4.29	SPT	15,25/140
		PP	>400kPa
		PLT	PL(D)=3.5MPa
UCS	5.00 – 5.22		

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

PLANT: Truck Mounted Drill Rig
OPERATOR: Ground Test
LOGGED: Chaplin
METHOD: Solid flight auger to 4.66m, then NMLC coring to 10m depth
CASING: HQ to 4.5m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 176.5 AHD
COORDINATE: E:303317.6, N:6430366.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 4
PROJECT No: 224763.00
DATE: 21/09/23
SHEET: 2 of 2

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS	SAMPLE TYPE	INTERVAL / DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
171		[CONT] CORE LOSS				0	0					
	5.96	SANDSTONE: brown with orange brown iron staining, fine to coarse grained; pebbly	MW to HW	5.96	H	100	0					
	6.05			6.05								
	6.18	CORE LOSS		6.18								
		SANDSTONE: brown with orange brown iron staining, fine to coarse grained; pebbly	MW		H	94	94	6.41m: P, SH, PR, Fe, RF			PLT PLT	PL(D)=2.9MPa PL(A)=2.3MPa
170								6.69m: P, SH, PR, TI Fe, RF				
	7										PLT PLT	PL(D)=1.3MPa PL(A)=1.6MPa
											PLT PLT	PL(D)=1.8MPa PL(A)=1.6MPa
169								7.48m: JT/10°, PR, Fe, RF				
				7.55	M							
	8			7.99	VH						PLT PLT PLT PLT	PL(D)=0.73MPa PL(A)=0.83MPa PL(D)=3.6MPa PL(D)=7.1MPa
		From 8.12m: colour becomes grey	FR	8.12								
				8.29	M							
168			SW to FR	8.48							PLT PLT	PL(D)=0.4MPa PL(A)=0.89MPa
	8.64	CORE LOSS		8.64		20	0					
	8.83	SANDSTONE: brown with orange brown iron staining, fine to coarse grained; pebbly	MW to SW	8.83				8.97m: P, SH, PR, RF				
	9											
167			SW to FR	9.40	M	100	91		UCS	9.49 – 9.71	PLT PLT	PL(A)=0.76MPa PL(D)=0.61MPa
	10.00	Borehole discontinued at 10.00m depth. Limit of investigation.										

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger to 4.66m, then NMLC coring to 10m depth
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 4.5m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 178.7 AHD
COORDINATE: E:303155.7, N:6430320.1
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 5
PROJECT No: 224763.00
DATE: 19/09/23
SHEET: 1 of 1

Groundwater	RL (m)	Depth (m)	Description of Strata	Graphic	Origin(#)	Consis.(*) / Density.(*)	Moisture	Remarks	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
No free groundwater observed			FILL / Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel.		FILL	H	w<PL		B	0.05		
	178								U50	0.50–0.86	PP	>400kPa
		1							U75	0.90–1.10	PP	>400kPa
									SPT	1.10–1.55	SPT	13,16,17 N=33
	177									1.55	PP	>400kPa
		2.05	Pebbly SANDSTONE, brown, highly weathered 2.05m: increase in drill resistance indicative of rock			NA	NA		SPT	2.50–2.72	SPT	25/70
	176	2.72	Borehole discontinued at 2.72m depth. TC bit refusal.							2.72		

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger with TC bit to 2.72m
REMARKS:

OPERATOR: Ground Test
CASING: Nil

LOGGED: Chaplin

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Refer to explanatory notes for symbol and abbreviation definitions

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT:	Ausgrid	**SURFACE LEVEL:**	179.6 AHD	**LOCATION ID:**	6
PROJECT:	Proposed Muswellbrook Substation	**COORDINATE:**	E:303197.1, N:6430318.1	**PROJECT No:**	224763.00
LOCATION:	20 Sandy Point Road, Muswellbrook, NSW	**DATUM/GRID:**	MGA2020 56	**DATE:**	20/09/23
		DIP/AZIMUTH:	90°/---°	**SHEET:**	1 of 2

CONDITIONS ENCOUNTERED — SOIL / ROCK; **SAMPLE**; **TESTING**

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS
No free groundwater observed	0.03	TOPSOIL, silt and organics, dry									
		Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel.	RS	NA	w<PL						
		3.80m: increase in drill resistance indicative of rock									
	3.80	Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel.	XWM	NA	w<PL						
	4.02	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly				HW	4.02	VL	100	84	
						XW	4.27 – 4.33				4.27-4.33m: CS
						HW	4.33	M			4.51-4.52m: P/10°, PR, RF 4.60m: P, SH, PR, RF 4.93m: JT/10°, PR, RF 5.46m: P, SH, PR,

RL (m): 179, 178, 177, 176, 175

SAMPLE TYPE	INTERVAL / DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
U50	0.50 – 0.81		
SPT	1.00 – 1.45	SPT	7,9,11 N=20
		PP	>400kPa
SPT	2.50 – 2.91	SPT	6,23,25/110
		PP	>400kPa
SPT	4.00		25/10
		PLT	PL(A)=0.08MPa
		PLT	PL(D)=0.1MPa
		PLT	PL(A)=0.4MPa
		PLT	PL(D)=0.41MPa

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

PLANT:	Truck Mounted Drill Rig	**OPERATOR:**	Ground Test	**LOGGED:**	Chaplin
METHOD:		**CASING:**	HQ to 4m		
REMARKS:					

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 179.6 AHD
COORDINATE: E:303197.1, N:6430318.1
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 6
PROJECT No: 224763.00
DATE: 20/09/23
SHEET: 2 of 2

CONDITIONS ENCOUNTERED															SAMPLE				TESTING	
					SOIL			ROCK												
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH (VL L M H VH EH)	RECOVERY (%)	RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	174		[CONT] SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly					HW		M	100	84		RF; 5.53m: JT/10°, PR, RF; 5.73m: JT/10°, PR, RF; 5.89m: JT/10°, PR, RF					PLT PLT	PL(D)=0.34MPa PL(A)=0.4MPa
		6														UCS		6.00 - 6.28		
																		6.28	PLT PLT	PL(D)=0.46MPa PL(A)=0.43MPa
	173							XW	6.42					6.42-6.76m: CS						
		7						MW	6.76		100	84		7.00m: JT/10°, PR, Fe, RF				7	PLT PLT	PL(A)=0.76MPa PL(D)=0.57MPa
			7.09m-10.00m: grey in colour					SW	7.09											
	172							MW	7.68										PLT PLT	PL(A)=0.88MPa PL(D)=0.98MPa
		8						FR	8.18	M								8	PLT PLT	PL(A)=0.89MPa PL(D)=0.8MPa
	171																		PLT PLT	PL(A)=0.41MPa PL(D)=0.76MPa
		9									100	100		8.90m: P, SH, PR, RF; 9.17m: JT/55°, PR, RF; 9.48m: P, SH, PR, RF				9		
	170																		PLT PLT	PL(A)=0.66MPa PL(D)=0.66MPa
		10.00	Borehole discontinued at 10.00m depth. Limit of investigation.															10		

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

PLANT: Truck Mounted Drill Rig
METHOD:
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 4m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 178.0 AHD
COORDINATE: E:303263.5, N:6430317.4
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 7
PROJECT No: 224763.00
DATE: 20/09/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.00	FILL / Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, sub-angular to sub-rounded gravel.		FILL	NA	w<PL		U50		0.05–0.73	PP	>400kPa
		0.50	FILL / Clayey Gravelly SILT (ML), with sand: dark brown; low plasticity; fine to coarse, angular to sub-angular gravel; fine to coarse sand; trace coal fragments, trace possible ash.		FILL	NA	w<PL		D		0.80		
	177	1							SPT		1.00–1.26	SPT	24,25/110
												PP	>400kPa
		1.20	FILL / Silty GRAVEL (GM): dark grey; trace coal fragments, trace possible ash.		FILL	NA	D		D		1.50		
	176	2.00	FILL / Clayey Gravelly SILT (ML), with sand: dark brown; low plasticity; fine to coarse, angular to sub-angular gravel; fine to coarse sand; trace coal fragments, trace possible ash.		FILL	NA	w<PL		SPT		2.50–2.95	SPT	16,18,18 N=32
	175	3											
		3.20	Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse, rounded to sub-rounded gravel.		XWM	H	w<PL						
		3.45	PEBBLY SANDSTONE: orange brown 3.45m: increase in drill resistance indicative of rock			VL	NA						
	174	4.01	Borehole discontinued at 4.01m depth. TC bit refusal.						SPT		4.00		25/10
	173												

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger with TC bit to 4.01m
REMARKS:

OPERATOR: Ground Test
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 179.5 AHD
COORDINATE: E:303323.0, N:6430306.4
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 8
PROJECT No: 224763.00
DATE: 19/09/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE
No free groundwater observed	0.00–0.50	FILL / Clayey SILT (ML), with sand, with gravel: brown grey; low plasticity; contains ash and coal fragments.	FILL	NA	w<PL
	0.50–3.35	Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel. 3.35m: increase in drill resistance indicative of rock	RS	H to Fr	w<PL
	3.35–3.50	Pebby SANDSTONE, brown, highly weathered		VL	NA
	3.50	Borehole discontinued at 3.50m depth. TC bit refusal.			

RL (m): 179 at 0.50; 178; 177; 176 at 3.50; 175

SAMPLE / TESTING AND REMARKS

TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
D	0.25		
U50	0.50–0.65	PP	>400kPa
B	0.65–1.00		
U75	1.00–1.24	PP	>400kPa
SPT	1.24–1.69	SPT	10,12,20 N=32
SPT	2.50–2.77	SPT	10,25/120
	2.77	PP	>400kPa

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger with TC bit to 3.50m
REMARKS:

OPERATOR: Ground Test
CASING: Nil

LOGGED: Chaplin

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 183.7 AHD
COORDINATE: E:303203.9, N:6430265.9
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 10
PROJECT No: 224763.00
DATE: 22/09/23
SHEET: 1 of 2

Groundwater: No free groundwater observed

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture
0.03	TOPSOIL, silt and organics, dry			
	Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse, rounded to sub-rounded gravel.	RS	H	w<PL
1.85	CORE LOSS			
2.00	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly. From 5.26m: becomes grey in colour			

Rock:

Depth (m)	Weath.	Strength
1.85–2.00	core loss	
2.00–2.22	HW	VL
2.22–2.36	XW	SOIL
2.36–2.44	HW	VL
2.44–2.73	XW	SOIL
2.73–2.81	HW	VL
2.81–2.86	XW	SEAM
2.86–2.92	HW	VL
2.92–2.96	XW	SEAM
2.96–3.01	HW	VL
3.01–3.03	XW	SEAM
3.03–3.09	HW	VL
3.09–3.13	XW	SEAM
3.13–3.20	HW	VL
3.20–3.24	XW	SEAM
3.24–3.31	HW	L
3.31–3.33	XW	SEAM
3.33–3.37	HW	L
3.37–3.42	XW	SEAM
3.42–3.58	HW	L
3.58–3.60	XW	SEAM
3.60–4.32	HW	L
4.32–4.44	HW	L to M
4.44–4.80	XW	SEAM
4.80–5.01	HW	L
5.01–5.26	MW	M
5.26–	SW	M

Recovery (%) / RQD: 1.85–4.32: 93 / 36; 4.32–: 100 / 84

Defects & Remarks:
- 2.00-2.22m: FC
- 2.81-2.86m: CS
- 2.92-2.96m: CS
- 3.01-3.03m: CS
- 3.09-3.13m: CS
- 3.20-3.24m: CS
- 3.31-3.33m: CS
- 3.37-3.42m: CS
- 3.58-3.60m: CS
- 3.88m: P, SH, PR, Fe, RF
- 4.40m: P, SH, PR, Fe, RF
- 4.44-4.80m: CS
- 5.00m: P, SH, PR, Fe, RF

Sample / Testing:

Depth (m)	Sample Type	Test Type	Results and Remarks
1.00–1.15	SPT	SPT	12,30
		PP	>400kPa
~2.2		PLT	PL(I)=0.07MPa
~2.4		PLT	PL(D)=0.06MPa
~3.05		PLT	PL(D)=0.03MPa
		PLT	PL(A)=0.07MPa
~3.5		PLT	PL(D)=0.11MPa
		PLT	PL(A)=0.12MPa
~4.4		PLT	PL(A)=0.33MPa
		PLT	PL(D)=0.27MPa
~5.0		PLT	PL(D)=0.27MPa
		PLT	PL(A)=0.25MPa

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger to 1.85m, then NMLC to 10m depth
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 1.85m
LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 183.7 AHD
COORDINATE: E:303203.9, N:6430265.9
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 10
PROJECT No: 224763.00
DATE: 22/09/23

Depth (m)	Description of Strata	Weath.	Depth (m)	Recovery (%)	RQD	Defects & Remarks	Test Type	Results and Remarks
	[CONT] SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly	SW	5.68			5.64m: JT, 15° /20°, UN, Fe, RF	PLT PLT	PL(D)=0.47MPa PL(A)=0.43MPa
6		MW	6.28			6.02m: P, SH, UN, Fe, RF		
		FR		100	84		PLT PLT	PL(D)=0.36MPa PL(A)=0.58MPa
7						7.17m: JT, 10° /15°, PR, RF	PLT PLT	PL(A)=0.43MPa PL(D)=0.27MPa
			7.85					
8		MW	8.10			7.95m: JT/10°, UN, Fe, RF 8.02m: P, SH, PR, Fe, RF		
9		FR		100	96		PLT PLT	PL(A)=0.58MPa PL(D)=0.28MPa
10.00							PLT PLT	PL(A)=0.66MPa PL(D)=0.7MPa
	Borehole discontinued at 10.00m depth. Limit of investigation.							

RL (m): 178, 177, 176, 175, 174. Strength: M.

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger to 1.85m, then NMLC to 10m depth
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 1.85m

LOGGED: Chaplin

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 183.7 AHD
COORDINATE: E:303263.9, N:6430265.4
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 11
PROJECT No: 224763.00
DATE: 25/09/23
SHEET: 1 of 2

Groundwater	Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
No free groundwater observed	0.03	TOPSOIL, silt and organics, dry													
		Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel. 2.10m: increase in drilling resistance indicative of rock	RS	H	w<PL							SPT	1.00–1.14	SPT / PP	25/140 / >400kPa
	2.16	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly				HW	2.16	VL	100	55					
						XW	2.39–2.42				2.39-2.42m: CS				
						HW	2.42	VL						PLT	PL(A)=0.04MPa
						XW	2.61				2.61-2.77m: CS				
						HW to MW	2.77	L						PLT / PLT	PL(A)=0.13MPa / PL(D)=0.05MPa
							2.98	VL							
						XW	3.05				3.05-3.13m: CS				
						MW	3.13	L						PLT / PLT	PL(D)=0.17MPa / PL(A)=0.27MPa
						XW	3.51–3.55				3.51-3.55m: CS				
						HW	3.55	L			3.95m: JT/45°, PR, Fe, RF			PLT / PLT	PL(A)=0.22MPa / PL(D)=0.21MPa
							4.18	VL							
							4.32	M	100	100	4.41m: P, SH, PR, RF			PLT / PLT	PL(A)=0.4MPa / PL(D)=0.45MPa
											5.24m: JT/45°, CU, Fe, RF				
											5.41m: JT/80°, PR, TI Fe, RF				

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

PLANT: Truck Mounted Drill Rig
METHOD:
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 2m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 183.7 AHD
COORDINATE: E:303263.9, N:6430265.4
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 11
PROJECT No: 224763.00
DATE: 25/09/23

Depth (m)	Description of Strata	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks	Test Type	Results and Remarks
	[CONT] SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly	HW	5.91	H			5.64m: JT/85°, PR, Tl Fe, RF	PLT PLT	PL(D)=1.9MPa PL(A)=1.6MPa
6							5.91m: JT/15°, PR, Fe, RF		
		HW	6.35	M	100	100	6.37m: P, SH, PR, Fe, RF	PLT PLT	PL(D)=0.72MPa PL(A)=0.54MPa
								PLT PLT	PL(A)=2.2MPa PL(D)=1MPa
7				H				PLT PLT	PL(D)=1.8MPa PL(A)=1.4MPa
8		HW to MW			100	100		PLT PLT	PL(A)=1.7MPa PL(D)=1MPa
			8.23–8.39	VH				PLT	PL(D)=5.5MPa
9				H	100	100	9.52m: JT/45°, PR, Tl Fe, RF		
10.00								PLT	PL(D)=1.2MPa
	Borehole discontinued at 10.00m depth. Limit of invesitgation.								

RL (m): 178, 177, 176, 175, 174

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

PLANT: Truck Mounted Drill Rig
METHOD:
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 2m

LOGGED: Chaplin

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 183.3 AHD
COORDINATE: E:303325.8, N:6430257.4
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 12
PROJECT No: 224763.00
DATE: 19/09/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED

Groundwater	RL (m)	Depth (m)	Description of Strata	Origin	Consis./Density	Moisture
No free groundwater observed		0.00–0.15	FILL / Gravelly SILT (ML), with clay: brown; low plasticity; fine to coarse, angular to sub-angular gravel; trace ash.	FILL	NA	w<PL
	183	0.15–0.55	FILL / Clayey GRAVEL (GC), with silt: black; fine to medium, angular to sub-angular; possibly contains trace bituminous material.	FILL	NA	D
	182, 181, 180	0.55–3.90	Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel. 3.90m: increase in drill resistance indicative of rock	RS	H	w<PL
	179	3.90–4.22	SANDSTONE, highly weathered pebbly		VL	NA
		4.22	Borehole discontinued at 4.22m depth. TC bit refusal.			

SAMPLE / TESTING AND REMARKS

Remarks	Type	Interval Depth (m)	Test Type	Results and Remarks
	B	0.55–1.00		
U75 /	U50	1.05–1.26	PP	>400kPa
	SPT	1.26–1.71	SPT	4,14,20 N=34
		1.71	PP	>400kPa
	SPT	2.50–2.95	SPT	7,12,17 N=29
		2.95	PP	>400kPa
	SPT	4.00–4.22	SPT	4,25/70

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger with TC bit to 4.22m
REMARKS:

OPERATOR: Ground Test
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 185.1 AHD
COORDINATE: E:303325.7, N:6430211.1
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 13
PROJECT No: 224763.00
DATE: 26/09/23
SHEET: 1 of 2

CONDITIONS ENCOUNTERED

GROUNDWATER: No free groundwater observed

RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE
185	0.03	TOPSOIL, silt and organics, dry			
		Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse, rounded to sub-rounded gravel.	RS	H	w<PL
184	1			VSt	w=PL
183	2			H	w<PL
182	3.50	SANDSTONE: extremely weathered to highly weathered, very low strength 3.50m: increase in drill resistance indicative of rock		NA	NA
181	4.30	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly			
180	5				

ROCK

WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS
HW	4.30	VL	100	0	
XW	4.33	SEAM			4.33-4.35m: CS
HW	4.35	VL			
XW	4.39	SEAM			4.39-4.53m: CS
HW	4.53	VL			4.58m: P, SH, PR, Clay, SM
XW	4.69	SEAM			4.69-4.75m: CS
HW	4.75	VL			
XW	4.81	SEAM	100	12	4.81-5.07m: CS
HW	5.07	VL			5.23m: JT/15°, PR, Fe, SM 5.39-5.41m: FC

SAMPLE / TESTING

TYPE	INTERVAL DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
U50	0.50 – 0.65	PP	>400kPa
SPT	1.00 – 1.45	SPT	4,6,8 N=12
	1.45	PP	320-360kPa
SPT	2.50 – 2.90	SPT	9,20,25/100
	2.90	PP	>400kPa
SPT	4.00 – 4.14	SPT	25/140
		PLT	PL(A)=0.09MPa
		PLT	PL(D)=0.03MPa
		PLT	PL(A)=0.1MPa

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

PLANT: Truck Mounted Drill Rig
METHOD:
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 4.1m

LOGGED: Chaplin

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 185.1 AHD
COORDINATE: E:303325.7, N:6430211.1
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 13
PROJECT No: 224763.00
DATE: 26/09/23

Depth (m)	Description of Strata	Weath.	Rock Depth (m)	Recovery (%)	RQD	Defects & Remarks	Test Type	Results and Remarks
	[CONT] SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly	HW		100	12	5.88m: P, SH, PR, Fe, RF	PLT	PL(D)=0.19MPa
							PLT	PL(A)=0.09MPa
						6.23-6.25m: FC	PLT	PL(A)=0.27MPa
							PLT	PL(D)=0.08MPa
							PLT	PL(D)=0.07MPa
			6.92			6.83m: P, SH, PR, Fe, RF		
						7.08m: P, SH, PR, Fe, RF	PLT	PL(D)=0.1MPa
						7.13m: P, SH, PR, Fe, RF	PLT	PL(A)=0.23MPa
						7.22m: JT, 55°/60°, PR, Fe, RF		
				100	91	7.36m: JT/80°, PR, TI Fe, RF		
						7.42m: P, SH, PR, RF	PLT	PL(D)=0.35MPa
						7.46m: P, SH, PR, RF	PLT	PL(A)=0.21MPa
						7.60-7.65m: FC, Fe		
						7.98m: JT/60°, PR, TI Clay, SM		
						8.04m: JT/10°, PR, Fe, RF		
						8.70m: JT/80°, PR, TI, RF, HE	PLT	PL(A)=0.15MPa
							PLT	PL(D)=0.14MPa
							PLT	PL(A)=0.19MPa
							PLT	PL(D)=0.14MPa
						9.21m: P, SH, PR Fe, RF		
						9.29m: JT, 50°/55°, PR, TI Fe, SM, HE		
						9.45m: P, SH, PR, Fe, RF		
						9.86m: P, SH, PR, Fe, RF		
10.00	Borehole discontinued at 10.00m depth. Limit of investigation.							

Strength: VL (at 6.25m approx.)

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

PLANT: Truck Mounted Drill Rig
METHOD:
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 4.1m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 188.2 AHD
COORDINATE: E:303255.3, N:6430213.3
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 14
PROJECT No: 224763.00
DATE: 26/09/23

CONDITIONS ENCOUNTERED

Groundwater	Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
No free groundwater observed	0.03	TOPSOIL, silt and organics, dry													
		Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse, rounded to sub-rounded gravel.	RS	H	w<PL							U50	0.50–0.81	PP	>400kPa
												SPT	1.00–1.45	SPT	12,19,17 N=36
													1.45	PP	>400kPa
												SPT	2.50–2.66	SPT	24,25/10 (HB)
	2.66	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained				HW	2.66	VL	100	0	2.69m: P, SH, PR, Fe, RF; 2.72-2.74m: FC				
						XW	2.86	SEAM			2.86-2.96m: CS				
						HW	2.96	VL							
	3.07	CORE LOSS					3.07								
	3.15	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained				HW	3.15	M	97	92	3.70m: JT/10°, PR, Fe, RF	UCS	3.40–3.61	PLT / PLT	PL(A)=0.36MPa / PL(D)=0.32MPa
													4	PLT / PLT	PL(D)=0.31MPa / PL(A)=0.38MPa
											4.82m: JT/10°, PR, Fe, RF; 4.90m: JT/10°, PR, Fe, RF; 4.94m: P, SH, PR, Fe, RF			PLT / PLT	PL(D)=0.31MPa / PL(A)=0.5MPa
		5.19m-5.27m: clast													

RL (m): 188, 187, 186, 185, 184, 183

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger to 2.66m, then NMLC coring to 10m depth
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 2.66m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

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BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 188.2 AHD
COORDINATE: E:303255.3, N:6430213.3
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 14
PROJECT No: 224763.00
DATE: 26/09/23

Depth (m)	RL (m)	Description of Strata	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks	Sample Type	Sample Depth (m)	Test Type	Results and Remarks
5.5–10.00		[CONT] SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained	HW		M	97	92	5.75m: JT/60°, PR, Fe, RF; 5.81-5.86m: FC				
6	182									6	PLT; PLT; PLT; PLT	PL(D)=0.95MPa; PL(A)=0.92MPa; PL(A)=0.97MPa; PL(D)=0.94MPa
								6.30m: P, SH, PR, Fe, RF				
								6.78m: JT/80°, PR, TI Fe, RF, HE				
7	181					100	96	7.41m: P, SH, PR, Fe, RF		7	PLT	PL(D)=0.9MPa
				7.69–8.05	H to VH				UCS	7.65–7.96		
8	180										PLT; PLT	PL(D)=3.1MPa; PL(A)=2.7MPa
		8.81m-9.00m: clast						8.81m: JT/30°, PR, Fe, RF			PLT; PLT	PL(D)=0.42MPa; PL(A)=0.37MPa
9	179				M	100	100	9.23m: JT/45°, PR, Fe, RF		9		
								9.72m: JT/10°, PR, Fe, RF				
10.00		Borehole discontinued at 10.00m depth. Limit of investigation.								10		

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

PLANT: Truck Mounted Drill Rig
OPERATOR: Ground Test
LOGGED: Chaplin
METHOD: Solid flight auger to 2.66m, then NMLC coring to 10m depth
CASING: HQ to 2.66m
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 188.5 AHD
COORDINATE: E:303165.7, N:6430215.6
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 15
PROJECT No: 224763.00
DATE: 02/09/23
SHEET: 1 of 2

CONDITIONS ENCOUNTERED | SAMPLE | TESTING

Groundwater: No free groundwater observed

Depth (m)	Description of Strata	Origin	Consis./Density	Moisture	Weath.	Rock Depth (m)	Strength	Recovery (%)	RQD	Defects & Remarks
0.03	TOPSOIL, silt and organics, dry									
	Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel.	RS	VSt to H	w<PL						
1.00	Sandy CLAY, with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel.	XWM	H to Fr	w<PL						
2.57	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly				HW	2.57	VL	100	22	2.63-2.74m: FC
					XW	2.95	SEAM			2.95-3.07m: CS
					HW	3.07	VL			3.56-3.63m: FC; 3.85m: JT x2, SV, UN, Tl Clay, RF, extends from 3.63m to 4.03m
					XW	4.03	SEAM			4.03-4.31m: CS
					HW	4.31	L			
4.80	CORE LOSS					4.80		62	62	
5.25	SANDSTONE: pale brown with orange brown iron staining, fine to coarse				HW	5.25	M			

RL (m): 188, 187, 186, 185, 184

Sample Type	Depth (m)	Test Type	Results and Remarks
D	0.50		
SPT	1.00–1.29	SPT	15,25/140
		PP	>400kPa
SPT	2.50–2.57	SPT	25/70
		PP	>400kPa
		PLT	PL(A)=0.03MPa
		PLT	PL(D)=0.04MPa
		PLT	PL(A)=0.22MPa
		PLT	PL(D)=0.25MPa
	5.40		

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

PLANT: Truck Mounted Drill Rig
METHOD:
REMARKS:
OPERATOR: Ground Test
CASING: HQ to 2.5m
LOGGED: Chaplin

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 188.5 AHD
COORDINATE: E:303165.7, N:6430215.6
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 15
PROJECT No: 224763.00
DATE: 02/09/23

DEPTH (m)	DESCRIPTION OF STRATA	WEATH.	DEPTH (m)	STRENGTH	RECOVERY (%)	RQD	DEFECTS & REMARKS	SAMPLE TYPE
	grained; pebbly	HW	5.81	M	62	62		UCS
		MW	6.03					
6.03	CORE LOSS		6.12					
6.12	SANDSTONE: pale brown with orange brown iron staining, fine to coarse grained; pebbly	MW	6.21		75	0	6.19-6.26m: FC 6.30m: JT, SV, UN, RF, extends from 6.26m to 6.35m 6.35m: P, SH, PR, RF	
	6.50m: colour becomes grey	FR		M	100	100		
					100	100	9.87m: JT/70°, PR, Fe, RF	
10.00	Borehole discontinued at 10.00m depth. Limit of investigation.							

RL (m): 182, 181, 180, 179

TESTING

DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
5.75	PLT	PL(A)=0.34MPa
	PLT	PL(D)=0.45MPa
6	PLT	PL(D)=0.36MPa
	PLT	PL(A)=0.55MPa
	PLT	PL(D)=0.42MPa
7	PLT	PL(A)=0.31MPa
	PLT	PL(D)=0.4MPa
8	PLT	PL(D)=0.56MPa
	PLT	PL(A)=0.53MPa
	PLT	PL(D)=0.56MPa
	PLT	PL(A)=0.31MPa
9	PLT	PL(A)=0.4MPa
	PLT	PL(D)=0.34MPa
	PLT	PL(D)=0.55MPa
	PLT	PL(A)=0.51MPa
	PLT	PL(D)=0.5MPa

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

PLANT: Truck Mounted Drill Rig
METHOD:
REMARKS:

OPERATOR: Ground Test
CASING: HQ to 2.5m

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 183.0 AHD
COORDINATE: E:303255.0, N:6430281.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 16
PROJECT No: 224763.00
DATE: 27/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	183	0.00	FILL / SILT (ML), with sand, trace gravel: dark brown; low plasticity; interbedded pale brown ash. 0.00m-0.05m: with coal fragments scattered		FILL	NA	w<PL		D	0.30–0.50	0.30, 0.50		
	182	1							D	1.00–1.10	1.00, 1.10		
		1.10	Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to coarse, rounded to sub-rounded gravel.		RS	H to Fr	w<PL		SPT	1.00–1.45	1.00, 1.45	SPT	7,10,15 N=25
												PP	>400kPa
									D	1.45–1.50	1.45, 1.50		
									U50	1.50–1.73	1.50, 1.73		
	181	2											
									SPT	2.50–2.78	2.50, 2.78	SPT	9,25/130
												PP	>400kPa
		2.78	Borehole discontinued at 2.78m depth. Limit of investigation.										

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger with TC bit to 2.78m
REMARKS:

OPERATOR: Ground Test
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics | Environment | Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 181.7 AHD
COORDINATE: E:303255.2, N:6430296.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 17
PROJECT No: 224763.00
DATE: 27/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed			FILL / SILT (ML), with sand, with gravel: dark brown; low plasticity; fine to coarse sand; fine to coarse, sub-angular to sub-rounded gravel; contains coal fragments.	FILL	NA	w<PL		D	0.30–0.50		
								U50	0.50–0.66	PP	>400kPa (0.66)
		1.00	Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse, rounded to sub-rounded gravel.	RS	H	w<PL		SPT	1.00–1.45	SPT	10,14,17 N=31
									1.45	PP	>400kPa
								SPT	2.50–2.64	SPT	25/140
	179	2.64	Borehole discontinued at 2.64m depth. Limit of investigation.						2.64	PP	>400kPa

RL scale: 181, 180, 179

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger with TC bit to 2.64m
REMARKS:

OPERATOR: Ground Test
CASING: Nil

LOGGED: Chaplin

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Point Road, Muswellbrook, NSW

SURFACE LEVEL: 183.0 AHD
COORDINATE: E:303151.9, N:6430268.6
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 9
PROJECT No: 224763.00
DATE: 19/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.03	TOPSOIL, silt and organics, dry								
			Sandy CLAY (CI), with gravel: orange brown; medium plasticity; fine to coarse sand; fine to medium, rounded to sub-rounded gravel.	RS possibly XWM	H to Fr	w<PL		B	0.00–0.50		
	182	1						U75	1.00–1.21	PP	>400kPa (1.21)
								SPT	1.21–1.66	SPT	9,21,25 N=46
									1.66	PP	>400kPa
	181	2	2.30m: increase in drill resistance indicative of rock								
		2.40	Borehole discontinued at 2.40m depth. TC bit refusal at 2.4m, on sandstone.								

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

PLANT: Truck Mounted Drill Rig
METHOD: Solid flight auger with TC bit to 2.4m
REMARKS:

OPERATOR: Ground Test
CASING: Nil

LOGGED: Chaplin

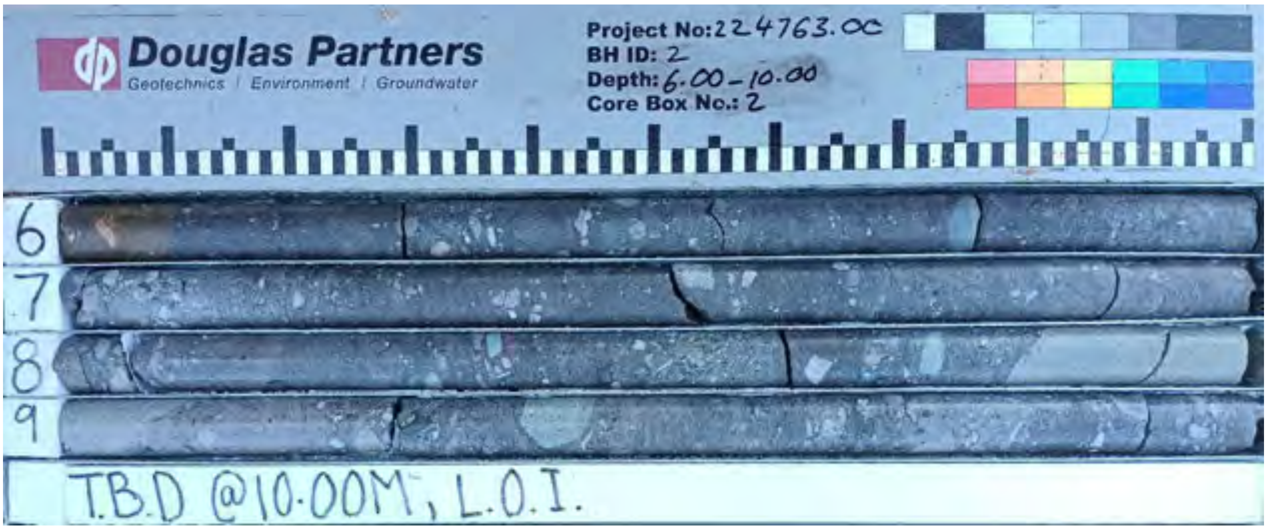
Refer to explanatory notes for symbol and abbreviation definitions

Bore 1 – 3.52 m to 7.0 m

Bore 1 – 7.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	214763.00
	New 132KV Sub-Transmission Substation	PLATE No:	1
	20 Sandy Creek Road, Muswellbrook	REV:	0
	CLIENT: Ausgrid	DATE:	12-Oct-23

Bore 2 – 2.05 m to 6.0 m



Bore 1 – 6.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	214763.00
	New 132KV Sub-Transmission Substation	PLATE No:	2
	20 Sandy Creek Road, Muswellbrook	REV:	0
	CLIENT: Ausgrid	DATE:	12-Oct-23

Bore 4 – 4.66 m to 9.0 m

Bore 4 – 9.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	214763.00
	New 132KV Sub-Transmission Substation	PLATE No:	3
	20 Sandy Creek Road, Muswellbrook	REV:	0
	CLIENT: Ausgrid	DATE:	12-Oct-23

Bore 6 – 4.02 m to 8.0 m

Bore 6 – 8.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates** **New 132KV Sub-Transmission Substation** **20 Sandy Creek Road, Muswellbrook**	PROJECT:	214763.00
		PLATE No:	3
		REV:	0
	CLIENT: Ausgrid	DATE:	12-Oct-23

Bore 10 – 1.15 m to 5.0 m

Bore 10 – 5.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates** **New 132KV Sub-Transmission Substation** **20 Sandy Creek Road, Muswellbrook**	PROJECT:	214763.00
		PLATE No:	5
		REV:	0
	CLIENT: Ausgrid	DATE:	12-Oct-23

Bore 11 – 2.16 m to 5.0 m

Bore 11 – 5.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	214763.00
	New 132KV Sub-Transmission Substation	PLATE No:	6
	20 Sandy Creek Road, Muswellbrook	REV:	0
	CLIENT: Ausgrid	DATE:	12-Oct-23

Bore 13 – 4.3 m to 8.0 m

Bore 13 – 8.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates** **New 132KV Sub-Transmission Substation** **20 Sandy Creek Road, Muswellbrook**	PROJECT: PLATE No: REV:	214763.00 7 0
	CLIENT: Ausgrid	DATE:	12-Oct-23

Bore 14 – 2.66 m to 6.0 m

Bore 14 – 6.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	214763.00
	New 132KV Sub-Transmission Substation	PLATE No:	8
	20 Sandy Creek Road, Muswellbrook	REV:	0
	CLIENT: Ausgrid	DATE:	12-Oct-23

Bore 15 – 2.57 m to 6.0 m

Bore 15 – 6.0 m to 10.0 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	214763.00
	New 132KV Sub-Transmission Substation	PLATE No:	9
	20 Sandy Creek Road, Muswellbrook	REV:	0
	CLIENT: Ausgrid	DATE:	12-Oct-23

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 176.0 AHD
COORDINATE: E:303248.8, N:6430334.2
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 101-1
PROJECT No: 224763.01
DATE: 20/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	176	0.00	FILL / Sandy CLAY (CL), with silt, trace gravel: brown; low plasticity; fine to medium, sub-angular gravel.		FILL	ND	w<PL	PFAS/	D/ES		0.10	PID	1ppm
		0.20	FILL / Sandy GRAVEL (GP): grey dark grey; fine to coarse, angular to sub-angular; fine to medium sand; gravels comprise coal reject and imported gravels.		FILL	ND	D		D/ES		0.30	PID	<1ppm
								PFAS/	D/ES		0.50	PID	1ppm
	175	0.60	FILL / Gravelly SAND (SP): pale brown pale grey; fine; fine to coarse, angular to sub-rounded gravel; inclusions of concrete, brick, metal bars, copper wires and tile.		FILL	ND	D		B		0.60–0.80		
									D/ES		1.00	PID	<1ppm
								PFAS/	D/ES		1.50	PID	<1ppm
	174	2.00	Test Pit discontinued at 2.00m depth. Limit of investigation.								2		

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.5 AHD
COORDINATE: E:303248.4, N:6430339.3
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 101-2
PROJECT No: 224763.01
DATE: 20/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.00–0.15	FILL / Sandy CLAY (CL), with silt, trace gravel: brown; low plasticity; fine to medium, sub-angular gravel.		FILL	ND	w<PL		D/ES	0.10		
	175	0.15–1.10	FILL / Sandy GRAVEL (GP): grey dark grey; fine to coarse, angular to sub-angular; fine to medium sand; gravels comprise coal reject and imported gravels.		FILL	ND	D	PFAS/	B	0.20–0.40	PID	<1ppm (0.30)
									D/ES	0.40		
									D/ES	0.80	PID	<1ppm (0.80)
											PID	<1ppm (1)
		1.10–1.30	FILL / Gravelly SAND (SP): pale brown pale grey; fine; fine to coarse, angular to sub-rounded gravel; inclusions of concrete, brick, metal rods, copper wires and tile.		FILL	ND	D	PFAS/	D/ES	1.20	PID	<1ppm (1.20)
	174	1.30	Test Pit discontinued at 1.30m depth. Refusal on concrete.									
	173											

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.1 AHD
COORDINATE: E:303247.4, N:6430348.4
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 101-3
PROJECT No: 224763.01
DATE: 20/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	175	0.00	FILL / Sandy CLAY (CL), with silt, trace gravel: brown; low plasticity; fine to medium, sub-angular gravel.	FILL	ND	w<PL	PFAS/	D/ES	0.10	PID	<1ppm
								D/ES	0.30	PID	<1ppm
		0.50	FILL / Sandy GRAVEL (GP): grey dark grey; fine to coarse, angular to sub-angular; fine to medium sand; gravels comprise coal reject and imported gravels.	FILL	ND	D		D/ES	0.60	PID	<1ppm
	174	0.80	FILL / Gravelly SAND (SP): pale brown pale grey; fine; fine to coarse, angular to sub-rounded gravel; inclusions of concrete, brick, metal rods, copper wires and tile.	FILL	ND	D		B	0.80–1.00		
							PFAS/	D/ES	1.00	PID	<1ppm
		1.20	Test Pit discontinued at 1.20m depth. Refusal on concrete.								
	173	2							2		

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

PLANT: Hyundai 210LC-9 21.0T Excavator
METHOD: 450mm bucket wth teeth
REMARKS:

OPERATOR: JE & J Robinson
LOGGED: Helbig

Refer to explanatory notes for symbol and abbreviation definitions

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 174.9 AHD
COORDINATE: E:303246.5, N:6430354.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 101-4
PROJECT No: 224763.01
DATE: 20/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed			FILL / Sandy CLAY (CL), with silt, trace gravel: brown; low plasticity; fine to medium, sub-angular gravel.		FILL	ND	w<PL		D/ES		0.10	PID	<1ppm
		0.30	FILL / Sandy GRAVEL (GP): grey dark grey; fine to coarse, angular to sub-angular; fine to medium sand; gravels comprise coal reject and imported gravels.		FILL	ND	D		D/ES		0.50	PID	<1ppm
		0.60	FILL / Gravelly SAND (SP): pale brown pale grey; fine; fine to coarse, angular to sub-rounded gravel; inclusions of concrete, brick, metal rods, copper wires and tile.		FILL	ND	D		D/ES		0.80	PID	1ppm
	174	0.90	Sandy CLAY (CI): grey mottled orange; medium plasticity; fine to medium sand.		RS	ND	w<PL				1	PP	330-350kPa
								PFAS/	D/ES		1.20	PID	<1ppm
		1.40	Test Pit discontinued at 1.40m depth. Limit of investigation.										
	173	2									2		
	172												

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 174.9 AHD
COORDINATE: E:303244.9, N:6430364.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 101-5
PROJECT No: 224763.01
DATE: 20/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		FILL / Sandy CLAY (CL), with silt, trace gravel: brown; low plasticity; fine to medium, sub-angular gravel.	FILL	ND	w<PL	, PFAS/	D/ES	0.10	PID	<1ppm
	0.25	FILL / Sandy GRAVEL (GP): grey dark grey; fine to coarse, angular to sub-angular; fine to medium sand; gravels comprise coal reject and imported gravels.	FILL	ND	D		D/ES	0.30	PID	1ppm
	0.40	FILL / Gravelly SAND (SP): pale brown pale grey; fine; fine to coarse, angular to sub-rounded gravel; inclusions of concrete, brick, metal rods, copper wires and tile.	FILL	ND	D		B	0.40–0.50		
							B	0.70		
							D/ES	0.80	PID	<1ppm
	1.20	Sandy CLAY (CI): grey mottled orange; medium plasticity; fine to medium sand.	RS	ND	w<PL		D/ES	1.30	PID	<1ppm
	1.40	Test Pit discontinued at 1.40m depth. Limit of investigation.								

RL (m): 174, 173, 172

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
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TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 174.7 AHD
COORDINATE: E:303243.1, N:6430378.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 101-6
PROJECT No: 224763.01
DATE: 20/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE
No free groundwater observed	0.10	FILL / Sandy CLAY (CL), with silt, trace gravel: brown; low plasticity; fine to medium, sub-angular gravel.	FILL	ND	w<PL
	0.20	FILL / Sandy GRAVEL (GP): grey dark grey; fine to coarse, angular to sub-angular; fine to medium sand; gravels comprise coal reject and imported gravels.	FILL	ND	D
	0.80	FILL / Gravelly SAND (SP): pale brown pale grey; fine; fine to coarse, angular to sub-rounded gravel; inclusions of concrete, brick, metal rods, copper wires, tile, ACM, concrete pipe.	FILL	ND	D
	1.80	Sandy CLAY (CI): grey mottled orange; medium plasticity; fine to medium sand.	RS	ND	w<PL
		Test Pit discontinued at 1.80m depth. Limit of investigation.			

RL (m): 174, 173, 172

SAMPLE REMARKS	SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	D/ES	0.05	PID	<1ppm
	D/ES	0.15	PID	<1ppm
0.6	B	0.40		
PFAS/	D/ES	0.70	PID	<1ppm
	B	1.00 – 1.30		
	D/ES	1.50	PID	<1ppm

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 176.1 AHD
COORDINATE: E:303293.2, N:6430349.4
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-1
PROJECT No: 224763.01
DATE: 18/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	176		FILL / SAND (SP), with silt, trace gravel: brown; fine to medium; fine to coarse, sub-angular to sub-rounded, imported gravel; inclusions of concrete.		FILL	ND	M		D/ES		0.10	PID	<1ppm
								PFAS/	D/ES		0.30	PID	<1ppm
		0.40	FILL / Gravelly SAND (SP): pale brown; fine to medium; fine to coarse, angular to sub-angular gravel; inclusions of concrete, reinforced bar, ceramic, timber, coal reject, metal platting and wire.		FILL	ND	M		D/ES		0.60	PID	<1ppm
	175	1									1		
								PFAS/	D/ES		1.20	PID	<1ppm
		1.50	Clayey SAND (SP), with gravel: brown mottled orange; fine to coarse; fine to medium, sub-rounded gravel.		XWM	ND	M		D/ES		1.80	PID	<1ppm
		2.00	SANDSTONE: pale grey, low to medium strength, highly weathered			NA	NA				2		
	174	2.10	Test Pit discontinued at 2.10m depth. Limit of investigation.										

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.1 AHD
COORDINATE: E:303223.5, N:6430345.3
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-10
PROJECT No: 224763.01
DATE: 19/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.00–0.30	FILL / Clayey SAND (SP), with silt, trace gravel: brown; fine to medium; fine to medium, sub-rounded gravel; rootlets.	FILL	ND	D		D/ES	0.10	PID	<1ppm
	0.30–0.80	FILL / Gravelly SAND (SP): dark grey; fine to medium; fine to coarse, angular to sub-rounded gravel; comprising imported sedimentary and igneous, as well as coal reject, inclusions of concrete, brick, steel, beaming, tile.	FILL	ND	M	PFAS/	B, D/ES	0.40, 0.50, 0.60	PID	1ppm
	0.80–1.00	FILL / Sandy GRAVEL (GP): brown red; fine to coarse, angular to sub-rounded; fine to medium sand.	FILL	ND	D		D/ES	0.90	PID	<1ppm
	1.00–1.50	SAND (SP), with clay: orange grey; fine to coarse; grading to rock.	XWM	ND	D		D/ES	1.40	PID	<1ppm
	1.50–1.60	SANDSTONE: orange grey, low to medium strength, highly weathered		NA	NA					

RL (m): 175, 174, 173

Test Pit discontinued at 1.60m depth.
Refusal on rock.

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.1 AHD
COORDINATE: E:303212.6, N:6430345.4
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-11
PROJECT No: 224763.01
DATE: 20/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	175	0.00–0.20	FILL / Sandy CLAY (CL), trace gravel: brown orange; low plasticity; fine to medium, sub-angular to sub-rounded gravel; with rootlets, coal reject.		FILL	ND	w<PL	PFAS/	D/ES	0.10	PID	<1ppm
		0.20–0.60	FILL / Gravelly SAND (SP): dark grey; fine to medium; (gravels comprise angular to sub-angular imported graves and coal reject), inclusion of brick, concrete, steel beams, copper wire.		FILL	ND	M		B	0.20–0.40		
									B	0.50	PID	<1ppm
		0.60–0.90	FILL / Sandy GRAVEL (GP): pale brown red; fine to coarse, angular to sub-angular; fine to medium sand.		FILL	ND	M		D/ES	0.60		
								PFAS/	D/ES	0.80	PID	<1ppm
	174	0.90	Test Pit discontinued at 0.90m depth. Refusal on concrete.									
	173	1, 2								1, 2		

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.2 AHD
COORDINATE: E:303203.3, N:6430345.5
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-12
PROJECT No: 224763.01
DATE: 20/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	175	0.25	FILL / Sandy CLAY (CL), trace gravel: brown orange; low plasticity; fine to medium, sub-angular to sub-rounded gravel; with rootlets, coal reject.		FILL	ND	w<PL		D/ES	0.10	PID	1ppm
		1.00	FILL / Gravelly SAND (SP): dark grey; fine to medium; (gravels comprise angular to sub-angular imported graves and coal reject), inclusion of brick, concrete, steel beams, copper wire.		FILL	ND	M	PFAS/	D/ES	0.30	PID	1ppm
									B	0.30–0.60		
									D/ES	0.80	PID	<1ppm
	174	1.70	Sandy CLAY (CI): grey mottled orange; medium plasticity; fine to medium sand. From 1.20m: grading to extremely weathered rock		RS	ND	w<PL	PFAS/	B	1.00–1.20		
									D/ES	1.10	PID	<1ppm
										1.20	PP	>400kPa
									D/ES	1.60	PID	<1ppm
		1.90	SANDSTONE: orange grey, low to medium strength, highly weathered			NA	NA		D	1.80	PID	<1ppm
	173	2	Test Pit discontinued at 1.90m depth. Refusal on rock.							2		

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.8 AHD
COORDINATE: E:303289.4, N:6430349.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-2
PROJECT No: 224763.01
DATE: 18/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.00	FILL / SAND (SP), with silt, trace gravel: brown; fine to medium; fine to coarse, sub-angular to sub-rounded, imported gravel; inclusions of concrete.		FILL	ND	M		D/ES	0.10	PID	<1ppm
							PFAS/	D/ES	0.30	PID	<1ppm
	0.55	FILL / Gravelly SAND (SP): pale brown; fine to medium; fine to coarse, angular to sub-angular gravel; inclusions of concrete, reinforced bar, ceramic, timber, coal reject, metal platting and wire.		FILL	ND	M		D/ES	0.60	PID	<1ppm
							PFAS/	D/ES	1.20	PID	<1ppm
	1.50	Clayey SAND (SP), with gravel: brown mottled orange; fine to coarse; fine to medium, sub-rounded gravel.		XWM	ND	M		D/ES	1.80	PID	<1ppm
	1.90	SANDSTONE: pale grey, low to medium strength, highly weathered			NA	NA					
	2.00	Test Pit discontinued at 2.00m depth. Refusal on rock.									

RL (m): 175, 174, 173

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.7 AHD
COORDINATE: E:303285.4, N:6430348.9
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-3
PROJECT No: 224763.01
DATE: 18/09/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.00	FILL / SAND (SP), with silt, with gravel: brown; fine to medium; fine to coarse, angular to sub-rounded gravel; inclusions of reinforced bar, concrete, coal reject, ceramic, timber, ACM, bricks.		FILL	ND	M		D/ES		0.10	PID	<1ppm
								PFAS/	D/ES		0.50	PID	1ppm
	175												
		1							D/ES		1.00	PID	<1ppm
		1.40	FILL / Gravelly SAND (SP): pale brown; fine to medium; fine to coarse, angular to sub-rounded gravel; with imported igneous and sedimentary cobbles and boulders up to 250mm in size.		FILL	ND	D	PFAS/	D/ES		1.60	PID	<1ppm
	174												
		1.90	Sandy CLAY (CL), trace gravel: grey mottled orange; low plasticity; fine sand; fine to medium, sub-angular to sub-rounded gravel.		RS	ND	w>PL w=PL		D/ES		1.95	PID	1ppm
		2.00	SANDSTONE: pale grey, low to medium strength, ,highly weathered			NA	NA				2	PP	>400kPa
		2.10	Test Pit discontinued at 2.10m depth. Refusal on rock.										
	173												

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.5 AHD
COORDINATE: E:303277.8, N:6430348.2
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-4
PROJECT No: 224763.01
DATE: 18/09/23

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE: REMARKS	SAMPLE: TYPE	SAMPLE: INTERVAL / DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.00	FILL / SAND (SP), with silt, with gravel: brown; fine to medium; fine to coarse, angular to sub-angular gravel; inclusions of concrete, coal reject, rubber, sheet metal, bricks.	FILL	ND	D to M		B	0.30		
	175	0.50	FILL / Silty SAND (SP), with gravel: dark brown; fine to medium; fine to medium, angular gravel; comprising coal reject.	FILL	ND	D					
		0.90	FILL / Gravelly SAND (SP): pale brown; fine to medium; fine to coarse, angular to sub-rounded gravel; with imported igneous and sedimentary cobbles and boulders up to 250mm in size.	FILL	ND	D					
	174	1.60	Clayey SAND (SP): red brown; fine to coarse.	RS	ND	ND					
	173	2.20	Test Pit discontinued at 2.20m depth. Limit of investigation.								

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

PLANT: Hyundai 210LC-9 21.0T Excavator
METHOD: 450mm bucket wth teeth
REMARKS:

OPERATOR: JE & J Robinson
LOGGED: Helbig

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.4 AHD
COORDINATE: E:303274.6, N:6430348.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-5
PROJECT No: 224763.01
DATE: 19/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.00–0.50	FILL / SAND (SP), with clay, with silt: brown; fine to medium; rootlets to 0.05m, inclusions of concrete, metal wire, reinforced bar, coal reject.	FILL	ND	M	PFAS/	D/ES	0.10	PID	<1ppm
							B	0.20–0.50		
								0.30	PID	<1ppm
	0.50–0.80	FILL / Silty SAND (SP), with gravel: dark brown; fine to medium; fine to medium, angular gravel; comprising coal reject.	FILL	ND	D		D/ES	0.30–0.50		
						PFAS/	D/ES	0.70	PID	<1ppm
	0.80–1.40	FILL / Gravelly SAND (SP): pale brown; fine to medium; fine to coarse, angular to sub-rounded gravel; with imported igneous and sedimentary cobbles and boulders up to 250mm in size.	FILL	ND	D		D/ES	1.00	PID	<1ppm
	1.40–1.80	Clayey SAND (SP), with gravel: pale brown orange; fine to coarse; fine to coarse, sub-angular to sub-rounded gravel.	XWM	ND	M		D/ES	1.60	PID	<1ppm
	1.80	Test Pit discontinued at 1.80m depth. Limit of investigation.								

RL (m): 175, 174, 173

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.3 AHD
COORDINATE: E:303262.3, N:6430347.0
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-6
PROJECT No: 224763.01
DATE: 19/09/23
SHEET: 1 of 1

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	0.00–0.50	FILL / SAND (SP), with clay, with silt: brown; fine to medium; rootlets to 0.05m, inclusions of concrete, metal wire, reinforced bar, coal reject.	FILL	ND	M		D/ES; B; D/ES	0.10; 0.20; 0.30	PID; PID	<1ppm (0.10); <1ppm (0.30)
	0.50–0.90	FILL / Silty SAND (SP), with gravel: dark brown; fine to medium; fine to medium, angular gravel; comprising coal reject.	FILL	ND	D	PFAS/	D/ES	0.60	PID	<1ppm
	0.90–1.10	FILL / Gravelly SAND (SP): pale brown; fine to medium; fine to coarse, angular to sub-rounded gravel; with imported igneous and sedimentary cobbles and boulders up to 250mm in size.	FILL	ND	D		D/ES	1.00	PID	1ppm
	1.10–1.80	Sandy CLAY (CL): grey mottled orange; low plasticity; fine to medium sand.	RS	ND	w>PL w=PL	PFAS/	D/ES	1.50	PP; PID	300-320kPa; <1ppm (1.50)
	1.80	Test Pit discontinued at 1.80m depth. Limit of investigation.								

RL (m): 175, 174, 173

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.2 AHD
COORDINATE: E:303253.9, N:6430346.8
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-7
PROJECT No: 224763.01
DATE: 19/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	175		FILL / SAND (SP), with silt, with gravel: brown; fine to coarse; fine to coarse, sub-angular to sub-rounded gravel; inclusions of concrete, metal frame, coal reject, concrete pipe (ACM), fibro, rubber hosing (ACM), cables.		FILL	ND	M	PFAS/	D/ES, B	0.20	PID	<1ppm
		0.30	FILL / Gravelly SAND (SP), with silt: dark grey; fine to medium; fine to coarse, angular gravel; comprising imported igneous and coal reject, inclusions of concrete.		FILL	ND	M	PFAS/	B, D/ES	0.30, 0.40, 0.50, 0.60	PID	<1ppm
		0.70	FILL / Gravelly SAND (SP): pale brown; fine to medium; fine to coarse, angular to sub-rounded gravel; with imported igneous and sedimentary cobbles and boulders up to 250mm in size.		FILL	ND	D		D/ES	0.90	PID	<1ppm
	174, 173	1.00	Test Pit discontinued at 1.00m depth. Refusal on concrete slab.									

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.1 AHD
COORDINATE: E:303239.2, N:6430346.1
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-8
PROJECT No: 224763.01
DATE: 19/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed	175	0.00–0.20	FILL / Clayey SAND (SP), with silt, trace gravel: brown; fine to medium; fine to medium, sub-rounded gravel; rootlets.		FILL	ND	D		D/ES	0.10	PID	<1ppm
		0.20–0.70	FILL / Gravelly SAND (SP), with silt: dark grey; fine to medium; fine to coarse, angular gravel; comprising imported igneous and coal reject, inclusions of concrete.		FILL	ND	M		B (0.20–0.50)			
									D/ES	0.50	PID	<1ppm
		0.70–0.85	FILL / Sandy GRAVEL (GP): brown red; fine to coarse, sub-angular to sub-rounded; fine to medium sand.		FILL	ND	D	PFAS/	D/ES	0.80	PID	1ppm
	174	0.85–1.20	Sandy CLAY (CL): grey mottled orange; low plasticity; fine to medium sand.		RS	ND	w>PL w=PL		D/ES	1.00	PID PP	<1ppm 250->400kPa
		1.20–1.30	SANDSTONE: grey orange, medium strength, moderately weathered			NA	NA					
	173	1.30	Test Pit discontinued at 1.30m depth. Refusal on rock.									

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

TEST PIT LOG

CLIENT: Ausgrid
PROJECT: Proposed Muswellbrook Substation
LOCATION: 20 Sandy Creek Road, Muswellbrook, NSW

SURFACE LEVEL: 175.0 AHD
COORDINATE: E:303229.9, N:6430345.8
DATUM/GRID: MGA2020 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: 102-9
PROJECT No: 224763.01
DATE: 19/09/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL / DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
No free groundwater observed		0.15	FILL / Clayey SAND (SP), with silt, trace gravel: brown; fine to medium; fine to medium, sub-rounded gravel; rootlets.		FILL	ND	D		D/ES	0.10	PID	<1ppm
		0.60	FILL / Gravelly SAND (SP), with silt: dark grey; fine to medium; fine to coarse, angular gravel; comprising imported igneous and coal reject, inclusions of concrete.		FILL	ND	M		B	0.20–0.60		
										0.30	PID	<1ppm
	174	1.00	FILL / Sandy GRAVEL (GP): brown red; fine to coarse, sub-angular to sub-rounded; fine to medium sand.		FILL	ND	D		D/ES	0.60		
									D/ES	0.70	PID	<1ppm
			Test Pit discontinued at 1.00m depth. Refusal on concrete.									
	173	2										

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

PLANT: Hyundai 210LC-9 21.0T Excavator
OPERATOR: JE & J Robinson
LOGGED: Helbig
METHOD: 450mm bucket wth teeth
REMARKS:

Refer to explanatory notes for symbol and abbreviation definitions

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Appendix B

Laboratory Testing – Geotechnical
Laboratory Testing – Thermal Resistivity by Geotherm Australia

Material Test Report

Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676A
Date Sampled:	29/10/2023
Dates Tested:	18/10/2023 - 18/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH01, Depth: 0.5-0.85m**
Material:	Sandy Clay

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ilac-MRA NATA

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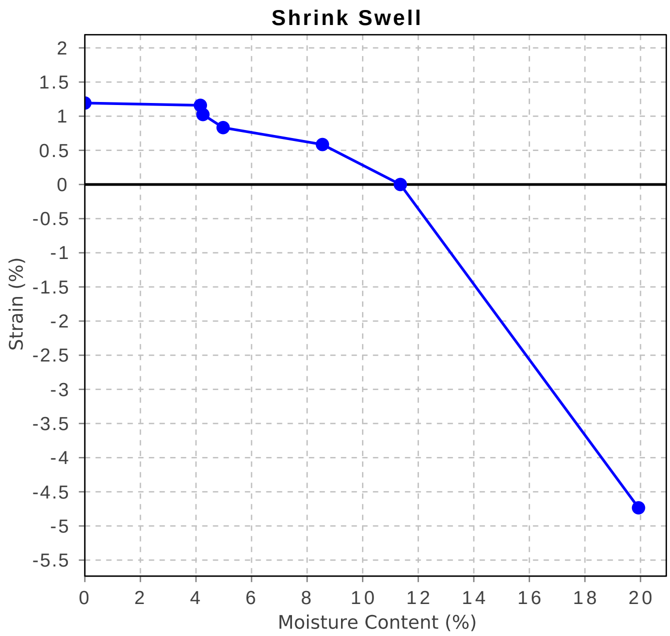
Approved Signatory: Peter Gorseski
Laboratory Manager
Laboratory Accreditation Number: 828

Shrink Swell Index (AS 1289 7.1.1 & 2.1.1)	
Iss (%)	**2.0**
Visual Description	Sandy Clay
* Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.	

Core Shrinkage Test	
Shrinkage Strain - Oven Dried (%)	**1.2**
Estimated % by volume of significant inert inclusions	5
Cracking	Slightly Cracked
Crumbling	No
Moisture Content (%)	11.4

Swell Test	
Initial Pocket Penetrometer (kPa)	>600
Final Pocket Penetrometer (kPa)	310
Initial Moisture Content (%)	10.5
Final Moisture Content (%)	19.9
Swell (%)	**4.7**
* NATA Accreditation does not cover the performance of pocket penetrometer readings.	



Material Test Report

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Approved Signatory: Peter Gorseski
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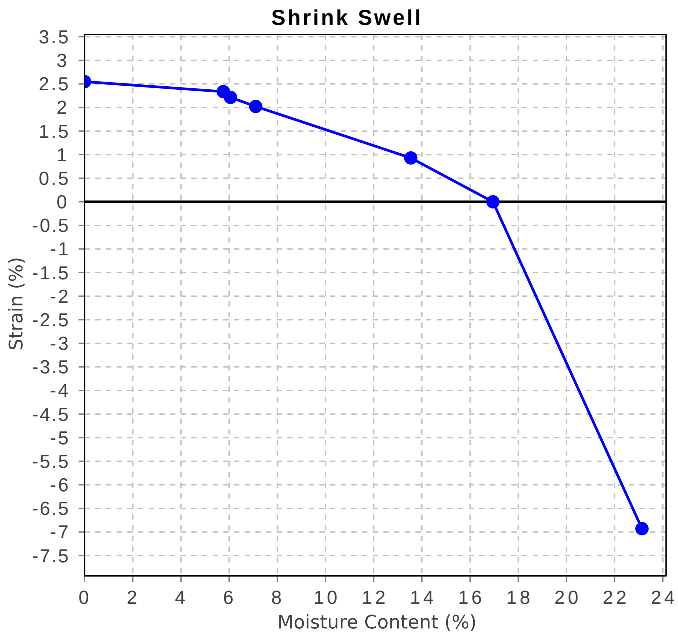
Laboratory Accreditation Number: 828

Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676B
Date Sampled:	29/10/2023
Dates Tested:	18/10/2023 - 18/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH05, Depth: 0.5-0.86m**
Material:	Sandy Clay

Shrink Swell Index (AS 1289 7.1.1 & 2.1.1)	
Iss (%)	**3.3**
Visual Description	Sandy Clay
* Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.	

Core Shrinkage Test	
Shrinkage Strain - Oven Dried (%)	**2.5**
Estimated % by volume of significant inert inclusions	0
Cracking	Uncracked
Crumbling	No
Moisture Content (%)	16.9

Swell Test	
Initial Pocket Penetrometer (kPa)	>600
Final Pocket Penetrometer (kPa)	230
Initial Moisture Content (%)	14.9
Final Moisture Content (%)	23.1
Swell (%)	**6.9**
* NATA Accreditation does not cover the performance of pocket penetrometer readings.	



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Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676C
Date Sampled:	29/10/2023
Dates Tested:	19/10/2023 - 19/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH14, Depth: 0.5-0.81m**
Material:	Sandy Clay

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	46		
Plastic Limit (%)	21		
Plasticity Index (%)	**25**		

Material Test Report

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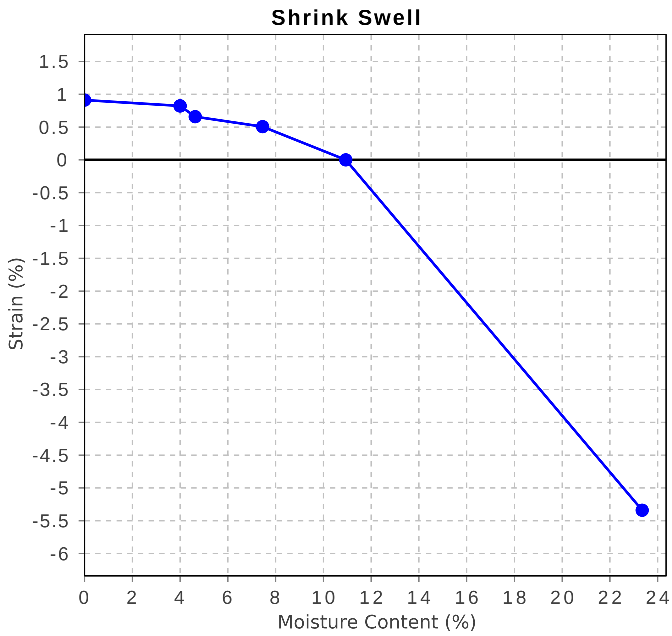
Laboratory Accreditation Number: 828

Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676D
Date Sampled:	29/10/2023
Dates Tested:	18/10/2023 - 18/10/2023
Sampling Method:	Sampled by Douglas Partners *The results apply to the sample as received*
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH16, Depth: 1.5-1.73m**
Material:	Sandy Clay

Shrink Swell Index (AS 1289 7.1.1 & 2.1.1)	
Iss (%)	**2.0**
Visual Description	Sandy Clay
* Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.	

Core Shrinkage Test	
Shrinkage Strain - Oven Dried (%)	**0.9**
Estimated % by volume of significant inert inclusions	0
Cracking	Uncracked
Crumbling	No
Moisture Content (%)	10.9

Swell Test	
Initial Pocket Penetrometer (kPa)	>600
Final Pocket Penetrometer (kPa)	340
Initial Moisture Content (%)	9.5
Final Moisture Content (%)	23.3
Swell (%)	**5.3**
* NATA Accreditation does not cover the performance of pocket penetrometer readings.	



Material Test Report

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Report Number: **224763.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224763.00
Project Name: Proposed Muswellbrook Substation
Project Location: Hebden Road, Muswellbrook NSW
Work Request: 10676
Sample Number: NC-10676E
Date Sampled: 29/10/2023
Dates Tested: 09/10/2023 - 09/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Preparation Method: AS 1289.1.1 - Sampling and preparation of soils
Sample Location: **BH2, Depth: 1.0-1.45m**
Material: Sandy Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Sandy Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	18.9		
* Mineral Present	Carbonate		

Material Test Report

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Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676F
Date Sampled:	29/10/2023
Dates Tested:	09/10/2023 - 09/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH5, Depth: 1.1-1.55m**
Material:	Sandy Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Sandy Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	18.8		
* Mineral Present	Carbonate		

Material Test Report

Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676G
Date Sampled:	29/10/2023
Dates Tested:	09/10/2023 - 09/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH8, Depth: 1.24-1.69m**
Material:	Sandy Clay

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Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**2**		
Soil Description	Sandy Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	20.0		

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Report Number: **224763.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224763.00
Project Name: Proposed Muswellbrook Substation
Project Location: Hebden Road, Muswellbrook NSW
Work Request: 10676
Sample Number: NC-10676H
Date Sampled: 29/10/2023
Dates Tested: 09/10/2023 - 09/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Preparation Method: AS 1289.1.1 - Sampling and preparation of soils
Sample Location: **BH9, Depth: 1.21-1.66m**
Material: Sandy Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Silty Sandy Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19.4		
* Mineral Present	Carbonate		

Material Test Report

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Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676I
Date Sampled:	29/10/2023
Dates Tested:	09/10/2023 - 09/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH14, Depth: 1.0-1.45m**
Material:	Sandy Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Silty Sandy Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19.4		
* Mineral Present	Carbonate		

Material Test Report

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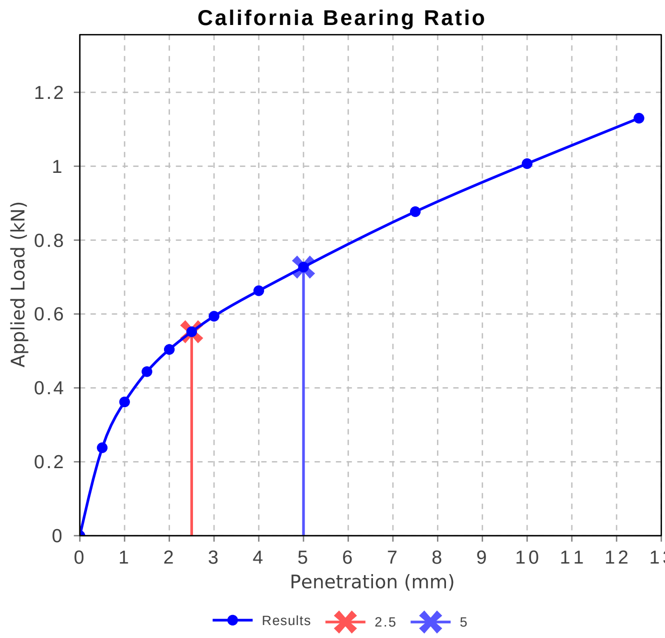
Report Number: **224763.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224763.00
Project Name: Proposed Muswellbrook Substation
Project Location: Hebden Road, Muswellbrook NSW
Work Request: 10676
Sample Number: NC-10676J
Date Sampled: 29/10/2023
Dates Tested: 16/10/2023 - 16/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Preparation Method: AS 1289.1.1 - Sampling and preparation of soils
Sample Location: **BH1, Depth: 0.0-0.5m**
Material: Sandy Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**4.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.63		
Optimum Moisture Content (%)	19.5		
Laboratory Density Ratio (%)	101.0		
Laboratory Moisture Ratio (%)	99.0		
Dry Density after Soaking (t/m^3)	1.62		
Field Moisture Content (%)	13.3		
Moisture Content at Placement (%)	19.1		
Moisture Content Top 30mm (%)	25.2		
Moisture Content Rest of Sample (%)	21.8		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	141.5		
Swell (%)	1.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



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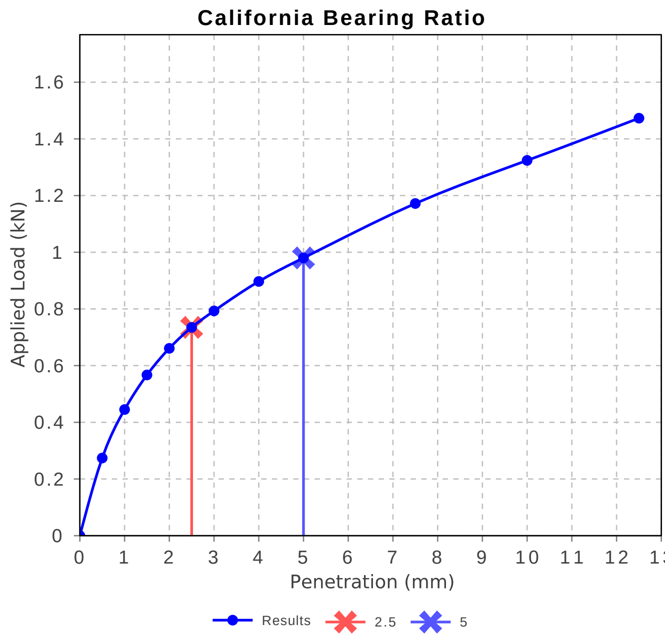
Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676K
Date Sampled:	29/10/2023
Dates Tested:	16/10/2023 - 16/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH5, Depth: 0.0-0.5m**
Material:	Sandy Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**6**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.83		
Optimum Moisture Content (%)	14.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	101.5		
Dry Density after Soaking (t/m^3)	1.80		
Field Moisture Content (%)	10.2		
Moisture Content at Placement (%)	14.9		
Moisture Content Top 30mm (%)	21.4		
Moisture Content Rest of Sample (%)	16.9		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	139.9		
Swell (%)	1.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



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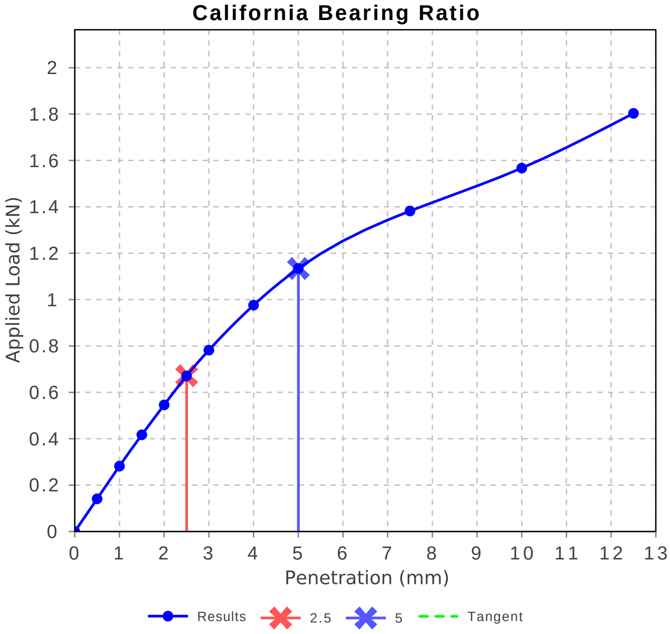
Report Number: **224763.00-1**
Issue Number: 1
Date Issued: 22/10/2023
Client: Ausgrid
Ausgrid, Sydney NSW 2000
Project Number: 224763.00
Project Name: Proposed Muswellbrook Substation
Project Location: Hebden Road, Muswellbrook NSW
Work Request: 10676
Sample Number: NC-10676L
Date Sampled: 29/10/2023
Dates Tested: 16/10/2023 - 16/10/2023
Sampling Method: Sampled by Douglas Partners
The results apply to the sample as received
Preparation Method: AS 1289.1.1 - Sampling and preparation of soils
Sample Location: **BH8, Depth: 0.0-0.5m**
Material: FILL: Clayey Silt with sand and gravel

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**6**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.81		
Optimum Moisture Content (%)	13.5		
Laboratory Density Ratio (%)	100.5		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.81		
Field Moisture Content (%)	9.0		
Moisture Content at Placement (%)	13.6		
Moisture Content Top 30mm (%)	14.9		
Moisture Content Rest of Sample (%)	14.9		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	139.8		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			



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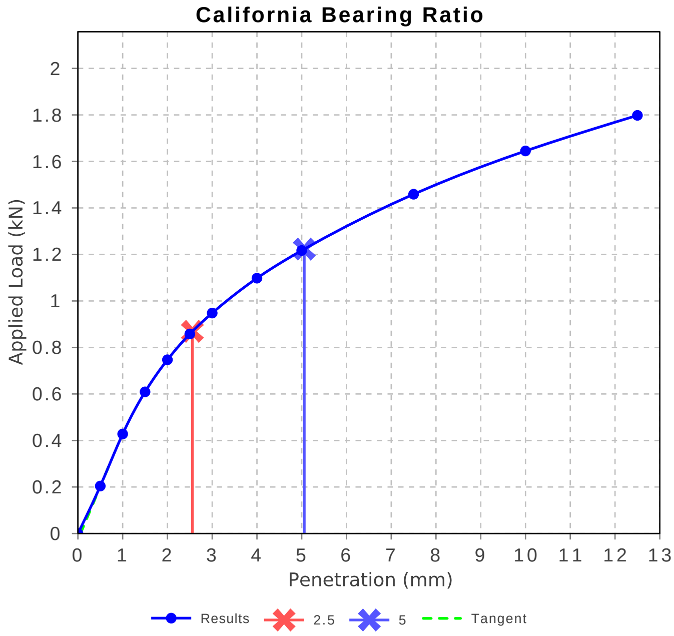
Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676M
Date Sampled:	29/10/2023
Dates Tested:	16/10/2023 - 16/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH9, Depth: 0.0-0.5m**
Material:	Sandy Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**7**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.77		
Optimum Moisture Content (%)	15.0		
Laboratory Density Ratio (%)	101.0		
Laboratory Moisture Ratio (%)	98.0		
Dry Density after Soaking (t/m^3)	1.79		
Field Moisture Content (%)	8.3		
Moisture Content at Placement (%)	14.6		
Moisture Content Top 30mm (%)	19.9		
Moisture Content Rest of Sample (%)	17.1		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	49.1		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Material Test Report

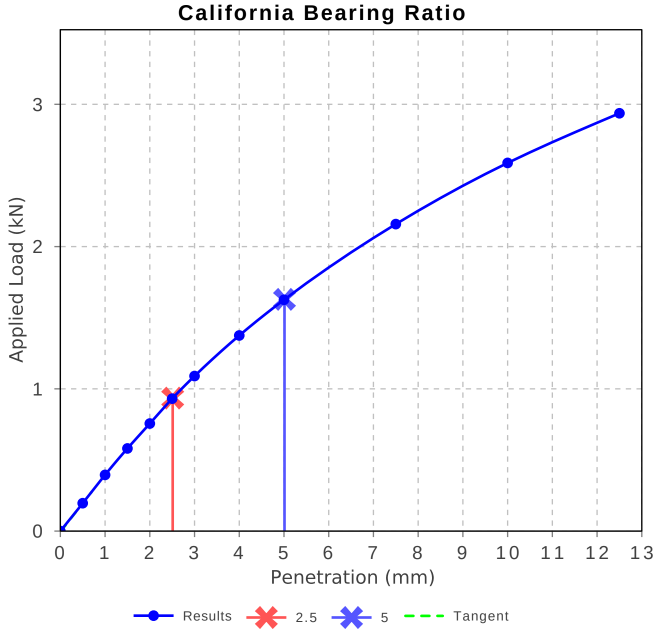
Report Number:	**224763.00-1**
Issue Number:	1
Date Issued:	22/10/2023
Client:	Ausgrid
	Ausgrid, Sydney NSW 2000
Project Number:	224763.00
Project Name:	Proposed Muswellbrook Substation
Project Location:	Hebden Road, Muswellbrook NSW
Work Request:	10676
Sample Number:	NC-10676N
Date Sampled:	29/10/2023
Dates Tested:	16/10/2023 - 16/10/2023
Sampling Method:	Sampled by Douglas Partners
	The results apply to the sample as received
Preparation Method:	AS 1289.1.1 - Sampling and preparation of soils
Sample Location:	**BH12, Depth: 0.55-1.05m**
Material:	Sandy Clay

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Newcastle Laboratory
15 Callistemon Close Warabrook Newcastle NSW 2310
Phone: (02) 4960 9600
Email: Peter.Gorseski@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Peter Gorseski
Laboratory Manager
Laboratory Accreditation Number: 828

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**8**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.85		
Optimum Moisture Content (%)	13.5		
Laboratory Density Ratio (%)	99.0		
Laboratory Moisture Ratio (%)	100.5		
Dry Density after Soaking (t/m^3)	1.83		
Field Moisture Content (%)	7.8		
Moisture Content at Placement (%)	13.6		
Moisture Content Top 30mm (%)	14.9		
Moisture Content Rest of Sample (%)	14.6		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	140.3		
Swell (%)	0.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



Test Report

Client : Douglas Partners	Project Number : 2135
	Project Details : Muswellbrook
	Order/Request Number :
Report Date : 26/10/2023	Report Number : 213501

Sample Details

Sample ID / Name / Number	TP1 - 1.0m
Soil Description	Light brown silty clay
Sampled by	Geotherm - as per procedure
Sample Type	Undisturbed
Date Sampled	21/9/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (^{O}C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
21/09/2023	Probe inserted into trench wall at 1.0m depth	As found	800	14.3	37.30	1.43	0.70

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (^{O}C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
11/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	9.1%	600	19.6	21.50	1.30	0.77
16/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	6.1%	500	18.6	20.00	1.00	1.00
18/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	2.9%	600	19.1	21.90	0.79	1.27
25/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	500	19.4	20.00	0.64	1.57

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density ($Kg/m^{3)}$)
A	175	60.5	928.7	1850

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BL. Wet specimens tested by BL. Dry and partially dry specimens tested by BH, BL,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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Website: www.geothermaust.com.au
ABN 35 097 576 611
NATA Accreditation Number 20321 – Site 24277

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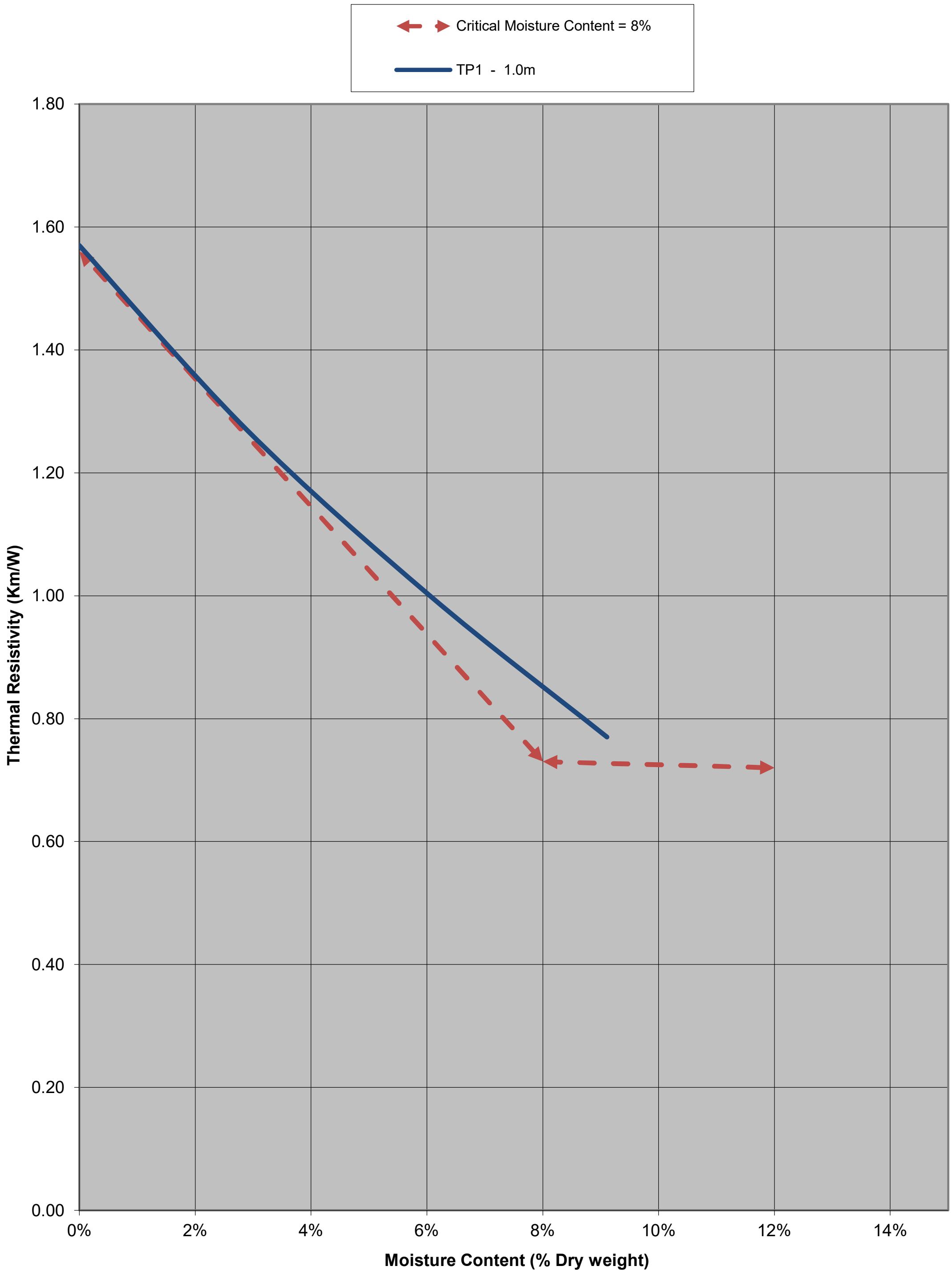
Dry-out Curve



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NATA Accreditation Number 20321 – Site 24277

Geotherm Australasia

Test Report

Client : Douglas Partners	**Project Number :** 2135
	Project Details : Muswellbrook
	Order/Request Number :
Report Date : 26/10/2023	**Report Number :** 213502

Sample Details

Sample ID / Name / Number	TP05 - 1.0m
Soil Description	Brown silty clay
Sampled by	Geotherm - as per procedure
Sample Type	Undisturbed
Date Sampled	21/9/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
21/09/2023	Probe inserted into trench wall at 1.0m depth	As found	800	15.7	37.30	1.15	0.87

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
11/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	10.1%	600	20.5	21.50	1.16	0.86
16/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	6.7%	400	19.5	20.00	1.00	1.00
17/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	3.3%	600	19.8	20.40	0.81	1.24
24/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	400	20.1	22.10	0.64	1.57

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^3)
A	174	60.5	833.4	1670

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BL. Wet specimens tested by BL. Dry and partially dry specimens tested by BH, BL,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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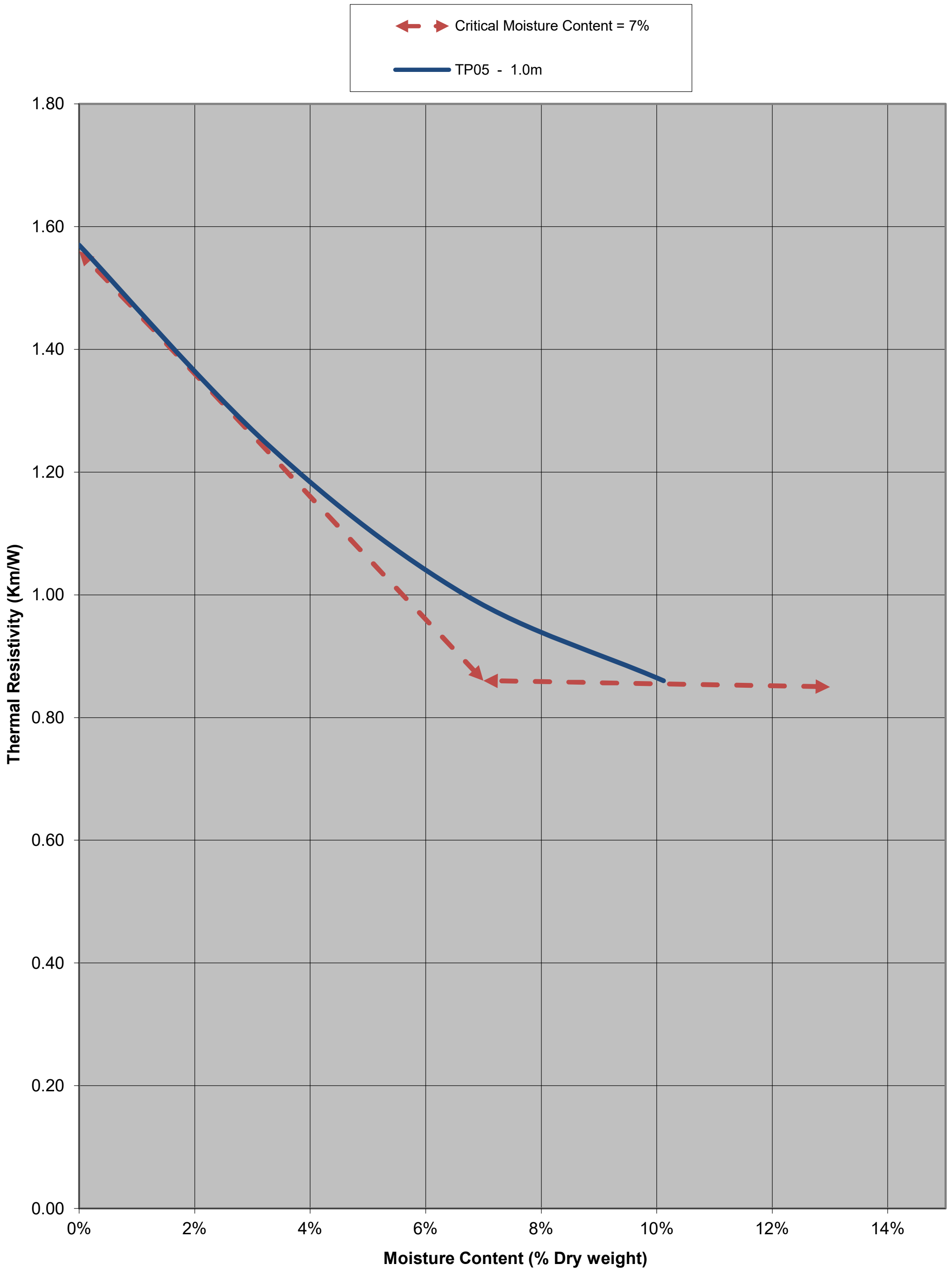
Dry-out Curve



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Geotherm Australasia

Test Report

Client : Douglas Partners	Project Number : 2135
	Project Details : Muswellbrook
	Order/Request Number :
Report Date : 26/10/2023	Report Number : 213503

Sample Details

Sample ID / Name / Number	TP8 - 1.0m
Soil Description	Brown silty clay with gravel
Sampled by	Geotherm - as per procedure
Sample Type	Undisturbed
Date Sampled	21/9/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
21/09/2023	Probe inserted into trench wall at 1.0m depth	As found	600	15.9	37.30	1.41	0.71

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
11/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	9.5%	400	20.5	21.50	1.67	0.60
16/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	6.6%	400	19.5	20.00	1.49	0.67
18/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	2.9%	400	20.1	21.90	1.12	0.89
25/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	400	20.1	20.00	0.87	1.15

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^3)
A	172	60.5	894.9	1810

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BL. Wet specimens tested by BL. Dry and partially dry specimens tested by BH, BL,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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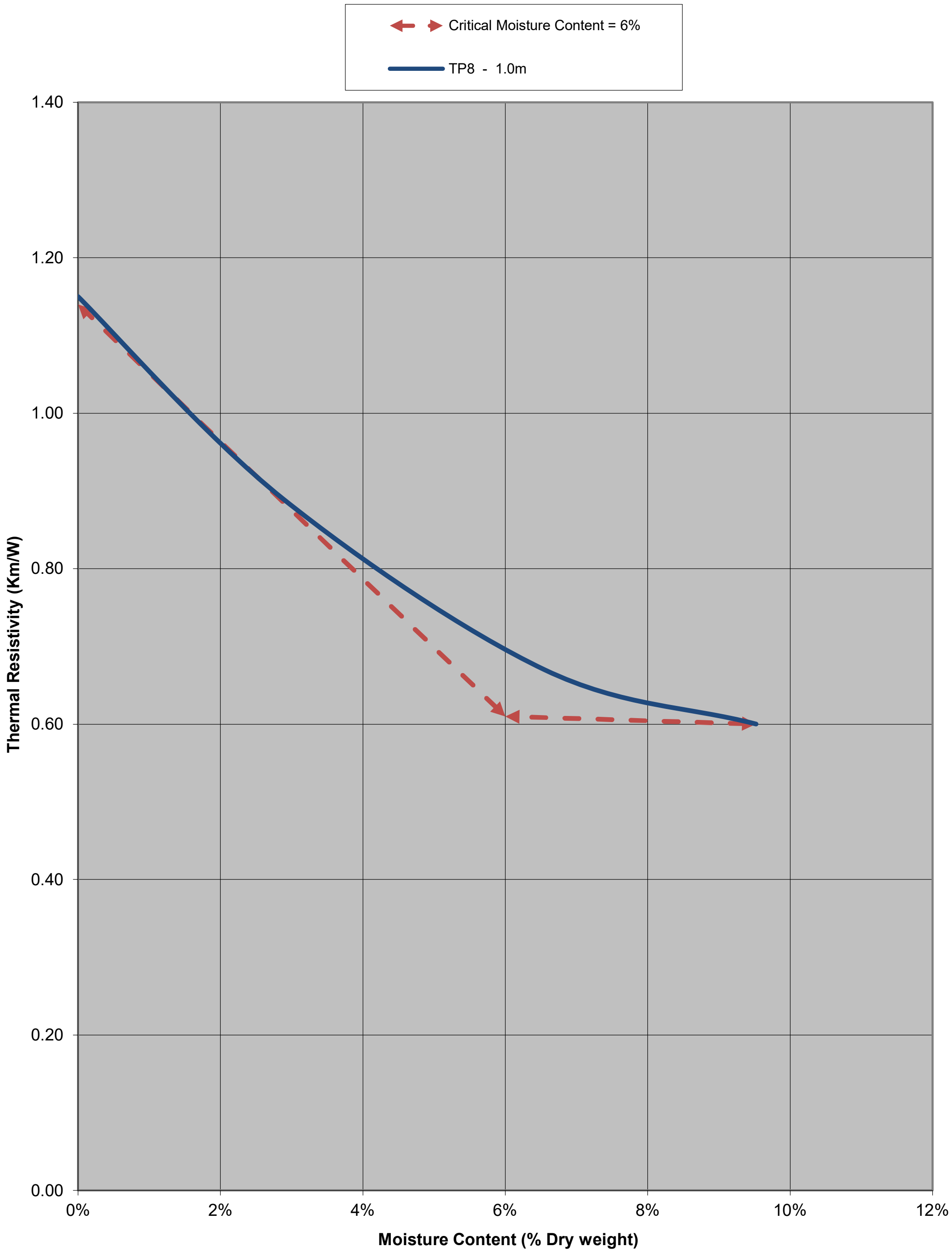
Dry-out Curve



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Geotherm Australasia

Test Report

Client : Douglas Partners	Project Number : 2135
	Project Details : Muswellbrook
	Order/Request Number :
Report Date : 26/10/2023	Report Number : 213504

Sample Details

Sample ID / Name / Number	TP09 - 1.0m
Soil Description	Brown silty clay & gravel
Sampled by	Geotherm - as per procedure
Sample Type	Undisturbed
Date Sampled	21/9/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
21/09/2023	Probe inserted into trench wall at 1.0m depth	As found	700	17.6	37.30	1.45	0.69

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
11/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	9.0%	600	19.9	21.50	1.54	0.65
17/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	4.5%	600	18.4	20.40	1.15	0.87
19/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	2.4%	600	19.6	21.70	0.99	1.01
25/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	500	19.4	20.00	0.85	1.17

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^3)
A	190	73	1411.8	1780

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BL. Wet specimens tested by BL. Dry and partially dry specimens tested by BH, BL,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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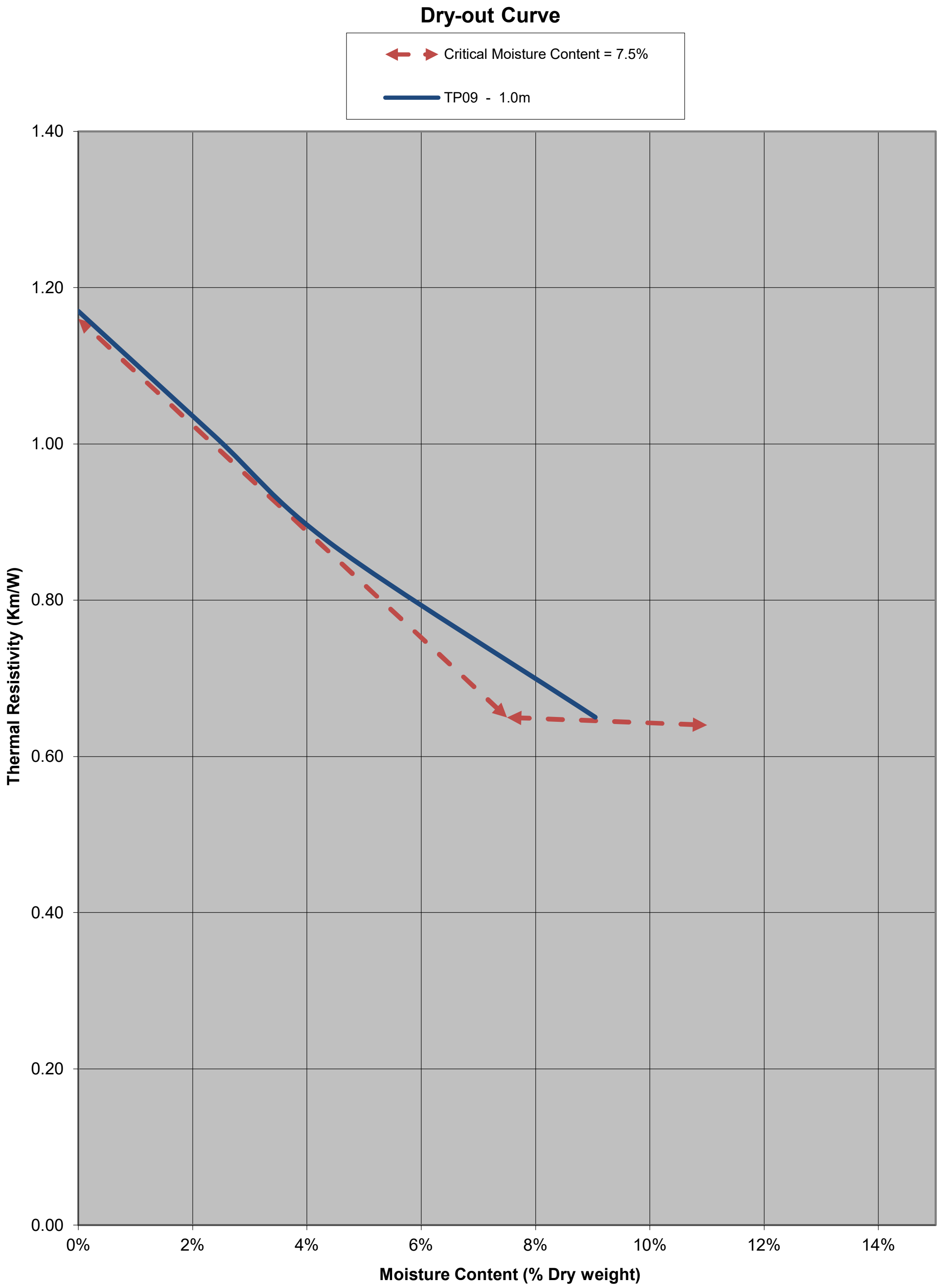

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Geotherm Australasia

Test Report

Client : Douglas Partners	Project Number : 2135
	Project Details : Muswellbrook
	Order/Request Number :
Report Date : 26/10/2023	Report Number : 213505

Sample Details

Sample ID / Name / Number	TP12 - 1.0m
Soil Description	Light brown silty clay
Sampled by	Geotherm - as per procedure
Sample Type	Undisturbed
Date Sampled	21/9/2023

Field Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
21/09/2023	Probe inserted into trench wall at 1.0m depth	As found	700	16.5	37.40	1.25	0.80

Thermal Conductivity (ASTM D5334)

Test Date	Preparation Method	Specimen	Moisture Content (%)	Test Duration (s)	Initial Temp. (°C)	Test Power (W/m)	Thermal Conductivity (W/m.K)	Thermal Resistivity (Km/W) *
11/10/2023	Probe inserted into undisturbed sample. As found moisture content.	A	11.1%	600	20.4	21.50	1.18	0.85
16/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	7.7%	500	19.5	20.00	1.00	1.00
19/10/2023	Probe inserted into undisturbed sample. Partially dry.	A	2.5%	600	20.3	21.70	0.70	1.43
25/10/2023	Probe inserted into undisturbed sample. Fully dry	A	0.0%	500	20.3	20.00	0.61	1.65

Specimen	Av. Length (mm)	Av. Diameter (mm)	Mass (g)	Dry Density (Kg/m^3)
A	174	60.5	850.1	1700

Notes

- *Thermal resistivity calculation = 1 / Thermal Conductivity.
- All testing undertaken at Geotherm's Hornsby Laboratory, unless noted.
- Specimens prepared by BL. Wet specimens tested by BL. Dry and partially dry specimens tested by BH, BL,
- Probe dimensions used for testing - Laboratory samples: Diameter = 3.2mm - Length 120mm. Field tests: Diameter = 6.0mm - Length 250mm
- The above samples will be discarded after 2 weeks.

Brett Hobson
Approved Signatory

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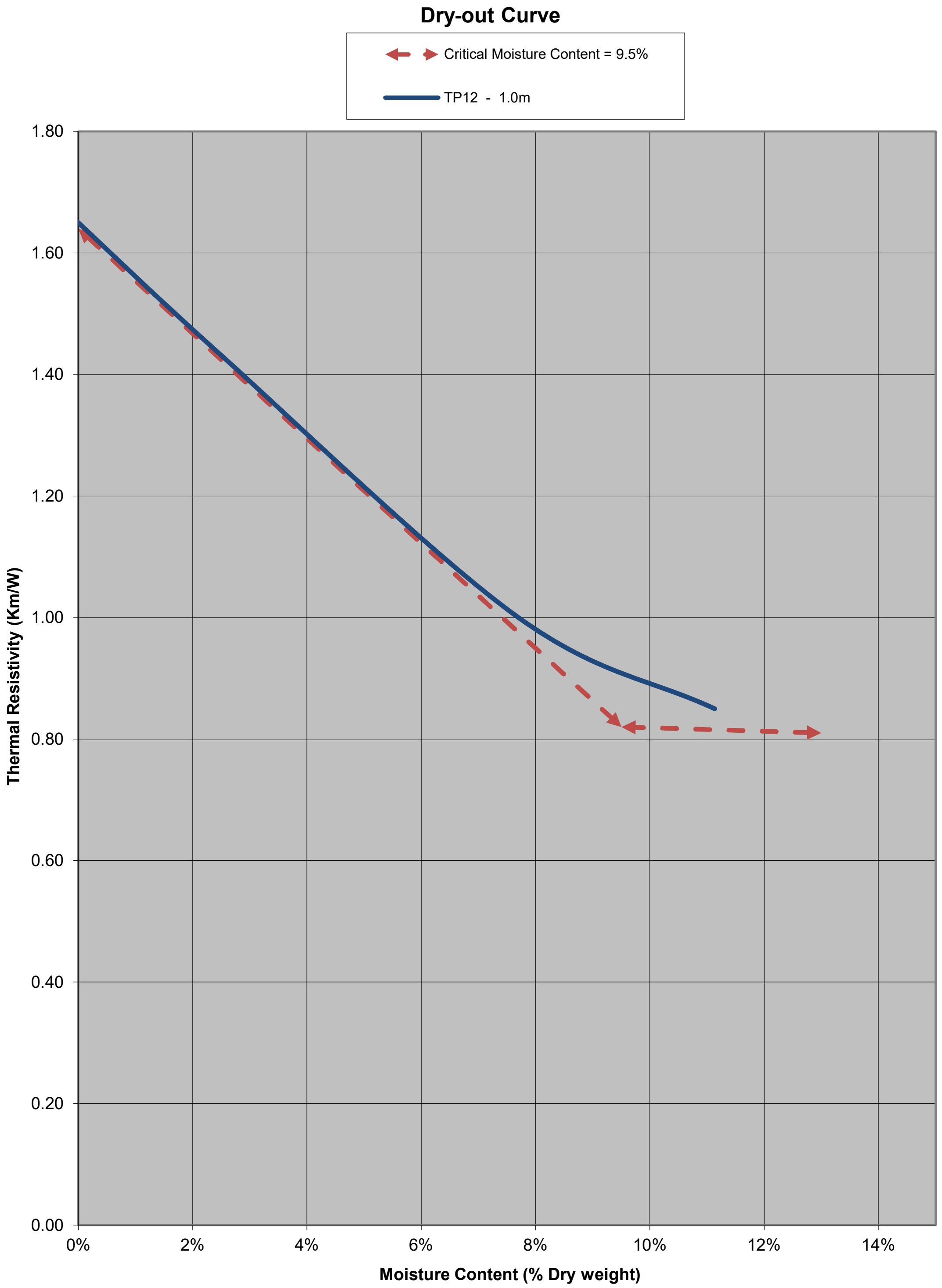
Geotherm Australasia



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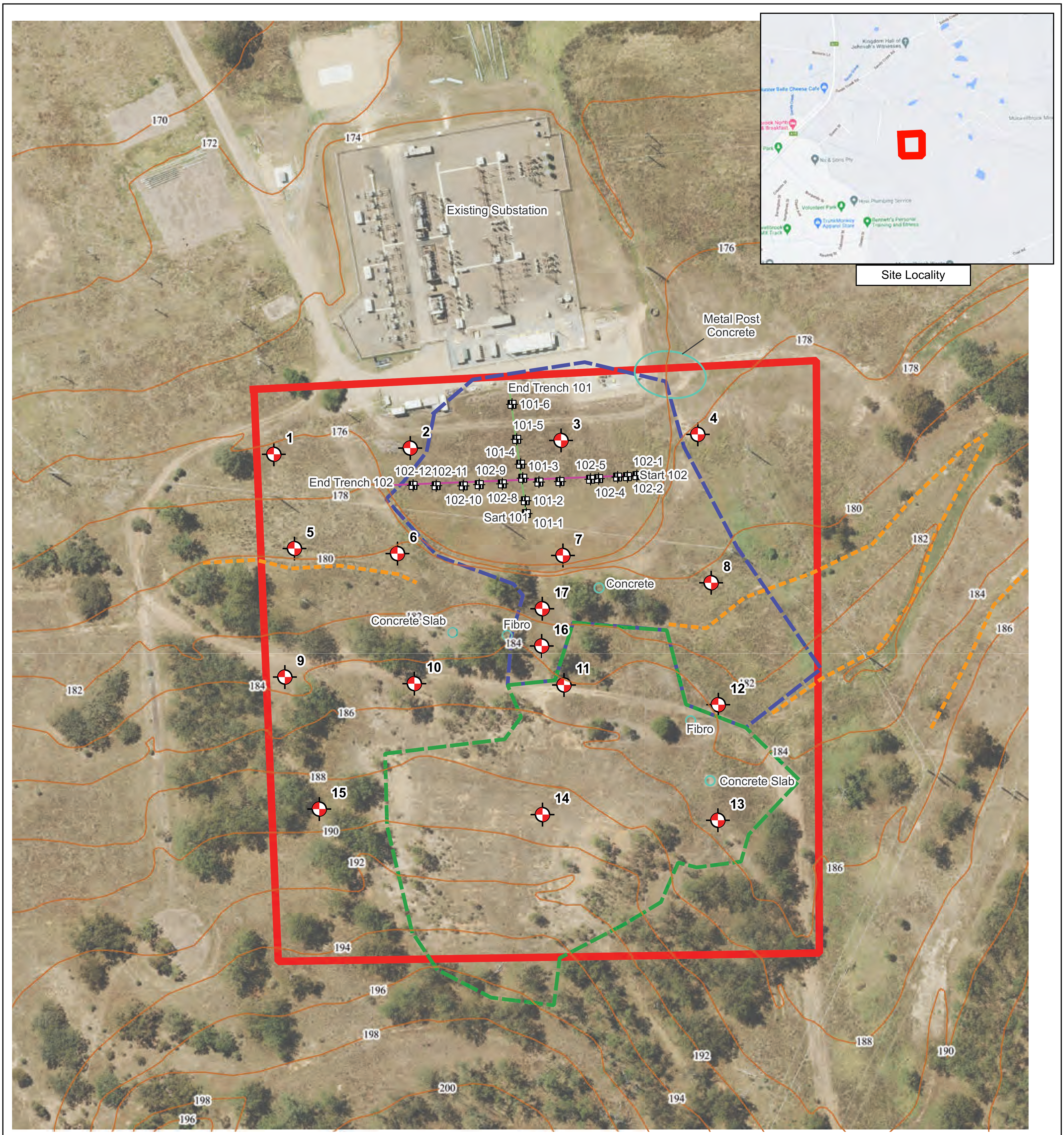
NATA Accreditation Number 20321 – Site 24277

Appendix C

Drawing 1 - Test Location Plan
ZN 228 Stockton – 33/11kV Substation 11 kV Switchgear
Replacement Civil & Structural Works Transportable 11 kV Switch
Building Support Structure Details – Sheet 1



Legend

Borehole Locations	Observed Surface Features
Test Pit Location	Mounded Drainage Berms
Costean 101	Possible Cleared or Distrubed Area
Costean 102	Areas of Fill
NSW 2m Contours	Approximate Site Boundary

0 50 100 m

Drawing adapted from aerial imagery from MetroMap dated 12.02.2023.
Test locations are approximate only and were located using differential GPS.

Douglas Partners
Geotechnics / Environment / Groundwater

TITLE: **Test Location Plan** **Geotechncial Investigation & Contamination Services** **New 132KV Sub-Transmission Substation** **20 Sandy Creek Road, Muswellbrook**		N	OFFICE: Newcastle DRAWN BY: PLH DATE: 12.October.2023
CLIENT: Ausgrid	PROJECT No: 224763.00	DRAWING No: 1	REVISION: Draft A
			SCALE: 1:1500 @A3

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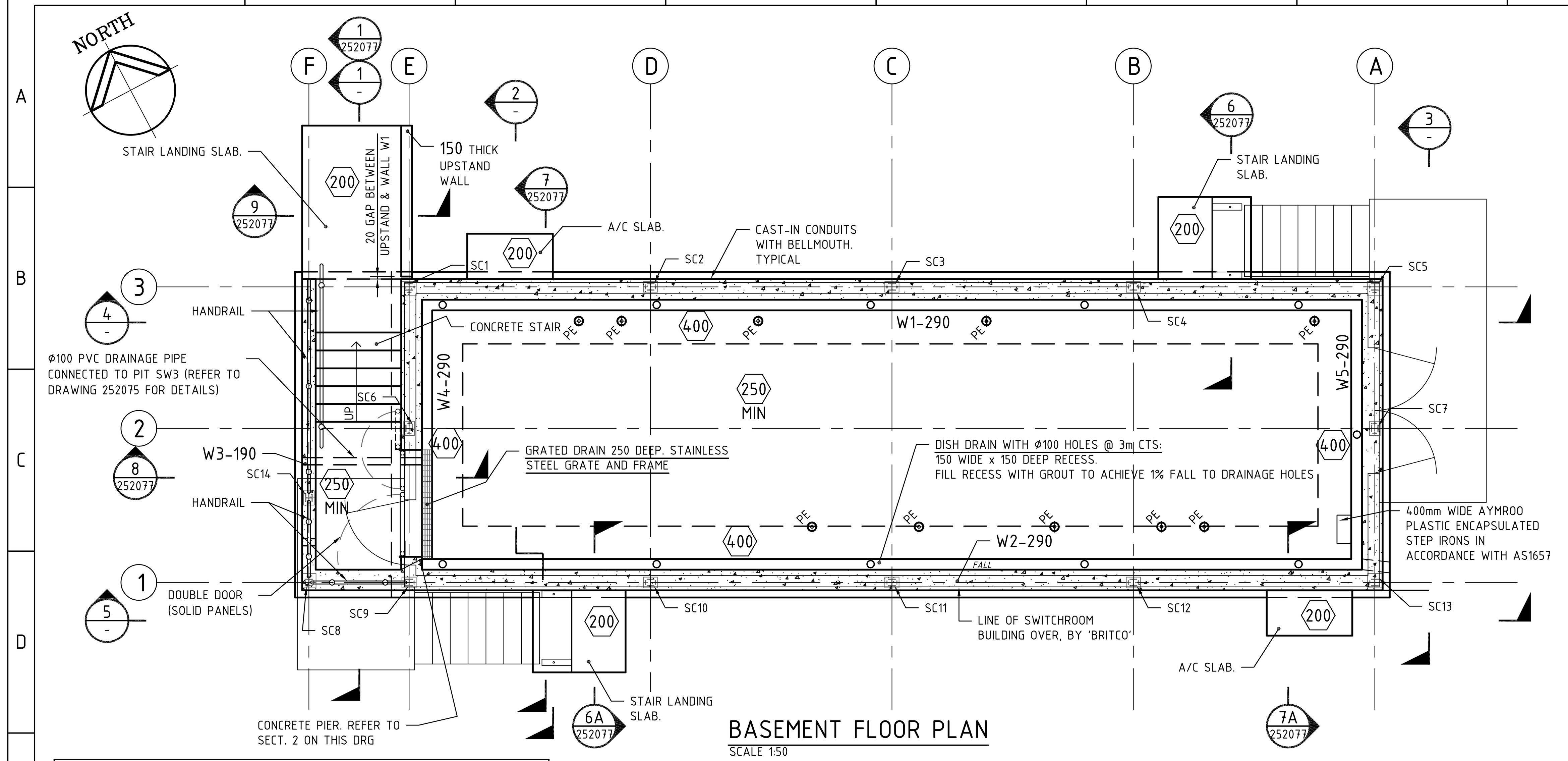


BASEMENT FLOOR PLAN

SCALE 1:50

'SC' ON PLAN DENOTES STEEL SUPPORT COLUMNS.
NOTE: TOP OF COLUMNS TO BE WITHIN ±1mm

DENOTES REINFORCED CAST-INSITU CONCRETE WALLS

PULLING EYE CAST INTO SLAB. FOR SET-OUT REFER TO ELECTRICAL LAYOUT DRG. No. 244789. FOR DETAIL REFER TO DRG No. 252077. TYP.

SLAB TO BE POURED ON A 75mm THICK WORKING SLAB

SLAB REINFORCEMENT NOTES:

UNLESS NOTED OTHERWISE
SLAB TO BE REINFORCED WITH SL82 FABRIC TOP & N16-200 BOTH WAYS BOTTOM.

COGS TO BE STANDARD

BARS IN THIS DIRECTION TO BE LAID 1ST BOTTOM

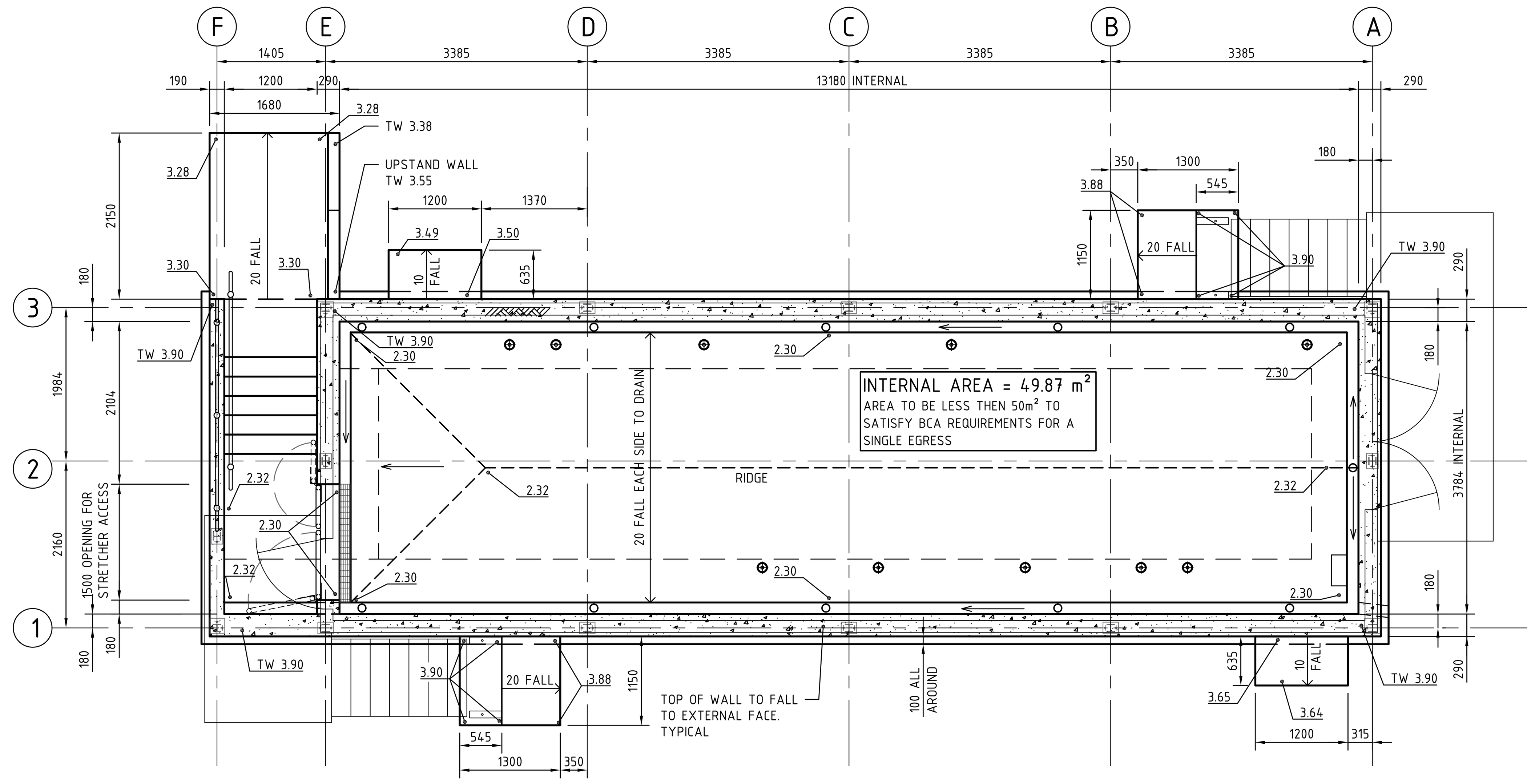
REINFORCEMENT TO HAVE 40mm COVER.

LAP BARS 650 WHERE REQ'D

2E DENOTES 2 x N16-100 EXTRA BARS BOTH FACES

FOR REINFORCEMENT DETAILS REFER TO DRG No. 252077
FOR WALL REINFORCEMENT DETAILS ON DRG No. 252077
FOR EARTHING DETAILS REFER TO DRG No.244800

CONSTRUCTION JOINT NOTE (NOTED C.J. ON DRAWINGS):
WHERE CONSTRUCTION JOINT NOTED REMOVE LAITANCE AND LIGHTLY SCABBLE SURFACE OF CONCRETE



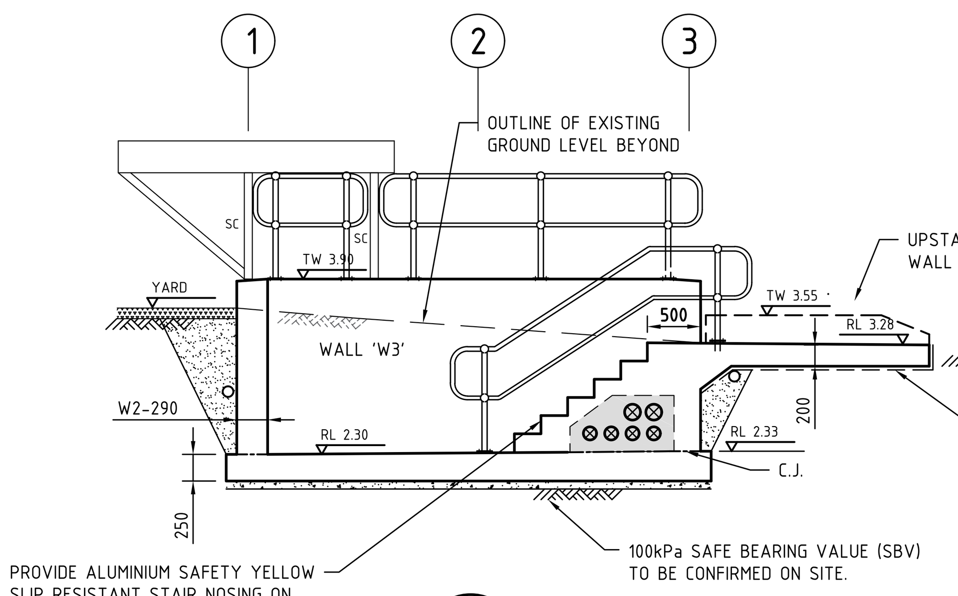
BASEMENT FLOOR SET-OUT PLAN

SCALE 1:50

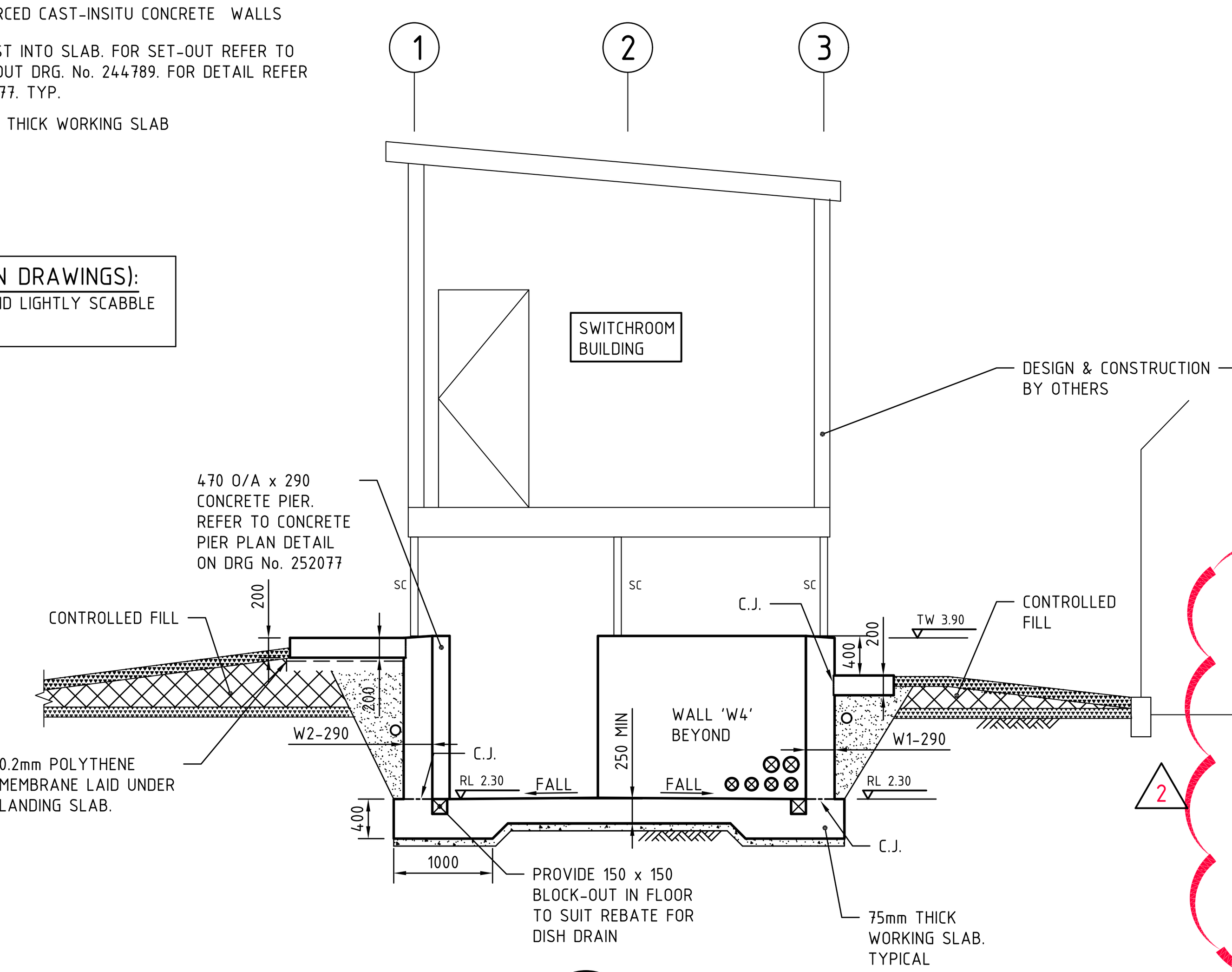
STEEL SUPPORT COLUMN CENTRELINES ARE ON GRIDS (REFER TO 'BRITCO' MODULAR BUILDING DRAWINGS).
TOP OF WALLS TO HAVE A TOLERANCE OF ±5mm

8.40 DENOTES DESIGN SURFACE LEVELS.

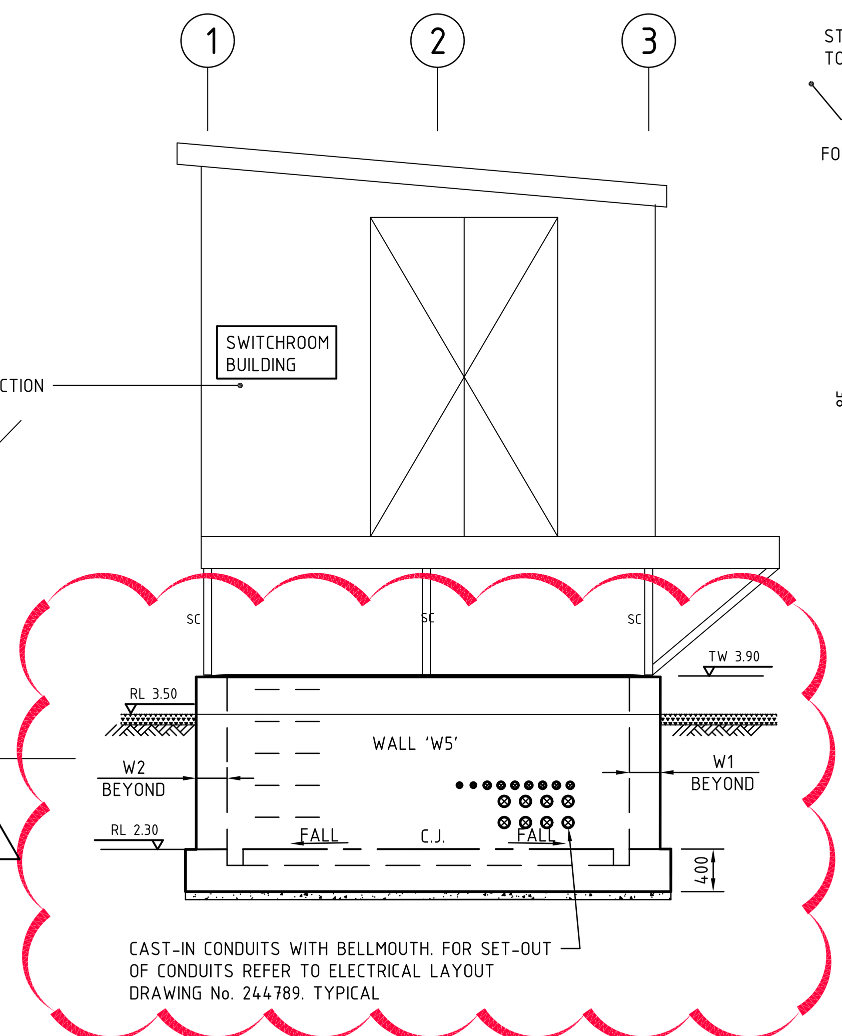
FOR EARTHWORKS AROUND SWITCHROOM REFER DRG No. 252075



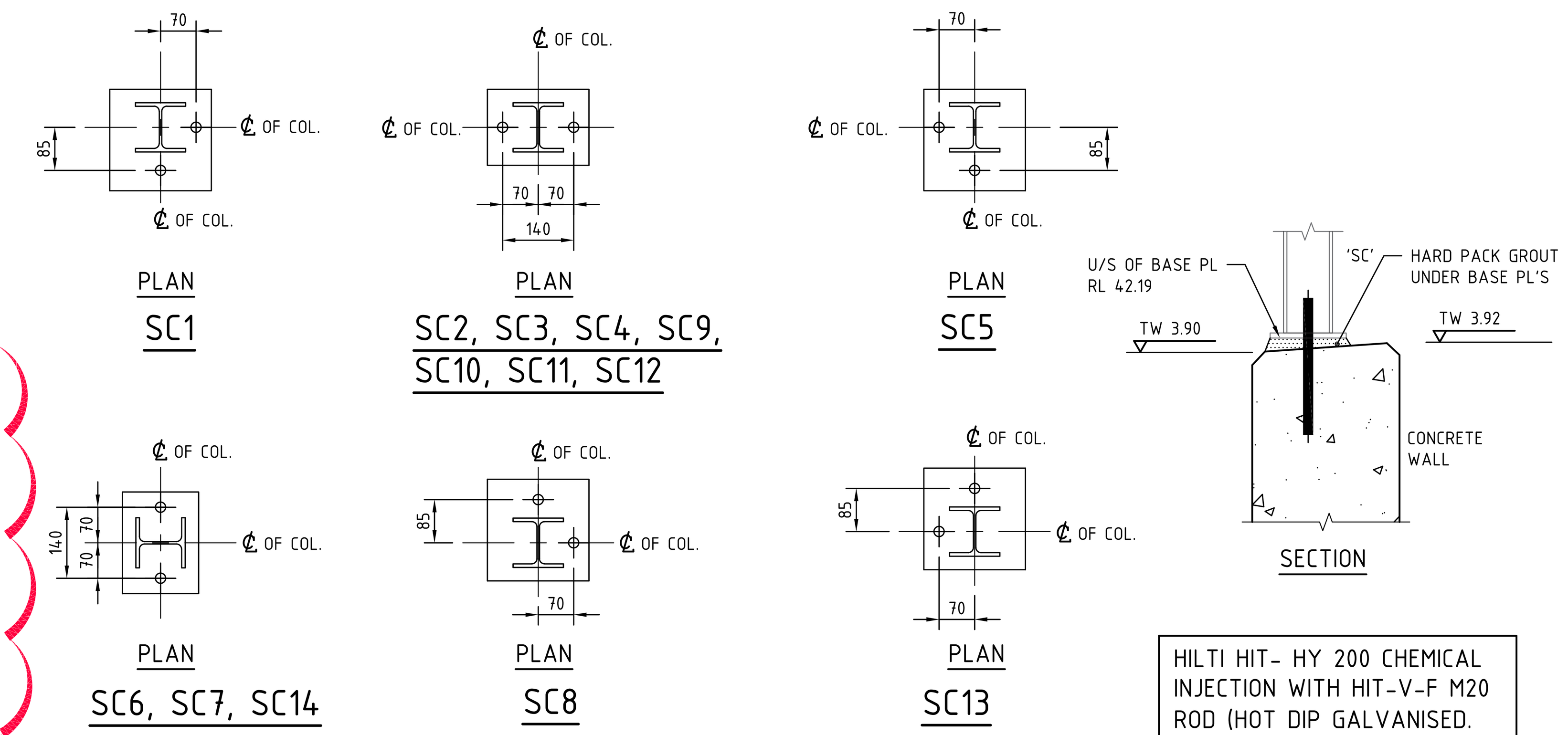
1 SECTION
SCALE 1:50



2 SECTION
SCALE 1:50



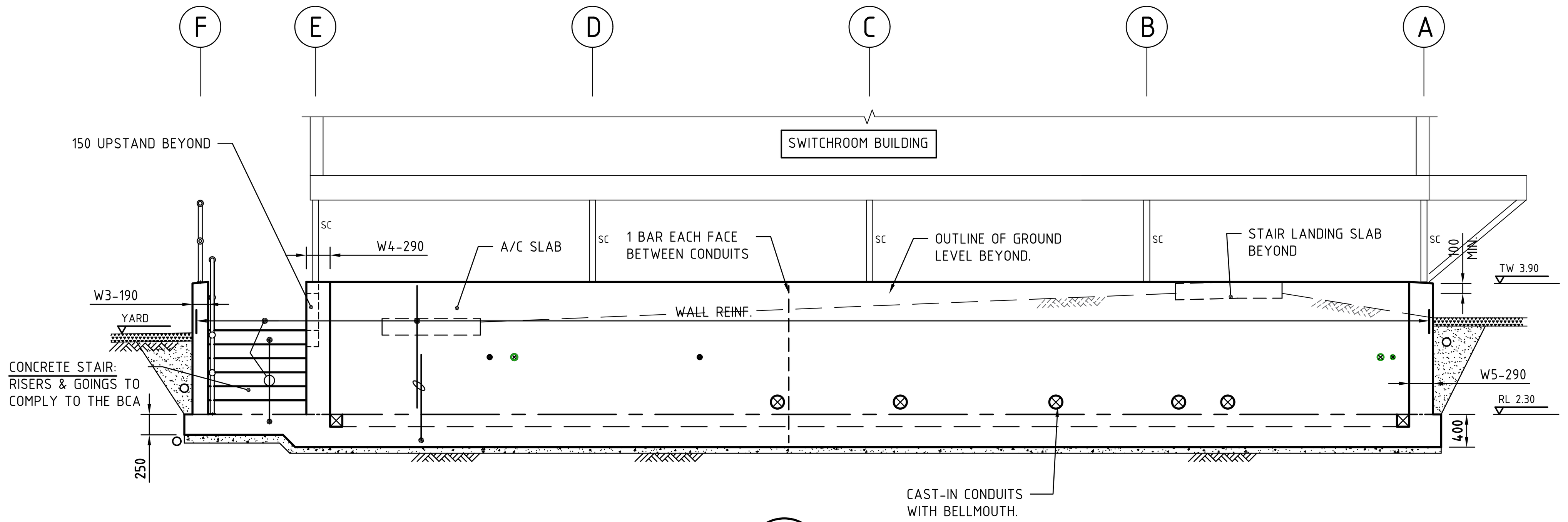
3 SECTION
SCALE 1:50



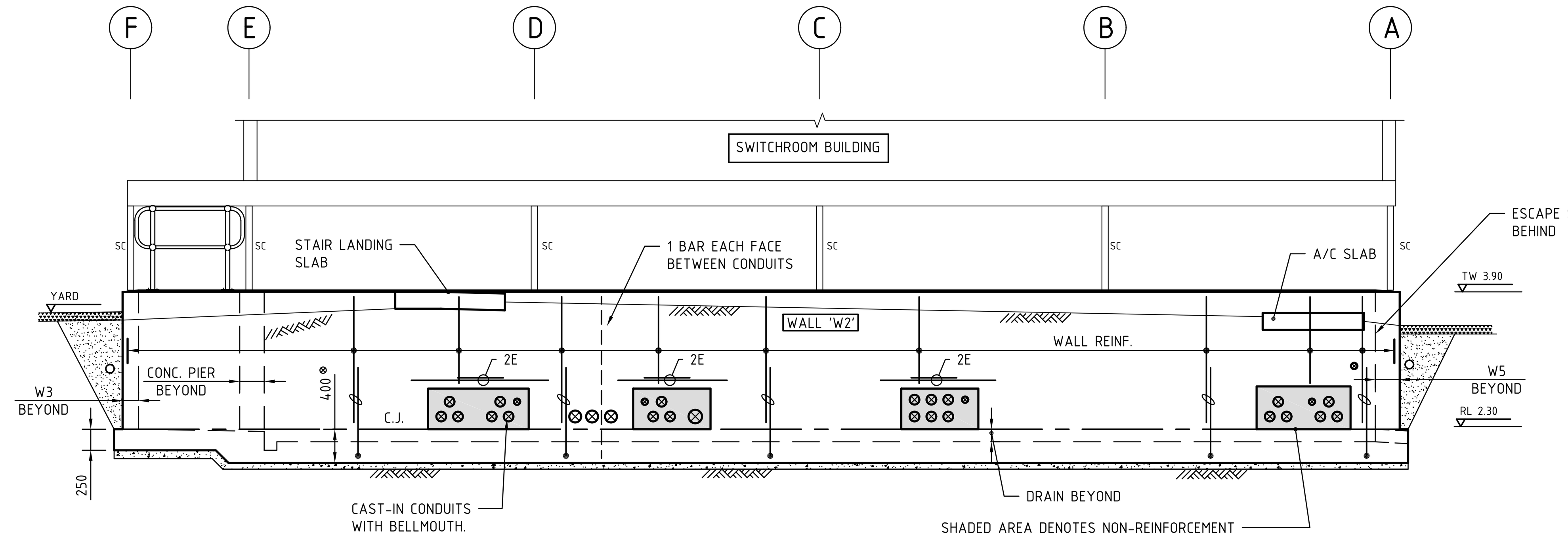
HD BOLT DETAILS

SCALE 1:10

HILTI HIT- HY 200 CHEMICAL INJECTION WITH HIT-V-F M20 ROD (HOT DIP GALVANISED. 170 EMBEDMENT AND 100 PROJECTION ABOVE CONCRETE



4 SECTION
SCALE 1:50



5 SECTION
SCALE 1:50

SHADED AREA DENOTES NON-REINFORCEMENT ZONE. ALL WALL REINFORCEMENT TO BE 100mm CLEAR OF ALL CONDUITS WHERE CONDUITS ARE IN BANKS. TYPICAL

FOR SAFETY AND CONSTRUCTION NOTES REFER TO DRAWING No. 252073

CAD DRAWING
DO NOT MANUALLY AMEND

AMENDMENTS

AMD	DATE	DESCRIPTION	DRAWN BY	DESIGNED BY	CHECKED BY	APPROVED BY
0	07-11-2019	TENDER ISSUE	MARKO LJOLJIC	DAVID STANBURY	PAUL LOVARINI	KATINA GALLEN
1	10/03/2020	CONSTRUCTION ISSUE	M.LJOLJIC	D.STANBURY	P.LOVARINI	K.GALLEN
2	29/09/2020	CONDUIT LAYOUT ADJUSTED. ISSUED FOR CONSTRUCTION	M.LJOLJIC	D.STANBURY	P.LOVARINI	K.GALLEN

Ausgrid
24-28 Campbell Street
SYDNEY NSW 2000

ISSUED FOR
CONSTRUCTION ISSUE

SCALE	AS SHOWN
DESIGNED	DAVID STANBURY
DRAWN	MARKO LJOLJIC
CHECKED	PAUL LOVARINI
APPROVED	KATINA GALLEN
DATE	07-11-2019
TRIM REF	2019/441/2
PROJECT NUMBER	SJ-00278

ZN 228 STOCKTON – 33/11 kV SUBSTATION
11 kV SWITCHGEAR REPLACEMENT
CIVIL & STRUCTURAL WORKS
TRANSPORTABLE 11kV SWITCH BUILDING
SUPPORT STRUCTURE DETAILS – SHEET 1

DRAWING No 252076 | SHEET 1 | AMD 2 | SIZE B1