DETAILED GEOTECHNICAL REPORT

PROPOSED CHILD CARE CENTRE

723-727 Warringah Road Forestville NSW

Prepared For:

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Report By:

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Field Work & Specialist Geotechnical Input By:

martens & Associates Pty Ltd

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1 INTRODUCTION

The Mostyn Copper Group, on behalf of clients, is involved in the planning, design and prospective development of a new childcare facility at 723-727 Warringah Road Forestville, NSW. A preliminary geotechnical report in relation to the proposed development was prepared and submitted in September 2020 was prepared and submitted

Mostyn Copper has submitted an S 4.56 modification regarding the development to Northern Beaches Council, the local government consent authority at interest, for review and approval. Northern Beaches Council has in turn requested that:

> *"an addendum letter or revised report is to be submitted addressing any additional impacts or changes to the recommendations of the original report. This is required as the modified development includes additional excavation".*

NG Child & Associates has been engaged to coordinate the preparation of the detailed geotechnical assessment required, including field work and specialist geotechnical input form Martens & Associates.

This document presents the detailed geotechnical assessment undertaken.

2 BACKGROUND

2.1 SITE LOCATION

Figure 2.1 below provides a road map identifying the site location, which is marked in blue at the approximate centre of the diagram.

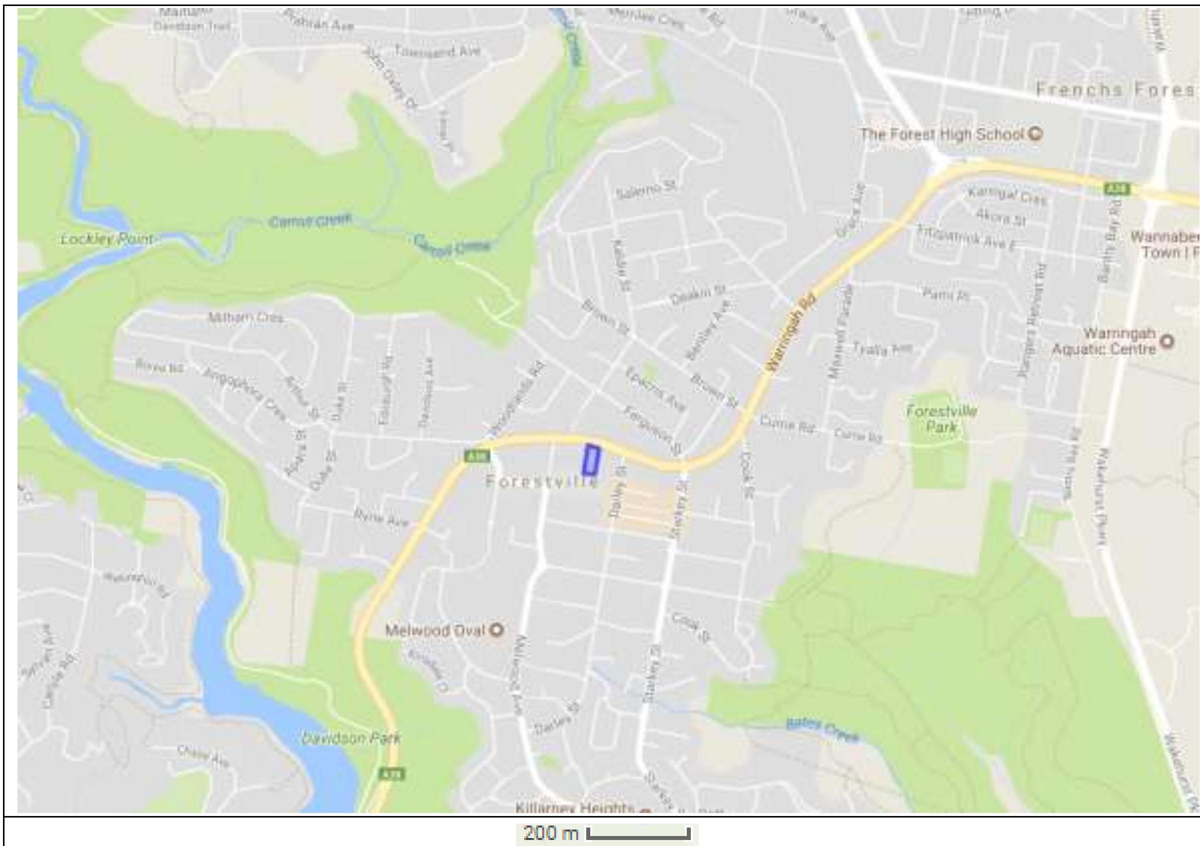

Figure 2.1 – Location of the Proposed Child Care Centre

The direction of north is towards the top of the diagram, and a scale has been included below. The prospective development site is 723-727 Warringah Road Forestville, NSW.

A recent (October 4th, 2021) satellite photograph of the site is provided in Figure 2.2, below.

Once again, the direction of north is towards the top of the diagram; a scale has been included below, and the site area is shown shaded in blue.

Figure 2.2 – Satellite Photograph of Site Location (October 4th, 2021)

Photographs of the site, including the existing building at the site, are provided in Figures 2.3 and 2.4, below.

Figure 2.3 – Site and Existing Dwellings Viewed from Warringah Road East to West

Figure 2.4 – Site and Existing Dwellings Viewed from Warringah Road West to East

2.2 LOCAL GOVERNMENT CONSENT AUTHORITY & ZONING

The site falls within the Northern Beaches Council local government area.

Relevant local government consents and approvals regarding the site and the proposed development reside with that Council.

The site area is zoned R2 ("Low Density Residential") and is shown at the lower centre of Figure 2.5 below, on the southern side of Warringah Road.

Surrounding land uses are also zoned R2, except for the Warringah Road corridor, which is zoned SP2 "Infrastructure – Road".

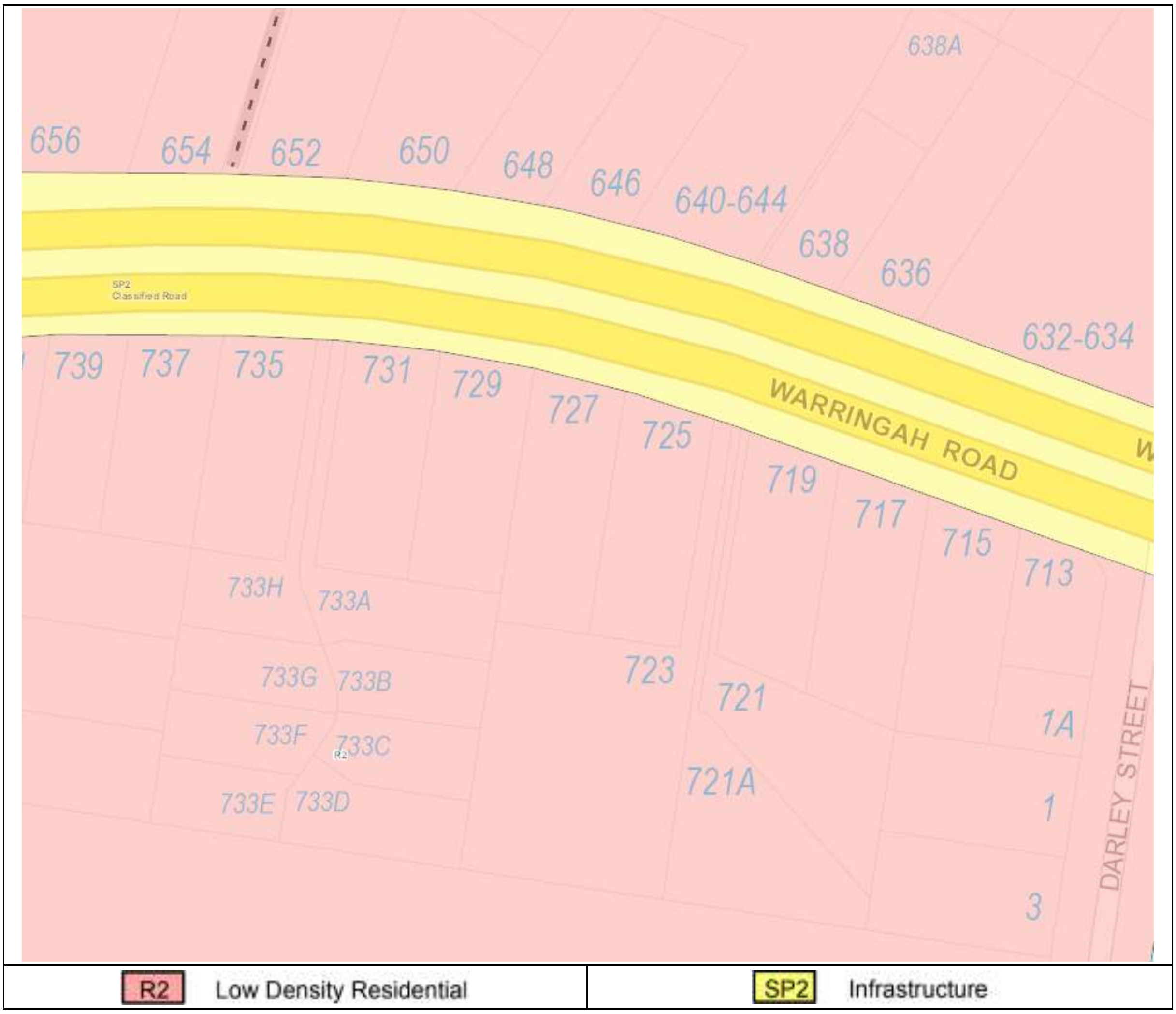

Figure 2.5 – Zoning Details

The proposed development site comprises 777723, 725 and 727 Warringah Road Forestville, which are formally identified as:

727 Warringah Road	Lot 1 DP 25050
725 Warringah Road	Lot 2 DP 25050
723 Warringah Road	Lot 3 DP 25050

3 THE PROSPECTIVE DEVELOPMENT

The prospective development involves the demolition of the existing dwellings at the site, and the development of a new, purpose designed and built childcare facility.

The project is defined by the plans and drawings included for reference on subsequent pages, as follows:

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Figure 3.3	Proposed Ground Floor
Figure 3.4	Proposed Level 1
Figure 3.5	Proposed Level 2
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Figure 3.7	Ground Floor Detailed Plan
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Figure 3.15	Proposed Detailed Elevations (East)
Figure 3.16	Proposed Site Sections
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Figure 3.1 – Cover

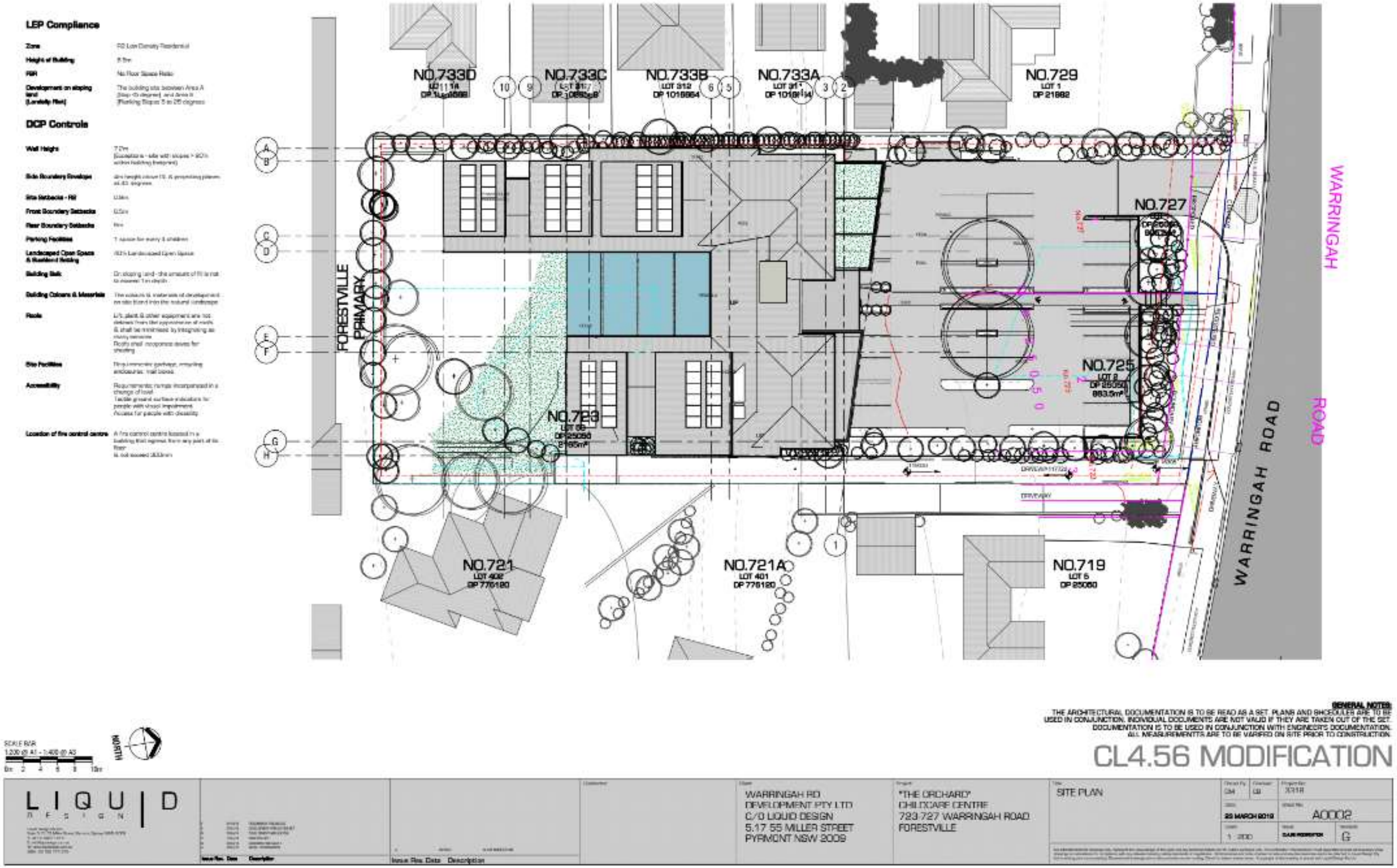

Figure 3.2 – Site Plan

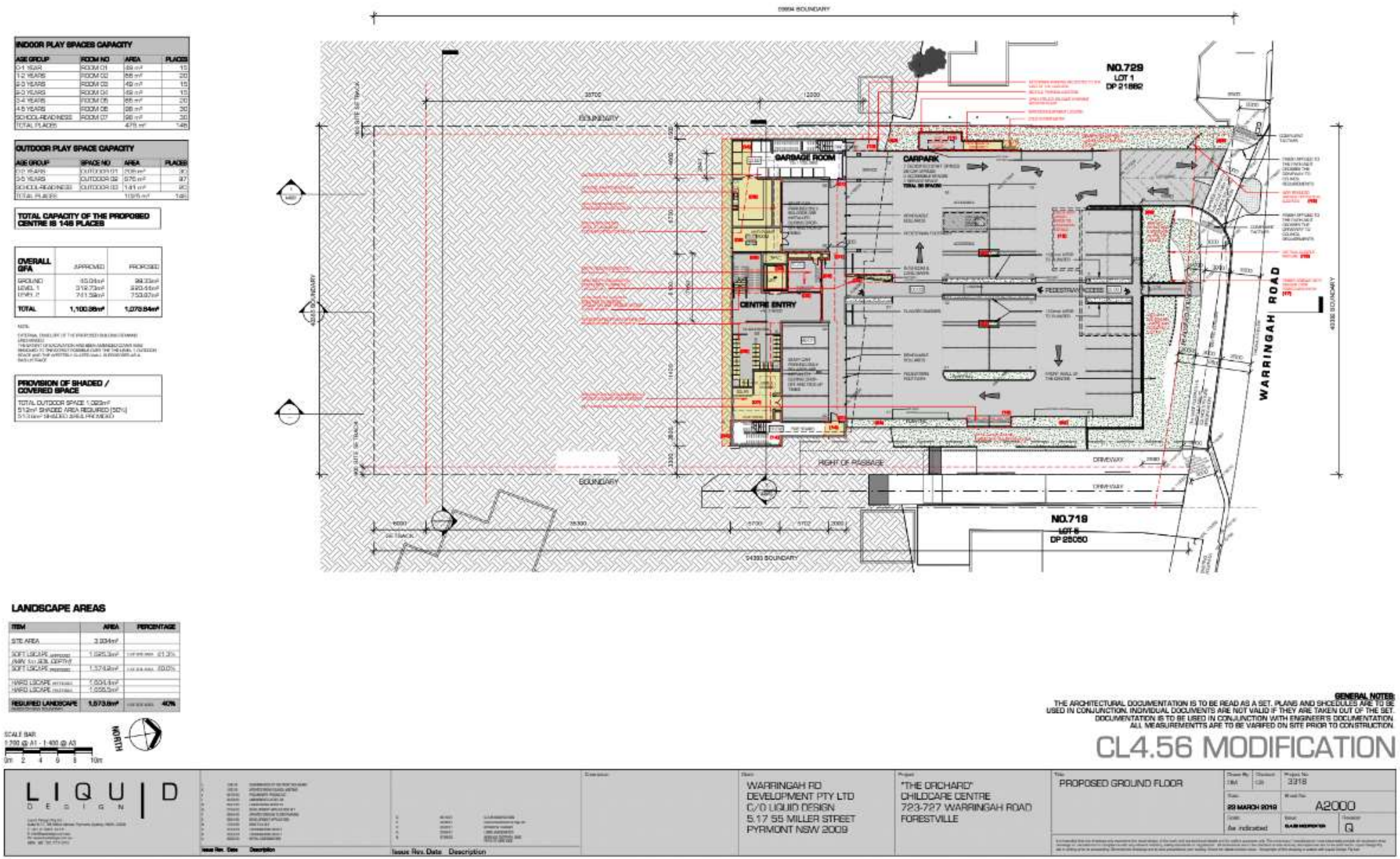

Figure 3.3 – Proposed Ground Floor

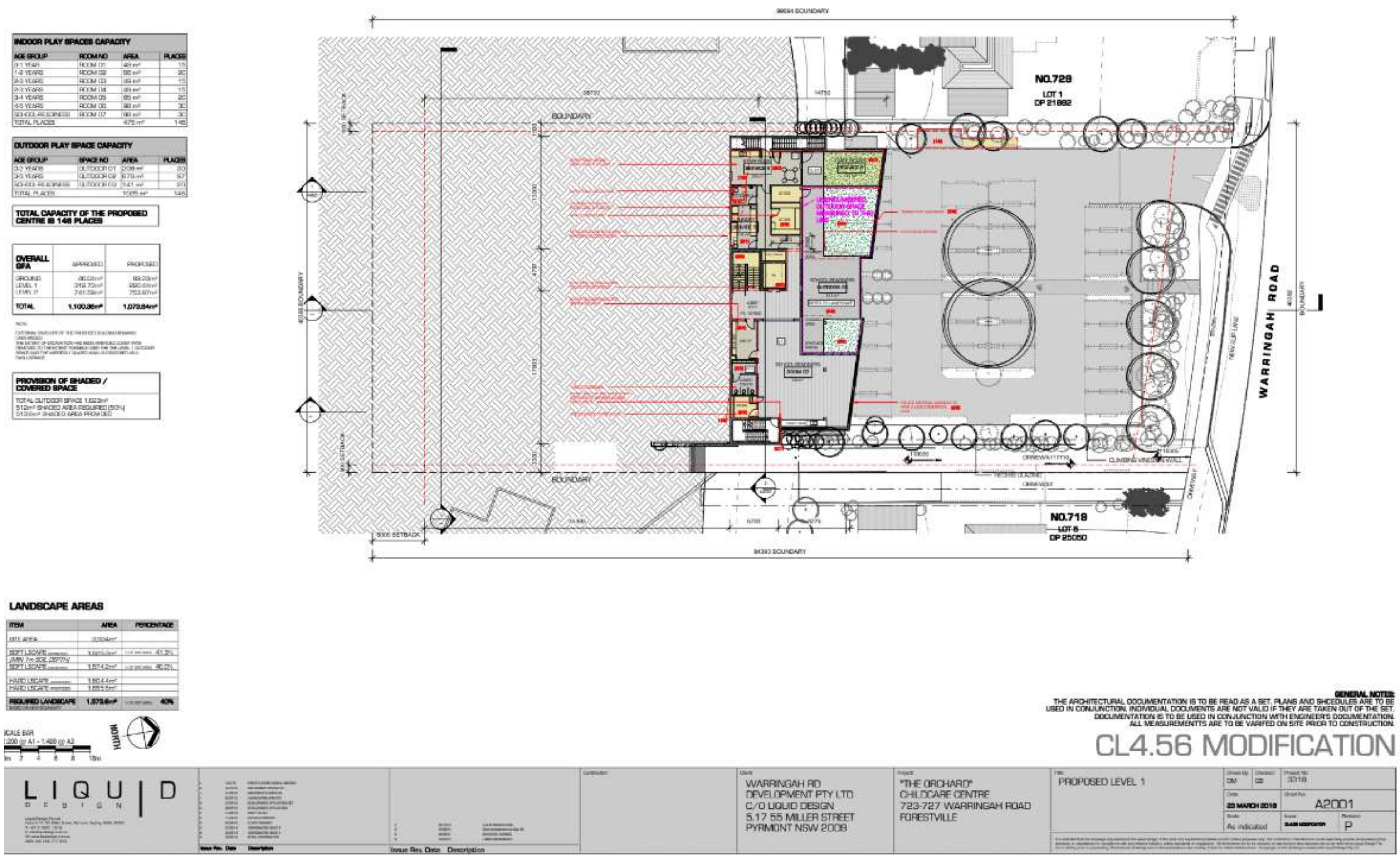

Figure 3.4 – Proposed Level 1

Figure 3.5 – Proposed Level 2

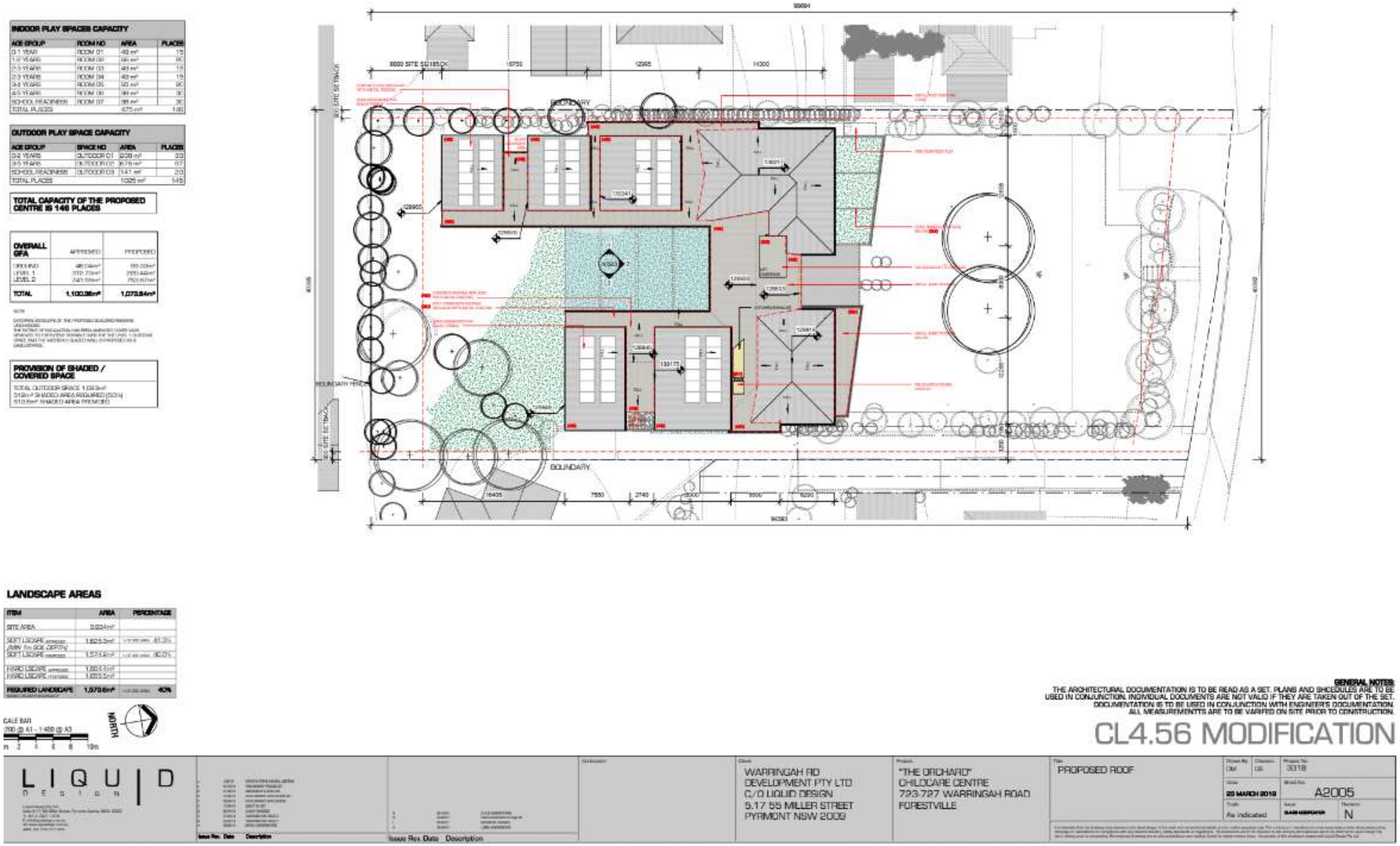

Figure 3.6 – Proposed Roof

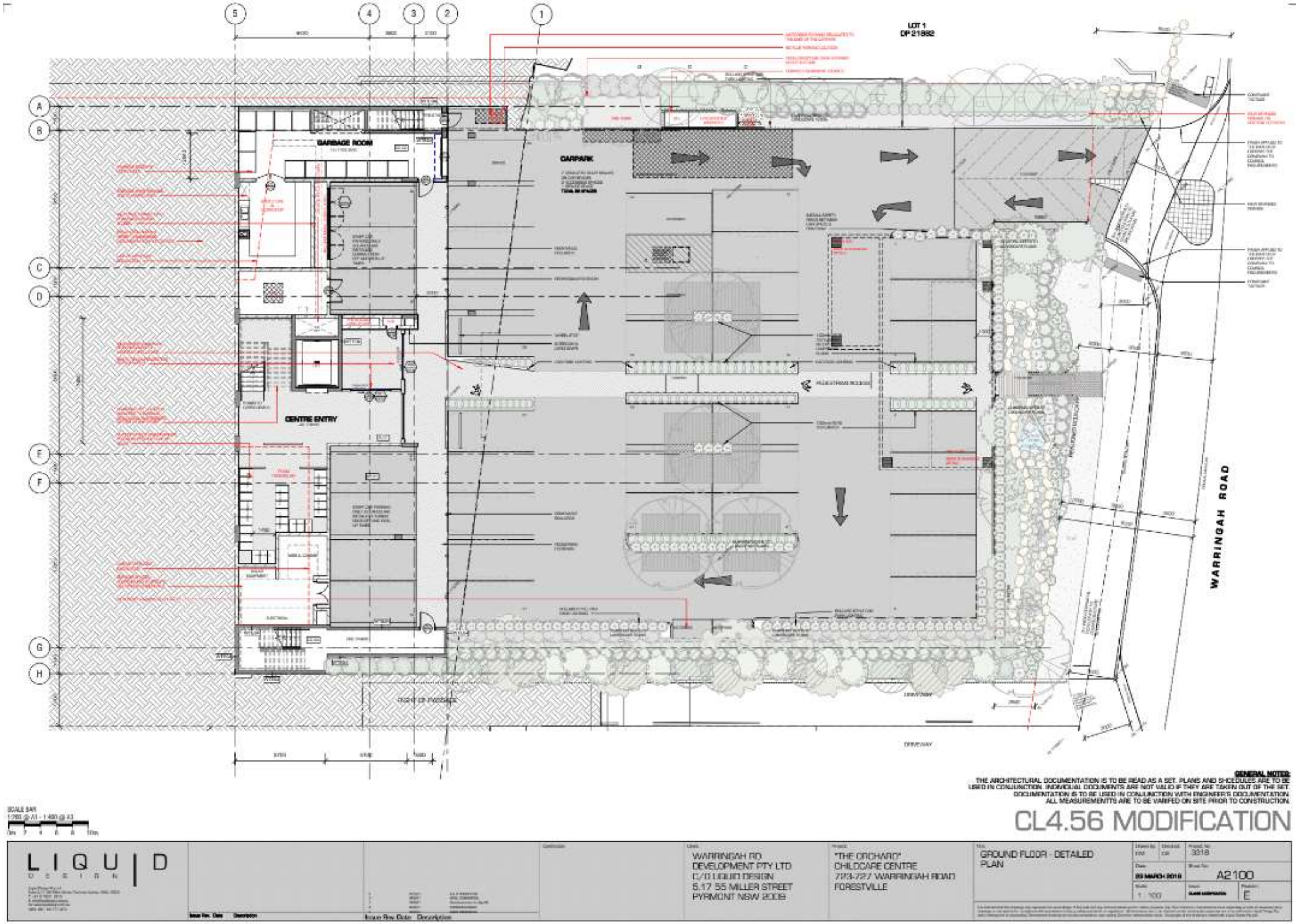

Figure 3.7 – Ground Floor Detailed Plan

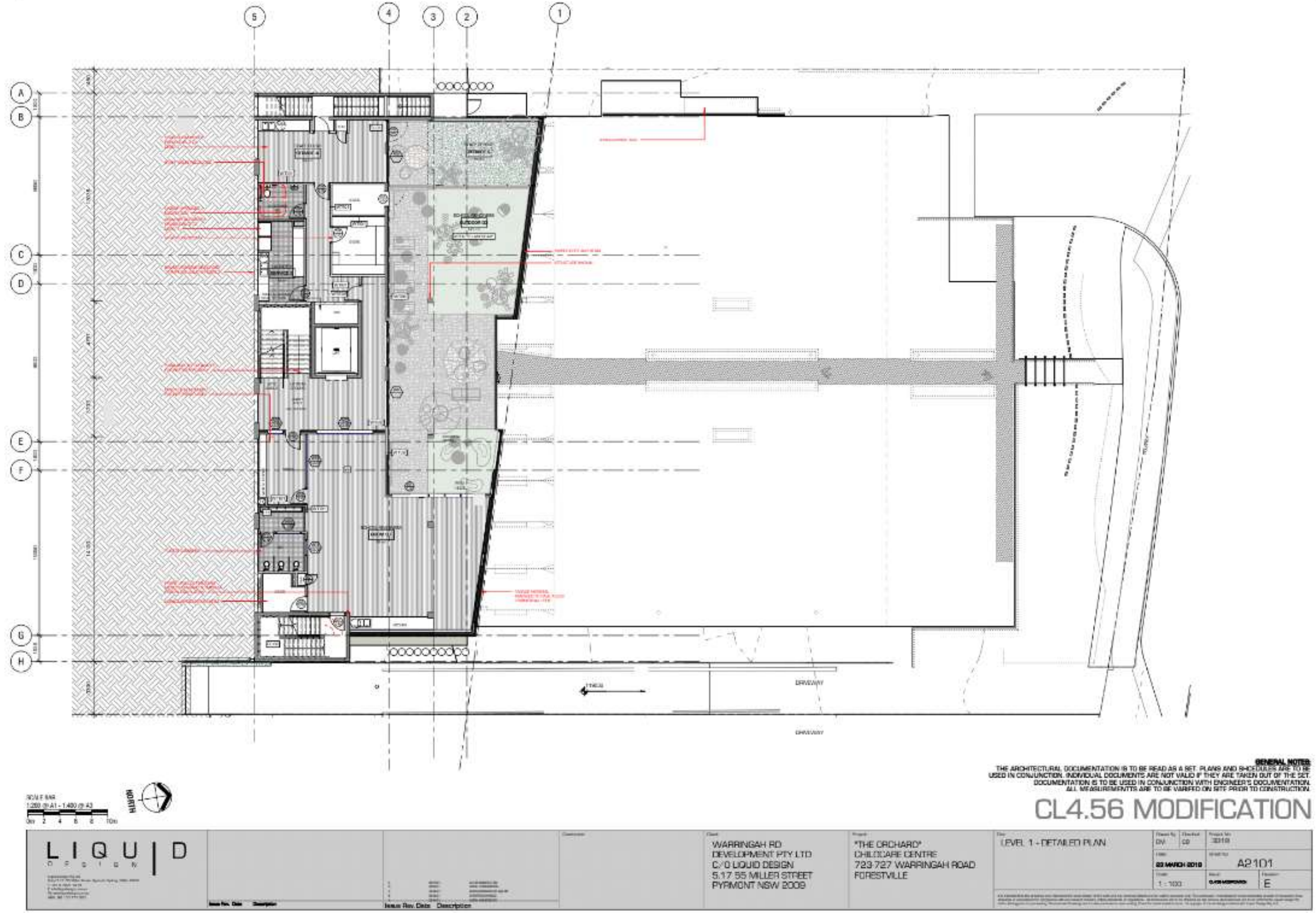

Figure 3.8 – Level 1 Detailed Plan

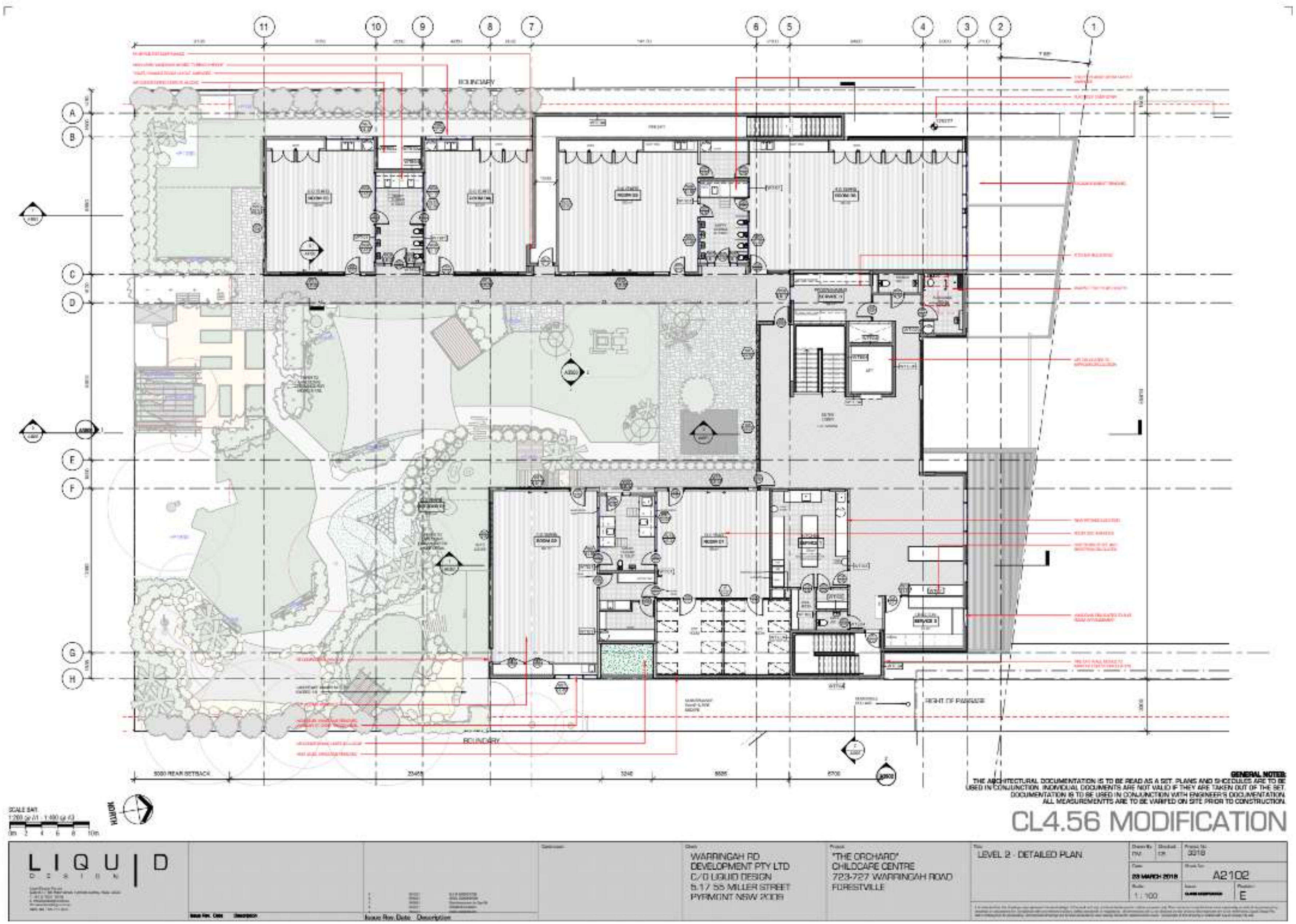

Figure 3.9 – Level 2 Detailed Plan

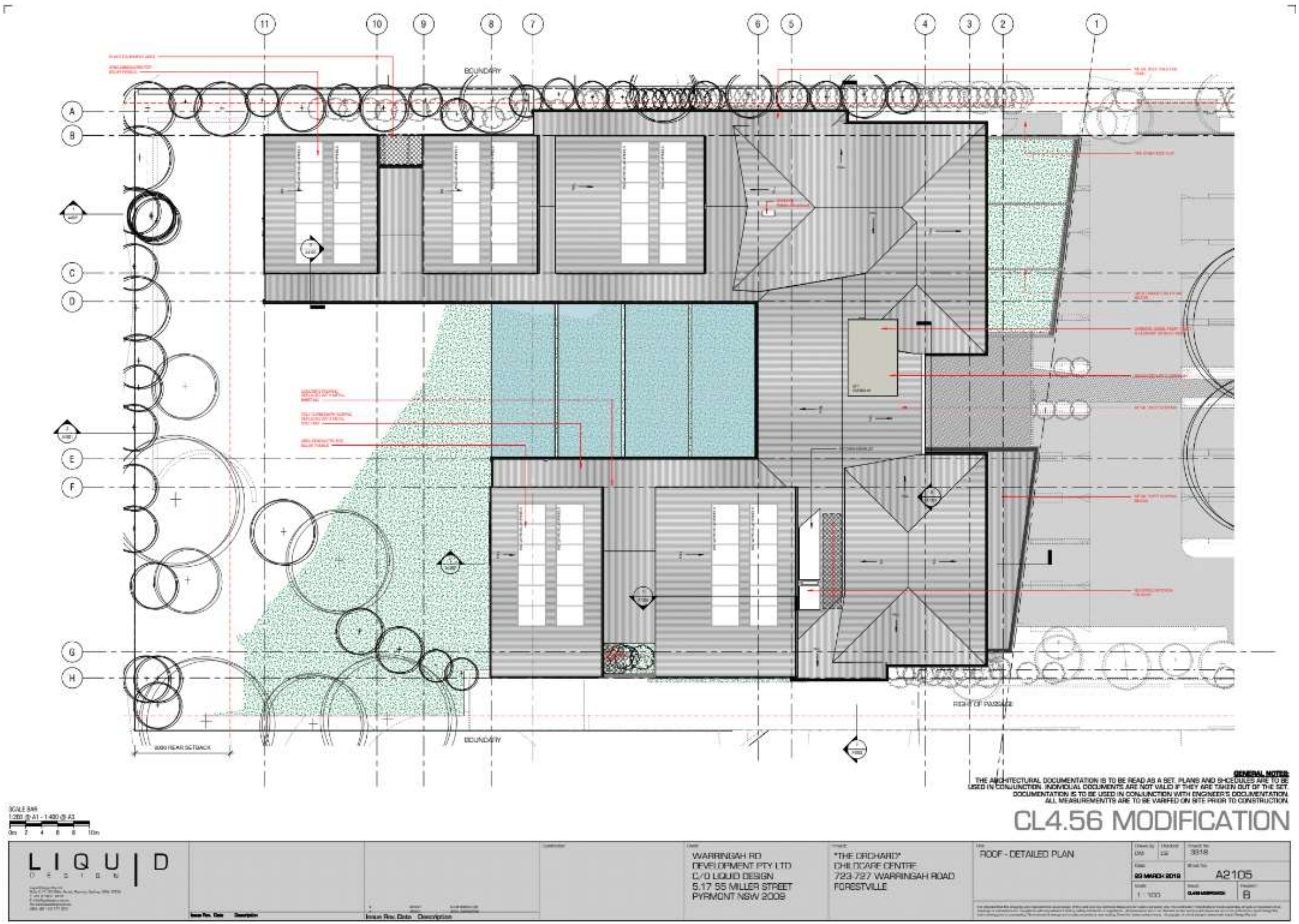

Figure 3.10 – Roof Detailed Plan

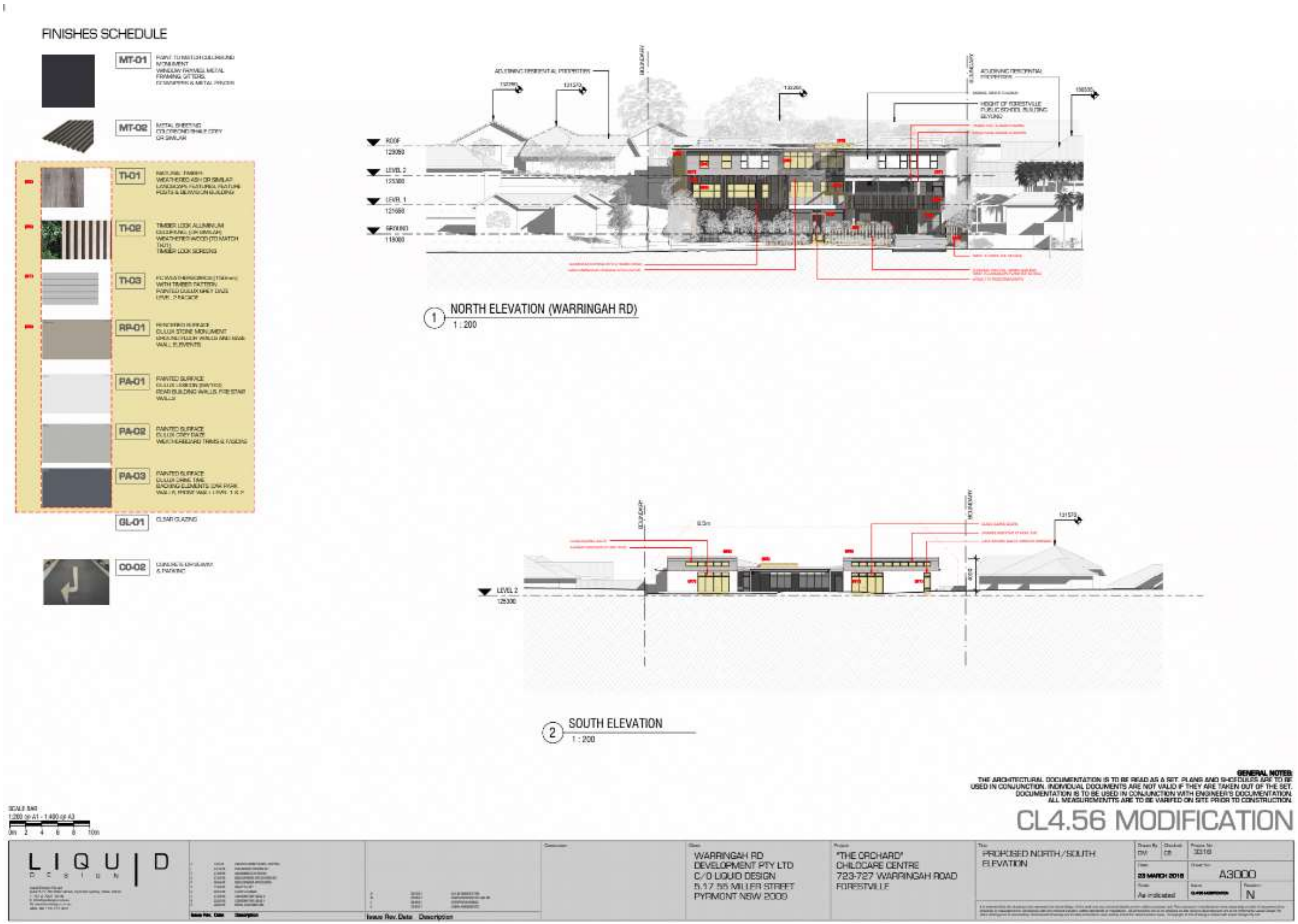

Figure 3.11 – Proposed Elevations (North/South)

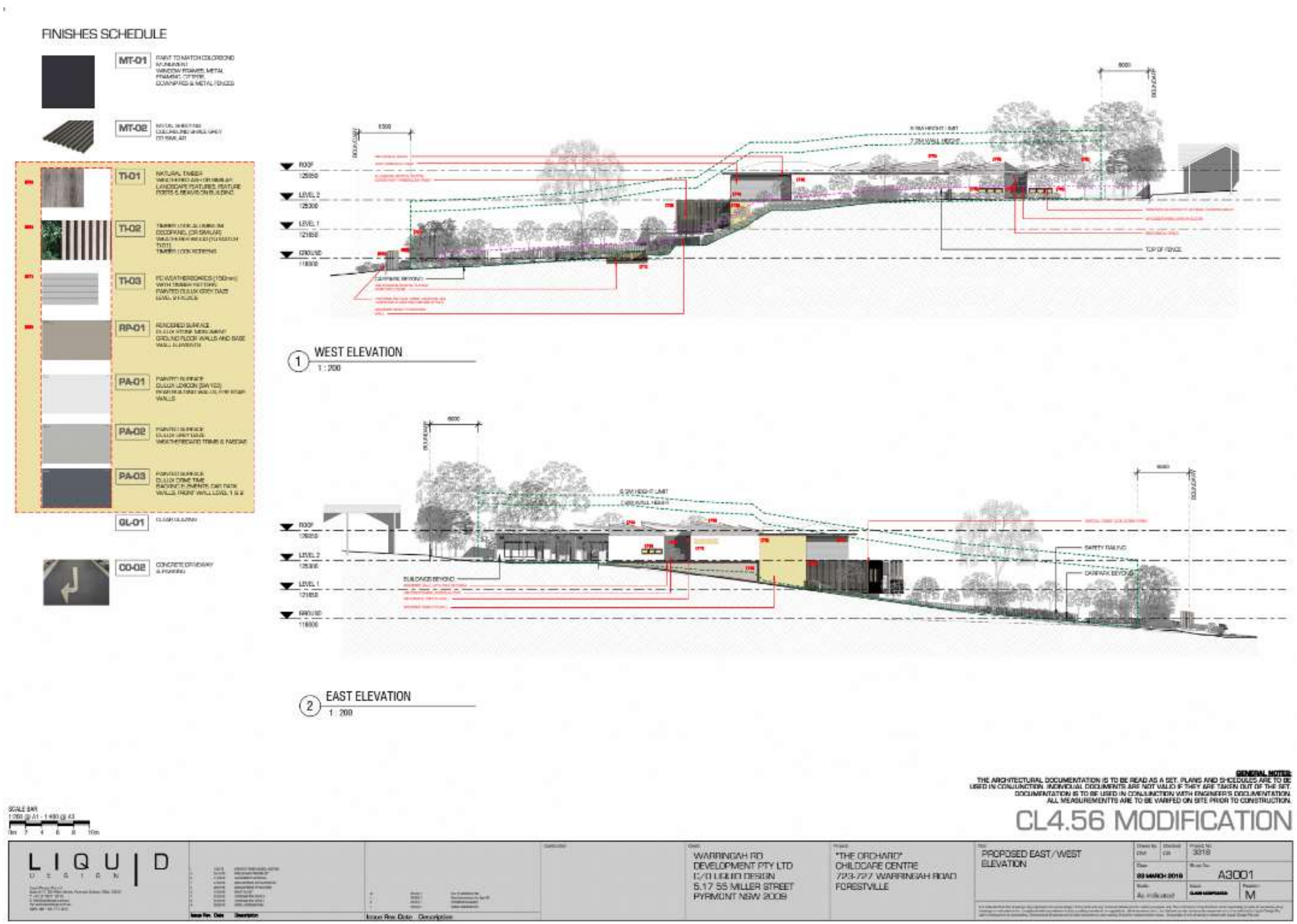

Figure 3.12 – Proposed Elevations (East/West)

Figure 3.13 – Proposed Detailed Elevations (North/South)

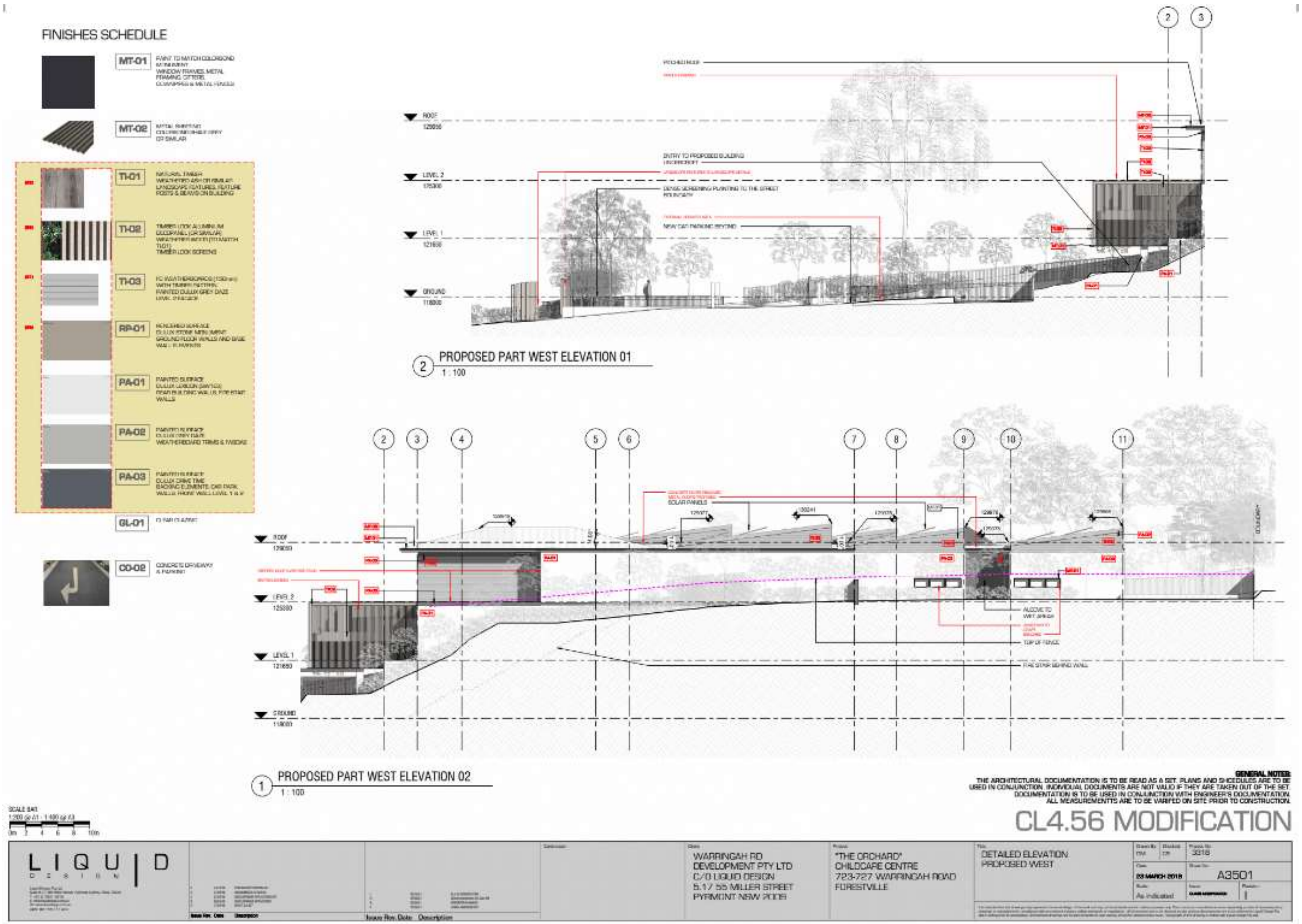

Figure 3.14 – Proposed Detailed Elevations (West)

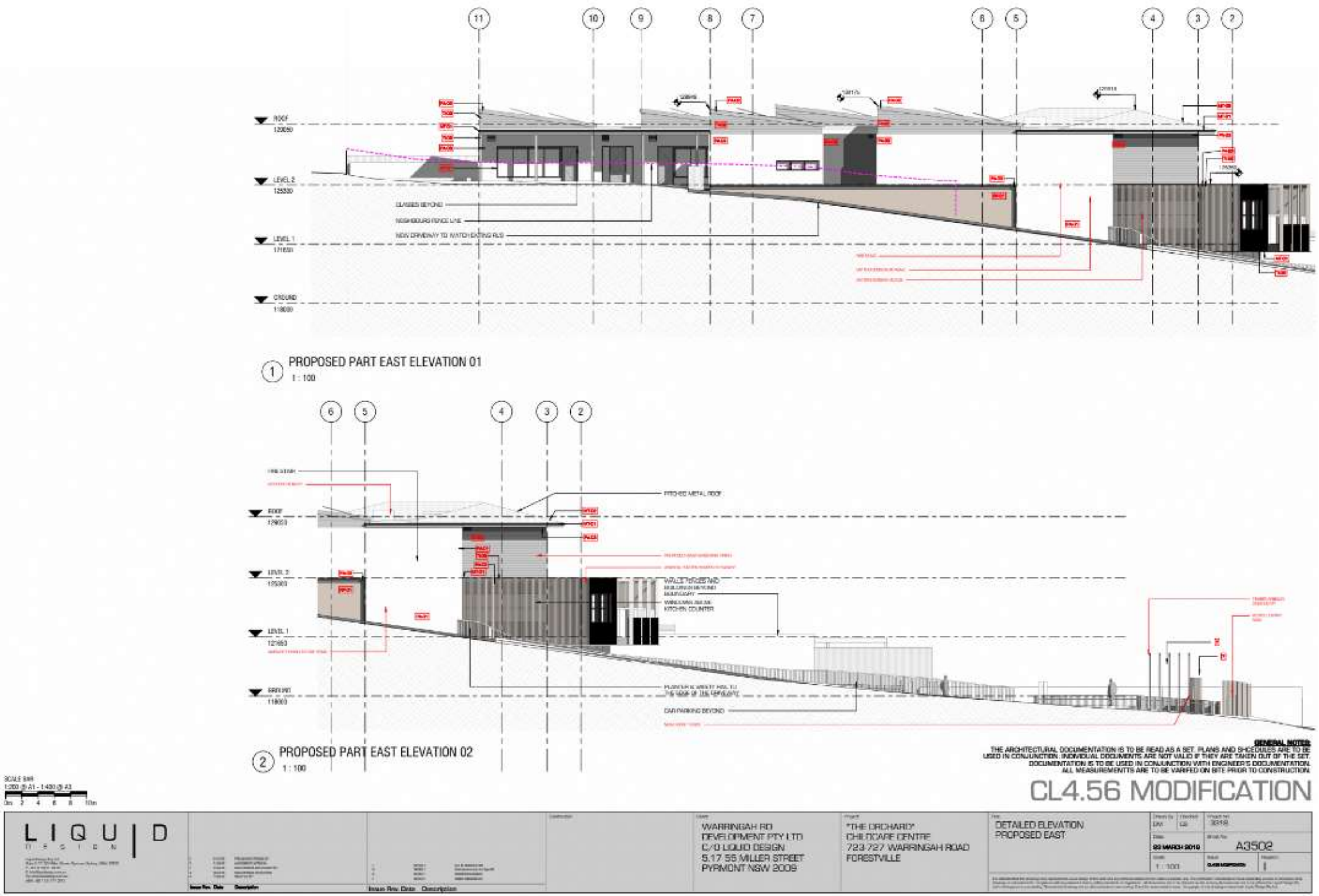

Figure 3.15 – Proposed Detailed Elevations (East)

Figure 3.16 – Proposed Site Sections

Figure 3.17 – Visualisations

4 SCOPE & APPROACH

4.1 FIELD WORK & SPECIALIST GEOTECHNICAL INPUT

The geotechnical assessment presented in this report has been coordinated by NG Child & Associates.

Field work and specialist geotechnical input has been provided by Martens Consulting Engineers (Martens).

The geotechnical findings presented in this report are based on a report provided by Martens, reviewed by NG Child & Associates. The Martens report is included for reference at Appendix A and provides the basis for the information presented in Sections 4, 5 and 6 of this covering report.

4.2 PREVIOUS ASSESSMENT

A preliminary geotechnical assessment of the site was previously provided by NG Child & Associates and Martens and Associates (MA) in September 2020.

Results of this previous assessment, including the Martens input and an overview by NG Child & Associates were presented in the document *Geotechnical Report: Proposed Childcare Centre 723-727 Warringah Road Forestville NSW (NG Child & Associates; Version 2: September 23rd, 2020)*.

The previous investigation included twelve boreholes (BH101 to BH109 and BH 111 to BH 113) and three Dynamic Cone Penetration (DCP) tests (DCP 101 to DCP 105) as illustrated at Appendix B. Borehole logs from the previous investigation are provided for reference at Appendix C, and DCP test results at Appendix D.

Results have not been repeated in this report unless integral to this detailed geotechnical assessment.

4.3 INVESTIGATION SCOPE AND LABORATORY TESTING

4.3.1 Field Investigation

Additional field investigations conducted by Martens on 17 September 2021 included:

- Review of DBYD survey plans and buried services search.
- A walkover inspection of the site to review local geology, soil exposures, surface hydrology, topography and drainage.
- Drilling of two boreholes (BH201 and BH202) including NMLC rock coring in the central portion of the site up to a maximum depth of 8.85 metres below ground level (mbgl).
- Collection of soil and rock samples for laboratory testing and future reference.
- One Standard Penetration Test (SPT) was undertaken in BH201 at the 1.0 m depth.

Refer Attachment C for borehole logs.

Rock core photos and borehole explanatory notes are presented in Attachments E and F, respectively.

Investigation locations are shown in Attachment A.

4.3.2 Laboratory Testing

Resource laboratories, a National Association of Testing Authorities (NATA) accredited laboratory, carried out point load strength index testing on five rock core samples. The relevant laboratory test certificate is provided in Attachment F.

5 SUBSURFACE CONDITIONS & GROUNDWATER

5.1 SUBSURFACE CONDITIONS

This investigation revealed the following generalised subsurface units likely underlie an asphalt / concrete pavement of thickness between approximately 50 mm and 150 mm in BH 201, BH 101, BH 103, BH 108, BH 111 and BH 112, and below ground surface levels across the remainder of the site:

Unit A:

- Topsoil / fill comprising generally clayey sand / silty sand / gravelly sand with varying densities and clay / sandy clay with varying consistencies, encountered up to between approximately 0.1 mbgl (BH106) and 1.3 mbgl (BH108). Thicker fill profile is encountered in the central portion of the site. Fill is inferred to have been placed under uncontrolled conditions for previous site development and / or levelling purposes.

Unit B: Residual Soil Comprising:

- B1: Medium dense to dense sand / clayey sand / silty sand, encountered below Unit A up to between approximately 0.4 mbgl (BH 103) and 2.1 mbgl (BH 111).

- B2: Firm to stiff clay / sandy clay, encountered below Unit A in the southern portion of the site up to between approximately 0.7 mbgl (BH 202) and 1.42 mbgl (BH 112).

- B3: Very stiff to hard clay / sandy clay, encountered below Unit B2 in the southern portion and below Unit B1 in the northern portion of the site up to between approximately 1.7 mbgl (BH 113) and 2.2 mbgl (BH 102).

Unit C: Weathered Sandstone, Encountered from between 0.7 and 2.2 Mbgl, Typically Comprises:

- C1: Highly weathered, low to medium strength (Class IV) sandstone encountered up to between approximately 0.9 mbgl (BH202) and 2.6 mbgl (BH102).

- C2: Moderately weathered, medium strength (Class III) sandstone encountered up to between approximately 3.4 mbgl (BH202) and 5.1 mbgl (BH201).

- C3: Moderately to slightly weathered, medium to high strength (Class II) sandstone encountered up to investigation termination depths of 6.25 mbgl in BH202 and
- 8.85 mbgl in BH201.

Rock classification (Class II to Class IV) is based on Pells et al. (1998) for Sydney Sandstone and Shale.

5.2 GROUNDWATER

Groundwater inflow was encountered during drilling of BH102 at 0.8 m and 1.6 mbgl, at 0.6 mbgl in BH 112 and at 0.4 mbgl in BH 113.

These groundwater levels are inferred to be perched groundwater located within the interface of residual soil / fill and within the residual soil.

Given the proximity to Carroll Creek, permanent groundwater may be encountered in the rock profile below 3.0 mbgl.

The inflow rate into excavation is expected to be low.

5 DETAILED GEOTECHNICAL ASSESSMENT

5.1 INTRODUCTION

The purpose of this investigation has been to provide a geotechnical assessment of the 723/727 Warringah Road Forestville site, in accordance with the scope and approach described in Section 4.

The soil samples used in this assessment were obtained by truck mounted augur at five locations at the site, and by hand augur at a further seven location.

Soil bores were drilled to refusal at rock or other resilient sub-surface strata.

5.2 GEOTECHNICAL ASSESSMENT

5.2.1 Laboratory Point Load Test Results

Laboratory point load strength index test results are summarised in Table 5.1.

Rock core photos are provided in Figures 2 - 3, Attachment D.

Table 5.1 - Point Load Strength Index Test Results

Borehole	Sample Depth (mbgl)	Point Load Strength Index $I_{s(50)}$ (MPa)		UCS [1] (MPa)	Rock Strength [2]
		Diametral	Axial		
BH201	1.8-1.9	0.41	0.55	8.2-11.0	Medium
	4.4-4.5	0.34	0.39	6.8-7.8	Medium
	8.3-8.4	1.20	1.50	24.0-30.0	High
BH202	2.1-2.2	0.34	0.51	6.8-10.2	Medium
	6.1-6.2	0.85	1.00	17.0-20.0	Medium to high

Notes:

1. Unconfined Compressive Strength (UCS) of intact material, assuming UCS = 20 x $I_{s(50)}$.
2. Strength classification based on AS1726 (2017).

Test results and observations during rock coring indicate that the bedrock across the site is likely to consist of highly weathered low to medium strength sandstone up to approximately 2.6 mbgl.

Moderately weathered, medium strength sandstone was encountered up to approximately 5.1 mbgl. Moderately to slightly weathered, medium to high strength sandstone with some higher strength bands / layers was encountered from between approximately 3.4 mbgl (BH 202) and 5.1 mbgl (BH 201) to maximum investigation termination depth of 8.85 mbgl (BH 201).

It should be considered that testing was carried out on relatively intact core samples.

Engineering properties of the rock mass will be impacted by the presence of the numerous defects and discontinuities, including weathered and fractured zones in the rock profile.

5.2.2 Material Properties

Material properties inferred from observations during borehole drilling, such as auger penetration resistance, SPT / DCP and laboratory test results as well as engineering assumptions are summarised in Table 5.2

Table 5.2 - Soil and Rock Strength Properties

Unit	Layer	$\gamma_{in-situ}$ [2] (kN/m³)	C_u [3] (kPa)	C' [4] (kPa)	Ø' [5] (deg)	E' [6] (MPa)
A	TOPSOIL / FILL [1]: Clayey SAND / Silty SAND / Gravelly SAND / CLAY / Sandy CLAY	17	NA [7]	NA [7]	NA [7]	NA [7]
B1	RESIDUAL: SAND / Clayey SAND / Silty SAND (medium dense to dense)	18	NA [7]	NA [7]	32	15
B2	RESIDUAL: Silty CLAY / CLAY (firm to stiff)	17	40	1	25	7
B3	RESIDUAL: Silty CLAY / CLAY (very stiff to hard)	18	150	5	28	30
D1	SANDSTONE: Class IV (highly weathered, low to medium strength)	22	NA [7]	100	30	200
D2	SANDSTONE: Class III (moderately weathered, medium strength)	23	NA [7]	150	32	350
D3	SHALE / SANDSTONE: Class II (moderately to slightly weathered, medium to high strength)	23	NA [7]	250	34	500

Notes:

1. Assumed 'uncontrolled' fill and variable in depth across the site.
2. Material in-situ unit weight, based on visual assessment (±10%).
3. Undrained shear strength (± 5 kPa) estimate assuming normally consolidated clay in a dry condition.
4. Drained cohesion estimate.
5. Average effective internal friction angle (±2 °) estimate assuming drained conditions; may be dependent on rock defect condition.
6. Effective elastic modulus (±10 %) estimate.
7. Not applicable, or not recommended either due to depth or potential internal settlement of materials.

5.2.3 Risk Of Slope Instability

No evidence of former or current slope movement was observed at the site. We consider the risk to property and loss of life by potential slope instability, such as landslide or soil creep, to be very low subject to the recommendations in this report and adoption of relevant engineering standards and guidelines. A detailed slope risk assessment in accordance with Australian Geomechanics Society's Landslide Risk Management Guidelines (2007) was not undertaken.

Recommendations presented in this report are provided to mitigate risks associated with potential excavation instability during construction.

5.2.4 Geotechnical Constraints

The proposed development is inferred to be impacted by the following key geotechnical constraints:

- Existing uncontrolled fill up to approximately 1.3 mbgl (BH 108) is considered unsuitable as foundation material.
- Variable foundation condition will likely be exposed in the northern (e.g. rock) and southern (residual soil) portions of the site following excavation and stripping of topsoil / uncontrolled fill.
- Excavation into medium or higher strength sandstone may require rock sawing techniques prior to the use of hydraulic rock breaker attachments (e.g. rock hammer).
- Excavation of pile into medium and higher strength rock band / layer present in the rock profile may be difficult with conventional piling rig and tools.

5.3 GEOTECHNICAL RECOMMENDATIONS

Geotechnical recommendations for site development are provided below.

Further general geotechnical recommendations are provided in Attachment G.

5.3.1 Excavations

Proposed basement excavations will encounter fill and residual soils over weathered sandstone.

In light of this, it is anticipated that the following excavation equipment will be required:

- **Soils:** Soils should be readily excavated using conventional earthmoving equipment. A 'toothed' bucket or a ripping tyne (or similar) may be required to excavate Class V rock, if encountered.
- **Low to medium (and higher) strength sandstone:** Hydraulic earthmoving equipment, rock breaker or ripping tyne attachment.

Consideration should be given to the use of rock sawing techniques for excavating low to medium and high strength sandstone prior to the use of hydraulic hammer equipment to reduce noise and ground vibrations, especially for excavations within close proximity to the adjacent neighbouring property boundaries to the east and west of the property.

All excavation work should be completed with reference to the most recent version of Code of Practice "Excavation Work", by Safe Work Australia.

5.3.2 Excavation Support

Excavations must be temporarily and permanently battered back / supported / retained to maintain excavation stability and limit potential adverse impacts on neighbouring properties / structures.

Unsupported excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk.

Where there is sufficient setback between excavation and site boundary, excavations may be temporarily battered back, provided any adjacent building foundations are located at least 2 m from slope crest or outside the zone of influence, whichever is greater.

Recommended temporary batter slopes are as follows:

- 1V :1.5H for fill and residual soil.
- 1V :0.5H for Class IV sandstone.
- 4V :1H or Vertical for Class III / II Sandstone.

Recommended Permanent batter slopes are as follows:

- Fill / residual soil: 1V :2H.
- Class IV Sandstone (low to medium strength): 1V :1H.
- Class III / II Sandstone (medium to high strength): 4V :1H.

Recommended batters are subject to inspection and approval by an experienced geotechnical engineer to confirm adopted batter slopes and to assess any impact on adjacent structures or infrastructure. Vertical unsupported excavations in Class III / II Sandstone should be inspected by a geotechnical engineer to assess stability of rock face and advice if rock support is required (see section 5.1.3).

Where there is insufficient setback or where it is desirable to minimise deflection due to adjacent structures, temporary excavation support or shoring should be provided.
Temporary shoring may comprise cantilevered or anchored soldier pile walls with concrete infill panels. Where retained height of the shoring walls exceed approximately 3.0 m or to minimise wall deflections (e.g. adjacent to neighbouring structures), consideration should be given to additional structural support (e.g. internal bracing, tie-back anchors etc.).

Preliminary shoring or retaining wall design should adopt preliminary earth pressure coefficients presented in Section 5.2 (Table 5).

Shoring / retaining wall design should also accommodate pressures imposed by a rock wedge with a failure plane extending at 45º away from excavation base level up to top of rock and surcharge imposed by piling rig and other equipment.

For cantilevered retaining walls, a triangular pressure distribution may be adopted. Where overburden soils comprising sand and clay with one row of ground anchor, a trapezoidal pressure distribution should be adopted to calculate earth pressures on retaining walls.

Temporary shoring walls may be designed to provide long term retention with lateral restraint provided by basement and ground floor slabs. Should the tie-back anchors be considered to minimise pile length and wall deflections, consideration should be given to the available space and permission from neighbouring land owners.

5.3.3 Rock Support

Steeply dipping joints, clay seams and other rock defects may have an adverse effect on unsupported sandstone face stability and construction safety as well as increased earth pressure on shoring wall due to rock wedges.

Geotechnical mapping of the excavation should be conducted at 1.5 m depth increments to identify such features and allow early mitigation of risks of rock face instability.

The presence of adverse jointing, highly weathered rock and clay seams will require shotcreting and / or rock bolting to maintain stability during excavation.

Rock support should be installed by contractors experienced in ground anchor technology and on advisement by an experienced geotechnical engineer.

Rock support should not extend beyond property boundaries unless approval has been granted by relevant property owners or stakeholders.

The actual amount of stabilisation which will be required cannot be quantified at this stage and can only be determined during inspections.

NG Child & Associates in conjunction with Martens can complete the necessary mapping and provide advice for possible remediation measures, where required.

5.3.4 Ground Vibrations

During demolition of existing buildings or excavation in low to medium (and higher) strength sandstone using a rock hammer, vibration management will be required in accordance with AS 2187.2, Appendix J to ensure no adverse impacts on the surrounding properties and infrastructure.

5.3.5 Dilapidation Surveys

Dilapidation surveys of adjacent structures should be carried out prior to excavation and following completion of the development.

5.3.6 Site Classification

The site is classified as a "P" site in accordance with AS 2870 (2011), due to presence of uncontrolled fill and variable ground condition across the site.

A reclassification to "M" and "A" may be possible for all shallow footings founding in at least medium dense / very stiff residual soil and rock, respectively.
These site classifications are subject to the recommendations presented in this report, the design of footings in accordance with the relevant Australian Standards and industry guidelines.

As previously advised by email on October 11th, 2021, any shallow footing or foundations tied to any of the loose fill present at the site would be subject to a “P” classification under AS 2870.

The presence of such fill at the site means that a “P” classification is generally applicable.

The real point is what classifications will apply to footings, shallow foundations or piering tied to the underlying rock, or in the case of any shallow footing tied to dense/stiff residual soil/rock.

While a “P” classification applies to any loose fill areas, it is assumed that these areas will not (and should not) be used for foundation purposes, and on this basis “M” and “A” classifications will apply in the case of the types of strata that will be used for foundation purposes.

5.3.7 Footings and Foundations

Variable foundation material will likely be exposed in the northern (e.g. rock) and southern portions (e.g. residual soil) of the site due to variable excavation depths.

Suitable foundations are likely to comprise pad or strip footings where competent bedrock is present at bulk excavation level. Installation of piles may be required where structural load on columns and walls exceeds the bearing capacity at bulk excavation level.

It is recommended that all foundations are founded on consistent materials to limit differential movement. Design parameters for shallow footings and piers / piles are provided in Section 5.3.

We recommend all footings within building footprint are founded within consistent material to minimise risk of differential foundation settlement.

Alternatively, a lower end bearing capacity should be adopted to limit differential movements.

End bearing capacity values and pile socket length should be confirmed by an experienced geotechnical engineer during construction stage.

5.3.8 Groundwater & Drainage Requirements

Permanent or ephemeral perched groundwater inflow, if encountered during excavation, is expected to be to be limited. We expect this inflow can be managed by sump and pump methods.

Appropriate surface and sub-surface drainage should be provided to divert overland flows and collected groundwater, away from excavations, retaining walls or foundations and limit ponding of water in excavations or near footings and beneath basement / ground floor slab.

Collected water should be discharged into council approved stormwater systems downslope of the site.

5.3.9 Soil Erosion Control

Removal of soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in the Council stormwater system and on neighbouring lands.

All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required.

5.3.10 Earthquake Site Subsoil Class

Earthquake site subsoil is classified as a class “Be (rock)” in accordance with AS 1170.4 (2007).

An earthquake Hazard Factor (z) of 0.08 may be adopted for the site.

5.7 GEOTECHNICAL DESIGN PARAMETERS

Design parameters for footings including earth pressure coefficients for retaining wall design are presented in Table 5.3.

These have been estimated from field and laboratory test results in conjunction with borehole derived soil / rock profile data.

The design parameters assume the base of excavation is free of loose / soft soils or debris and reasonably dry prior to placement of concrete and approved following inspection by an experienced geotechnical engineer.

Table 5.3 - Geotechnical Parameters for Soil and Rock Encountered in Boreholes

Layer	Shallow Footings	Piles / Piers [1]				
	ABC [2,4]	ABC [2,4]	ASF [3,4]	K_a [5]	K_p [5]	K_0 [5]
TOPSOIL / FILL : Clayey SAND / Silty SAND / Gravelly SAND / CLAY / Sandy CLAY	NA [6]	NA [6]	NA [6]	0.42	2.37	0.59
RESIDUAL: SAND / Clayey SAND / Silty SAND (medium dense to dense)	200	NA [6]	NA [6]	0.31	3.26	0.47
RESIDUAL: Silty CLAY / CLAY (firm to stiff)	NA [6]	NA [6]	NA [6]	0.41	2.46	0.58
RESIDUAL: Silty CLAY / CLAY (very stiff to hard)	250	NA [6]	20	0.36	2.77	0.53
SANDSTONE: Class IV (highly weathered, low to medium strength)	500	1000	150	NA [6]	NA [6]	NA [6]
SANDSTONE: Class III (moderately weathered, medium strength)	1000	1500	250	NA [6]	NA [6]	NA [6]
SHALE / SANDSTONE: Class II (moderately to slightly weathered, medium to high strength)	2000	3000	300	NA [6]	NA [6]	NA [6]

Notes:

1. Assuming bored cast in-situ pile.
2. Allowable end bearing capacity (kPa) for shallow footings embedded at least 0.3 m and piles embedded at least 0.5 m or 1 pile diameter, whichever is greater, subject to confirmation on site by a geotechnical engineer of inferred foundation conditions.
3. Allowable skin friction (kPa) below 1 m depth for bored pile in compression, assuming intimate contact between pile and foundation material.
4. ABC and ASF are recommended based on adopting a reduction factor of Øg = 0.4 in accordance with AS2159 (2009), typically adopted in geotechnical practice to limit settlement to an acceptable level for conventional building structures (< 1% of minimum footing width).
5. k_a = Coefficient of active earth pressure; k_p = Coefficient of passive earth pressure; k_0 = Coefficient of earth pressure at rest.
6. Not applicable.

5.8 PROPOSED ADDITIONAL WORKS

5.8.1 Works Prior to Construction Certificate

It is recommended that the final design is reviewed by a senior geotechnical engineer to confirm adequate consideration of the geotechnical risks and adoption of the recommendations provided in this report prior to construction.

5.8.2 Construction Monitoring and Inspections

It is recommended that the following works are inspected and monitored during construction phase of the project (Table 5.4).

Table 5.4 - Recommended Inspection & Monitoring Requirements during Site Works

Scope of Works	Frequency/Duration	Who to Complete
Inspect excavation retention (shoring, retaining wall, anchor, rock bolt) installations and monitor associated performance to assess need for additional support requirements.	Daily / As required [2]	Builder / MA [1]
Inspect unsupported rock excavation faces to assess stability and additional support requirements.	Every 1.5 m lift	MA [1]
Monitor groundwater seepage from excavation faces, if encountered, to assess stability of exposed materials and need for additional drainage requirements.	When encountered	Builder / MA [1]
Monitor excavation-induced vibrations if excavation of medium or higher strength rock by rock hammer is required.	At on-set of excavation and as agreed thereafter [2]	MA [1]
Monitor and analyse excavation-induced ground movement and settlement including retaining wall deflections.	At on-set of demolition and excavation and as agreed thereafter	MA [1]
Inspect exposed material at foundation / subgrade level to verify suitability as foundation / lateral support / subgrade.	Prior to reinforcement set-up and concrete placement	MA [1]
Monitor sedimentation down slope of excavated areas.	During and after rainfall events	Builder
Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil.	After rainfall events	Builder

<u>**Notes:**</u>

1. MA = Martens and Associates engineer.
2. MA inspection frequency to be determined based on initial inspection findings in line with construction program.

6 REFERENCES

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Herbert C. (1983) Sydney 1:100 000 Geological Sheet 9130, 1st edition, Geological Survey of New South Wales, Sydney.

Liquid Design (2018) Architectural Drawings, Project No. 3318, Drawing Nos. A 1000, Rev. G; A 2000, Rev. P; A 2001 & A 2002, Rev. O; A 2005 & A 3000, Rev. M; A 2100 - A 2102, Rev. C; A 2900, Rev. A; A 3001, Rev. L; A 3500, Rev. I; A 3501 & 3502, Rev. H; A 4000, Rev. J and A 4001, Rev. F; dated March 2018 (Liquid, 2018).

Martens and Associates Pty Ltd (2020) Geotechnical Drilling Works Summary: 723-727 Warringah Road, Forestville, NSW, document reference P2007886JC01V 01, dated September 2020 (MA, 2020).

NG Child & Associates (September 2021) Geotechnical Report: Proposed Childcare Centre 723-727 Warringah Road Forestville NSW (Version 2: September 23rd, 2020)

Standards Australia Limited (2004) AS 1289.6.3.1:2004, Determination of the penetration resistance of a soil – Standard penetration test (SPT), SA I Global Limited.

Standards Australia Limited (1997) AS 1289.6.3.2:1997, Determination of the penetration resistance of a soil – 9 kg dynamic cone penetrometer test, SA I Global Limited.

Standards Australia Limited (2017) AS 1726:2017, Geotechnical sit e investigations, SA I Global Limited.

Standards Australia Limited (2009) AS 2159:2009, Piling – Design and installation, SA I Global Limited.

Standards Australia Limited (2006) AS 2187.2:2006, Explosives—Storage, transport and use, Part 2: Use of explosives, SA I Global Limited.

Standards Australia Limited (2011) AS 2870:2011, Residential slabs and footings, SA I Global Limited.

Standards Australia Limited (2007) AS 3798:2007, Guidelines on earthworks for commercial and residential development s, SA I Global Limited.

7 LIMITATIONS

This report describes and presents the findings of a detailed geotechnical assessment of the 723-727 Warringah Road Forestville, with specific regard to the proposed development of a childcare facility at the site in accordance with the plans and drawings presented in Section 3 of this report, which in turn have formed the basis for an S 4.56 modification regarding the development that has been submitted to Northern Beaches Council.

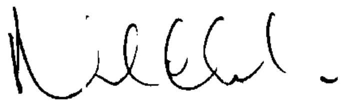
The information and advice presented in this document is considered to provide appropriate detail regarding the geotechnical conditions applicable at the site, subject to limitations imposed by the scope of the investigation, and the number of investigation points considered

Further geotechnical and structural engineering inspections and assessments should be carried out as recommended in this report during the final construction stages of the project to confirm relevant site preparation and construction approaches.

8 AUTHORISATION

This report describes and presents the findings of a detailed geotechnical assessment of the 723-727 Warringah Road Forestville site.

The data presented in this report is considered to be sound for planning, design and construction planning purposes, subject to the limitations described in Section 7 above, and detailed in this report, and the recommendations regarding further work presented in Section 5.8 of this report.



Noel Child BSc Environmental (Hons), EIANZ
Principal, NG Child & Associates

9 November 2021

APPENDIX A

Martens Report

Child and Associates

Geotechnical Assessment: Proposed Child Care Centre – 723-727 Warringah Road, Forestville, NSW

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P2007886JR01V03
October 2021

Limitations Statement

The sole purpose of this report and the associated services performed by Martens & Associates Pty Ltd is to complete a geotechnical assessment in accordance with the scope of services set out by Child and Associates (hereafter known as the Client). That scope of works and services were defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

Martens & Associates Pty Ltd derived the data in this report primarily from a number of sources including site inspections, correspondence regarding the proposal, examination of records in the public domain, interviews with individuals with information about the site or the project, and field explorations conducted on the dates indicated. The passage of time, manifestation of latent conditions or impacts of future events may require further examination / exploration of the site and subsequent data analyses, together with a re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, Martens & Associates Pty Ltd may have relied upon and presumed accurate certain information (or absence thereof) relative to the site. Except as otherwise stated in the report, Martens & Associates Pty Ltd has not attempted to verify the accuracy of completeness of any such information (including for example survey data supplied by others).

The findings, observations and conclusions expressed by Martens & Associates Pty Ltd in this report are not, and should not be considered an opinion concerning the completeness and accuracy of information supplied by others. No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings and conclusions are based solely upon site conditions, information and drawings supplied by the Client etc. in existence at the time of the investigation.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between Martens & Associates Pty Ltd and the Client. Martens & Associates Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

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3	Geotechnical Assessment	Final	26.10.2021	1E, 1H, 1P	1P		

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All enquiries regarding this project are to be directed to the Project Manager.

Contents

1 Proposed Development and Investigation Scope

The proposed development details and investigation scope are summarised in Table 1.

Table 1: Summary of proposed development and investigation scope.

Item	Details
Property Address	723-727 Warringah Road, Forestville, NSW ('the site')
Lot/DP	Lots 1, 2 and 3 in DP 25050 (refer Figure 1, Attachment A)
Site Area	Lot 1 (905.2 m²), Lot 2 (863.5 m²) and Lot 3 (2165 m²) in DP 25050 comprise a total area of 3933.7 m² (CMS, 2013)
LGA	Northern Beaches Council ('Council')
Assessment Purpose	Geotechnical assessment to assist detailed design of the proposed child care centre and to obtain Construction Certificate (CC) from Council.
Proposed Development	We understand from the proposal plans (Liquid, 2018) that the proposed development will include: o Demolition of existing structures on site. o Construction of a new child care facility comprising up to a three storey building with the inclusion of two underground levels. This will likely require bulk excavation of approximately 7.0 m below ground level (mbgl). The bulk excavation will be limited to the central portion of the site and the finished level of the lowest ground floor will be at 118.0 mAHD. Proposed excavations will be offset approximately 1.0 m from western site boundary and 3.0 m from eastern site boundary. Therefore, proposed excavations will likely extend into the zone of influence of neighbouring properties and / or other infrastructure to the west and east. The zone of influence is defined by an imaginary line drawn up at 45º from the base of the excavation extending up and away from the base of the excavation to the features in question (e.g. property boundary). Proposed bulk excavations will be offset > 7 m from the northern and southern site boundaries.
Previous Assessment	A preliminary geotechnical assessment was previously conducted by Martens and Associates (MA) at the site. Results of this assessment are presented in MA's letter report reference P2007886JC01V01, dated September 2020 (MA, 2020). The investigation included twelve boreholes (BH101 to BH109 and BH111 to BH113) and three Dynamic Cone Penetration (DCP) tests (DCP101 to DCP105) as shown in Figure 1, Attachment A (refer Attachment B for borehole logs and Attachment C for DCP results). Results have not been reproduced in this report unless integral to our assessment.

2 Investigation Scope and Laboratory Testing

2.1 Field investigation

Additional field investigations conducted on 17 September 2021 included:

- Review of DBYD survey plans and buried services search.
- A walkover inspection of the site to review local geology, soil exposures, surface hydrology, topography and drainage.
- Drilling of two boreholes (BH201 and BH202) including NMLC rock coring in the central portion of the site up to a maximum depth of 8.85 metres below ground level (mbgl).
- Collection of soil and rock samples for laboratory testing and future reference.
- One Standard Penetration Test (SPT) was undertaken in BH201 at the 1.0 m depth.

Refer Attachment B for borehole logs. Rock core photos and borehole explanatory notes are presented in Attachment D and Attachment G, respectively. Investigation locations are shown in Figure 1, Attachment A.

2.2 Laboratory Testing

Resource laboratories, a National Association of Testing Authorities (NATA) accredited laboratory, carried out point load strength index testing on five rock core samples. Laboratory test certificates are provided in Attachment E.

3 General Site Details and Subsurface Conditions

General site details and investigation findings are summarised in Table 2.

Table 2: Summary of general site conditions based on desktop review, site walkover and site investigations.

Item	Comment
Topography	Within undulating terrain, on the northern side and upper to mid slope of an east-west aligned ridge, approximately 415 m southeast of Carroll Creek.
Typical Slopes, Aspect, Elevation	The site has a north / north westerly aspect with an overall grade of between approximately 10 % and 20 %. Site elevation ranges between approximately 116.2 mAHD in the northern portion and 125.5 mAHD in the south corner (CMS, 2013).
Expected geology	Hawkesbury Sandstone consisting of medium to coarse-grained quartz sandstone, very minor shale and laminate lenses (*Sydney 1:100,000 Geological Sheet 9130, 1st edition*)
Existing Development	The existing site developments include: o Two storey brick and clad house with metal roof, attached verandah, carports, clad garage, metal shed, concrete hardstands, an in-ground swimming pool and timber deck on Lot 1. o A single storey brick house with tile roof, concrete drive way, a metal shed, brick walls and concrete path on Lot 2. o One and two storey brick house with tile roof, attached verandah, brick garage with tile roof, concrete block shed with tile roof, concrete drive way, timber pergolas, concrete / block retaining walls, concrete hardstands / tennis court and an in-ground fibro glass swimming pool on Lot 3.
Vegetation	Grass in the front and backyards of each lot and scattered trees particularly along the eastern and western site boundaries.
Drainage	Via overland flow to the north / northwest into the council's stormwater network along Warringah Road.
Neighbouring environment	The site is bordered by Warringah Road to the north, Forestville public school to the south, concrete driveway followed by one / two storey residential buildings to the east and one / two storey residential buildings to the west of the site.

3.1 Subsurface Conditions

Investigation revealed the following generalised subsurface units likely underlie an asphalt / concrete pavement of thickness between approximately 50 mm and 150 mm in BH201, BH101, BH103, BH108, BH111 and BH112, and below ground surface levels across the remainder of the site:

Unit A: Topsoil / fill comprising generally clayey sand / silty sand / gravelly sand with varying densities and clay / sandy clay with varying consistencies, encountered up to between approximately 0.1 mbgl (BH106) and 1.3 mbgl (BH108). Thicker fill profile is encountered in the central portion of the site. Fill is inferred to have been placed under uncontrolled conditions for previous site development and / or levelling purposes.

Unit B: Residual soil comprising:

B1: Medium dense to dense sand / clayey sand / silty sand, encountered below Unit A up to between approximately 0.4 mbgl (BH103) and 2.1 mbgl (BH111).

B2: Firm to stiff clay / sandy clay, encountered below Unit A in the southern portion of the site up to between approximately 0.7 mbgl (BH202) and 1.42 mbgl (BH112).

B3: Very stiff to hard clay / sandy clay, encountered below Unit B2 in the southern portion and below Unit B1 in the northern portion of the site up to between approximately 1.7 mbgl (BH113) and 2.2 mbgl (BH102).

Unit C: Weathered sandstone, encountered from between 0.7 m and 2.2 mbgl, typically comprises:

C1: Highly weathered, low to medium strength (Class IV) sandstone encountered up to between approximately 0.9 mbgl (BH202) and 2.6 mbgl (BH102).

C2: Moderately weathered, medium strength (Class III) sandstone encountered up to between approximately 3.4 mbgl (BH202) and 5.1 mbgl (BH201).

C3: Moderately to slightly weathered, medium to high strength (Class II) sandstone encountered up to investigation termination depths of 6.25 mbgl in BH202 and 8.85 mbgl in BH201.

Rock classification (Class II to Class IV) is based on Pells et al. (1998) for Sydney Sandstone and Shale.

3.2 Groundwater

Groundwater inflow was encountered during drilling of BH102 at 0.8 m and 1.6 mbgl, at 0.6 mbgl in BH112 and at 0.4 mbgl in BH113. These groundwater levels are inferred to be perched groundwater located within the interface of residual soil / fill and within the residual soil. Given the proximity to Carroll Creek, permanent groundwater may be encountered in the rock profile below 3.0 mbgl. The inflow rate into excavation is expected to be low.

4 Geotechnical Assessment

4.1 Laboratory Point Load Test Results

Laboratory point load strength index test results are summarised in Table 3. Rock core photos are provided in Figures 2 - 3, Attachment D.

Table 8: Point load strength index test results.

Borehole	Sample Depth (mbgl)	Point Load Strength Index $I_{s(50)}$ (MPa)		UCS [1] (MPa)	Rock Strength [2]
		Diametral	Axial		
BH201	1.8-1.9	0.41	0.55	8.2-11.0	Medium
	4.4-4.5	0.34	0.39	6.8-7.8	Medium
	8.3-8.4	1.20	1.50	24.0-30.0	High
BH202	2.1-2.2	0.34	0.51	6.8-10.2	Medium
	6.1-6.2	0.85	1.00	17.0-20.0	Medium to high

Notes:

1. Unconfined Compressive Strength (UCS) of intact material, assuming UCS = 20 x $I_{s(50)}$.
2. Strength classification based on AS1726 (2017).

Test results and observations during rock coring indicate that the bedrock across the site is likely to consist of highly weathered low to medium strength sandstone up to approximately 2.6 mbgl. Moderately weathered, medium strength sandstone was encountered up to approximately 5.1 mbgl. Moderately to slightly weathered, medium to high strength sandstone with some higher strength bands / layers was encountered from between approximately 3.4 mbgl (BH202) and 5.1 mbgl (BH201) to maximum investigation termination depth of 8.85 mbgl (BH201).

It should be considered that testing was carried out on relatively intact core samples. Engineering properties of the rock mass will be impacted by the presence of the numerous defects and discontinuities, including weathered and fractured zones in the rock profile.

4.2 Material Properties

Material properties inferred from observations during borehole drilling, such as auger penetration resistance, SPT / DCP and laboratory test results as well as engineering assumptions are summarised in Table 4.

Table 4: Soil and rock strength properties.

Unit	Layer	$\gamma_{in\text{-}situ}$ [2] (kN/m³)	C_u [3] (kPa)	C' [4] (kPa)	Ø' [5] (deg)	E' [6] (MPa)
A	TOPSOIL / FILL [1]: Clayey SAND / Silty SAND / Gravelly SAND / CLAY / Sandy CLAY	17	NA [7]	NA [7]	NA [7]	NA [7]
B1	RESIDUAL: SAND / Clayey SAND / Silty SAND (medium dense to dense)	18	NA [7]	NA [7]	32	15
B2	RESIDUAL: Silty CLAY / CLAY (firm to stiff)	17	40	1	25	7
B3	RESIDUAL: Silty CLAY / CLAY (very stiff to hard)	18	150	5	28	30
D1	SANDSTONE: Class IV (highly weathered, low to medium strength)	22	NA [7]	100	30	200
D2	SANDSTONE: Class III (moderately weathered, medium strength)	23	NA [7]	150	32	350
D3	SHALE / SANDSTONE: Class II (moderately to slightly weathered, medium to high strength)	23	NA [7]	250	34	500

Notes:

1. Assumed 'uncontrolled' fill and variable in depth across the site.
2. Material in-situ unit weight, based on visual assessment (±10 %).
3. Undrained shear strength (± 5 kPa) estimate assuming normally consolidated clay in a dry condition.
4. Drained cohesion estimate.
5. Average effective internal friction angle (±2 °) estimate assuming drained conditions; may be dependent on rock defect condition.
6. Effective elastic modulus (±10 %) estimate.
7. Not applicable, or not recommended either due to depth or potential internal settlement of materials.

4.3 Risk of Slope Instability

No evidence of former or current slope movement was observed at the site. We consider the risk to property and loss of life by potential slope instability, such as landslide or soil creep, to be very low subject to the recommendations in this report and adoption of relevant engineering standards and guidelines. A detailed slope risk assessment in accordance with Australian Geomechanics Society's Landslide Risk Management Guidelines (2007) was not undertaken.

Recommendations presented in this report are provided to mitigate risks associated with potential excavation instability during construction.

4.4 Geotechnical Constraints

The proposed development is inferred to be impacted by the following key geotechnical constraints:

- Existing uncontrolled fill up to approximately 1.3 mbgl (BH108) is considered unsuitable as foundation material.
- Variable foundation condition will likely be exposed in the northern (e.g. rock) and southern (residual soil) portions of the site following excavation and stripping of topsoil / uncontrolled fill.
- Excavation into medium or higher strength sandstone may require rock sawing techniques prior to the use of hydraulic rock breaker attachments (e.g. rock hammer).
- Excavation of pile into medium and higher strength rock band / layer present in the rock profile may be difficult with conventional piling rig and tools.

5 Geotechnical Recommendations

5.1 Recommendations

Geotechnical recommendations for site development are provided below. Further general geotechnical recommendations are provided in Attachment F.

5.1.1 Excavations

Proposed basement excavations will encounter fill and residual soils over weathered sandstone. In light of this, we expect the following excavation equipment will be required:

- Soils: Soils should be readily excavated using conventional earthmoving equipment. A 'toothed' bucket or a ripping tyne (or similar) may be required to excavate Class V rock, if encountered.
- Low to medium (and higher) strength sandstone: Hydraulic earthmoving equipment, rock breaker or ripping tyne attachment.

Consideration should be given to the use of rock sawing techniques for excavating low to medium and high strength sandstone prior to the use of hydraulic hammer equipment to reduce noise and ground vibrations, especially for excavations within close proximity to the adjacent neighbouring property boundaries to the east and west of the property.

All excavation work should be completed with reference to the most recent version of Code of Practice 'Excavation Work', by Safe Work Australia.

5.1.2 Excavation Support

Excavations must be temporarily and permanently battered back / supported / retained to maintain excavation stability and limit potential adverse impacts on neighbouring properties / structures. Unsupported excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk.

Where there is sufficient setback between excavation and site boundary, excavations may be temporarily battered back, provided any adjacent building foundations are located at least 2 m from slope crest or outside the zone of influence, whichever is greater.

Recommended temporary batter slopes are as follows:

- 1V:1.5H for fill and residual soil.
- 1V:0.5H for Class IV sandstone.
- 4V:1H or Vertical for Class III / II Sandstone.

Recommended Permanent batter slopes are as follows:

- Fill / residual soil: 1V:2H.
- Class IV Sandstone (low to medium strength): 1V:1H.
- Class III / II Sandstone (medium to high strength): 4V:1H.

Recommended batters are subject to inspection and approval by an experienced geotechnical engineer to confirm adopted batter slopes and to assess any impact on adjacent structures or infrastructure. Vertical unsupported excavations in Class III / II Sandstone should be inspected by a geotechnical engineer to assess stability of rock face and advice if rock support is required (see section 5.1.3).

Where there is insufficient setback or where it is desirable to minimise deflection due to adjacent structures, temporary excavation support or shoring should be provided. Temporary shoring may comprise cantilevered or anchored soldier pile walls with concrete infill panels. Where retained height of the shoring walls exceed approximately 3.0 m or to minimise wall deflections (e.g. adjacent to neighbouring structures), consideration should be given to additional structural support (e.g. internal bracing, tie-back anchors etc.). Preliminary shoring or retaining wall design should adopt preliminary earth pressure coefficients presented in Section 5.2 (Table 5). Shoring / retaining wall design should also accommodate pressures imposed by a rock wedge with a failure plane extending at 45° away from excavation base level up to top of rock and surcharge imposed by piling rig and other equipment. For cantilevered retaining walls, a triangular pressure distribution may be adopted. Where overburden soils comprising sand and clay with one row of ground anchor, a trapezoidal pressure distribution should be adopted to calculate earth pressures on retaining walls.

Temporary shoring walls may be designed to provide long term retention with lateral restraint provided by basement and ground floor slabs. Should the tie-back anchors be considered to minimise pile length and wall deflections, consideration should be given to the available space and permission from neighbouring land owners.

5.1.3 Rock Support

Steeply dipping joints, clay seams and other rock defects may have an adverse effect on unsupported sandstone face stability and construction safety as well as increased earth pressure on shoring wall due to rock wedges. Geotechnical mapping of the excavation should be conducted at 1.5 m depth increments to identify such features and allow early mitigation of risks of rock face instability. The presence of adverse jointing, highly weathered rock and clay seams will require shotcreting and / or rock bolting to maintain stability during excavation.

Rock support should be installed by contractors experienced in ground anchor technology and on advisement by an experienced geotechnical engineer. Rock support should not extend beyond property boundaries unless approval has been granted by relevant property owners or stakeholders. The actual amount of stabilisation which will be required cannot be quantified at this stage and can only be determined during inspections. MA can complete the necessary mapping and provide advice for possible remediation measures, where required.

5.1.4 Ground Vibrations

During demolition of existing buildings or excavation in low to medium (and higher) strength sandstone using a rock hammer, vibration management will be required in accordance with AS 2187.2, Appendix J to ensure no adverse impacts on the surrounding properties and infrastructure.

5.1.5 Dilapidation Surveys

Dilapidation surveys of adjacent structures should be carried out prior to excavation and following completion of the development.

5.1.6 Site Classification

The site is classified as a "P" site in accordance with AS 2870 (2011), due to presence of uncontrolled fill and variable ground condition across the site. A reclassification to "M" and "A" may be possible for all shallow footings founding in at least medium dense / very stiff residual soil and rock, respectively.

These site classifications are subject to the recommendations presented in this report, the design of footings in accordance with the relevant Australian Standards and industry guidelines.

5.1.7 Footings and Foundations

Variable foundation material will likely be exposed in the northern (e.g. rock) and southern portions (e.g. residual soil) of the site due to variable excavation depths. Suitable foundations are likely to comprise pad or strip footings where competent bedrock is present at bulk excavation level. Installation of piles may be required where structural load on columns and walls exceeds the bearing capacity at bulk excavation level. We recommend that all foundations are founded on consistent materials to limit differential movement. Design parameters for shallow footings and piers / piles are provided in Section 5.2 (Table 5).

We recommend all footings within building footprint are founded within consistent material to minimise risk of differential foundation settlement. Alternatively, a lower end bearing capacity should be adopted to limit differential movements. End bearing capacity values and pile socket length should be confirmed by an experienced geotechnical engineer during construction stage.

5.1.8 Groundwater / Drainage Requirements

Permanent or ephemeral perched groundwater inflow, if encountered during excavation, is expected to be to be limited. We expect this inflow can be managed by sump and pump methods.

Appropriate surface and sub-surface drainage should be provided to divert overland flows and collected groundwater, away from excavations, retaining walls or foundations and limit ponding of water in excavations or near footings and beneath basement / ground floor slab. Collected water should be discharged into council approved stormwater systems downslope of the site.

5.1.9 Soil Erosion Control

Removal of soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in the Council stormwater system and on neighbouring lands. All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required.

5.1.10 Earthquake Site Subsoil Class

Earthquake site subsoil is classified as a class 'B_e (rock)' in accordance with AS 1170.4 (2007). An earthquake Hazard Factor (z) of 0.08 may be adopted for the site.

5.2 Geotechnical Design Parameters

Design parameters for footings including earth pressure coefficients for retaining wall design are presented in Table 5. These have been estimated from field and laboratory test results in conjunction with borehole derived soil / rock profile data. The design parameters assume the base of excavation is free of loose / soft soils or debris and reasonably dry prior to placement of concrete and approved following inspection by an experienced geotechnical engineer.

Table 5: Geotechnical parameters for soil and rock encountered in boreholes.

Layer	Shallow Footings	Piles / Piers [1]				
	ABC [2,4]	ABC [2,4]	ASF [3,4]	K_a [5]	K_p [5]	K_0 [5]
TOPSOIL / FILL : Clayey SAND / Silty SAND / Gravelly SAND / CLAY / Sandy CLAY	NA [6]	NA [6]	NA [6]	0.42	2.37	0.59
RESIDUAL: SAND / Clayey SAND / Silty SAND (medium dense to dense)	200	NA [6]	NA [6]	0.31	3.26	0.47
RESIDUAL: Silty CLAY / CLAY (firm to stiff)	NA [6]	NA [6]	NA [6]	0.41	2.46	0.58
RESIDUAL: Silty CLAY / CLAY (very stiff to hard)	250	NA [6]	20	0.36	2.77	0.53
SANDSTONE: Class IV (highly weathered, low to medium strength)	500	1000	150	NA [6]	NA [6]	NA [6]
SANDSTONE: Class III (moderately weathered, medium strength)	1000	1500	250	NA [6]	NA [6]	NA [6]
SHALE / SANDSTONE: Class II (moderately to slightly weathered, medium to high strength)	2000	3000	300	NA [6]	NA [6]	NA [6]

Notes:

1. Assuming bored cast in-situ pile.
2. Allowable end bearing capacity (kPa) for shallow footings embedded at least 0.3 m and piles embedded at least 0.5 m or 1 pile diameter, whichever is greater, subject to confirmation on site by a geotechnical engineer of inferred foundation conditions.
3. Allowable skin friction (kPa) below 1 m depth for bored pile in compression, assuming intimate contact between pile and foundation material.
4. ABC and ASF are recommended based on adopting a reduction factor of Øg = 0.4 in accordance with AS2159 (2009), typically adopted in geotechnical practice to limit settlement to an acceptable level for conventional building structures (< 1% of minimum footing width).
5. k_a = Coefficient of active earth pressure; k_p = Coefficient of passive earth pressure; k_0 = Coefficient of earth pressure at rest.
6. Not applicable.

6 Proposed Additional Works

6.1 Works Prior to Construction Certificate

We recommend that the final design is reviewed by a senior geotechnical engineer to confirm adequate consideration of the geotechnical risks and adoption of the recommendations provided in this report prior to construction.

6.2 Construction Monitoring and Inspections

We recommend the following is inspected and monitored during construction phase of the project (Table 6).

Table 6: Recommended inspection / monitoring requirements during site works.

Scope of Works	Frequency/Duration	Who to Complete
Inspect excavation retention (shoring, retaining wall, anchor, rock bolt) installations and monitor associated performance to assess need for additional support requirements.	Daily / As required [2]	Builder / MA [1]
Inspect unsupported rock excavation faces to assess stability and additional support requirements.	Every 1.5 m lift	MA [1]
Monitor groundwater seepage from excavation faces, if encountered, to assess stability of exposed materials and need for additional drainage requirements.	When encountered	Builder / MA [1]
Monitor excavation-induced vibrations if excavation of medium or higher strength rock by rock hammer is required.	At on-set of excavation and as agreed thereafter [2]	MA [1]
Monitor and analyse excavation-induced ground movement and settlement including retaining wall deflections.	At on-set of demolition and excavation and as agreed thereafter	MA [1]
Inspect exposed material at foundation / subgrade level to verify suitability as foundation / lateral support / subgrade.	Prior to reinforcement set-up and concrete placement	MA [1]
Monitor sedimentation down slope of excavated areas.	During and after rainfall events	Builder
Monitor sediment and erosion control structures to assess adequacy and for removal of built up spoil.	After rainfall events	Builder

<u>Notes:</u>

1. MA = Martens and Associates engineer.
2. MA inspection frequency to be determined based on initial inspection findings in line with construction program.

7 References

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Herbert C. (1983) *Sydney 1:100 000 Geological Sheet 9130*, 1st edition, Geological Survey of New South Wales, Sydney.

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Standards Australia Limited (2017) AS 1726:2017, *Geotechnical site investigations*, SAI Global Limited.

Standards Australia Limited (2009) AS 2159:2009, *Piling – Design and installation*, SAI Global Limited.

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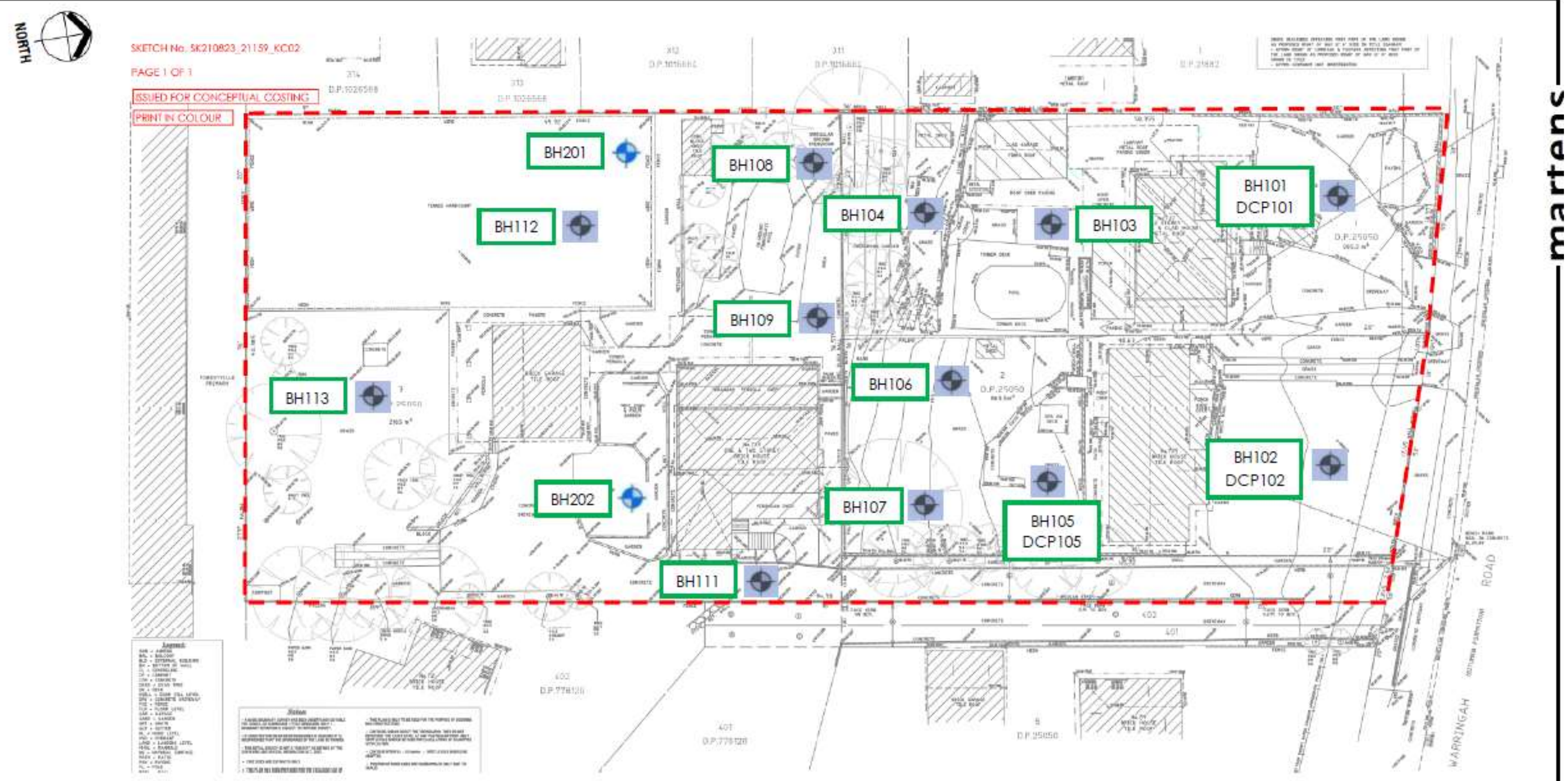
Standards Australia Limited (2011) AS 2870:2011, *Residential slabs and footings*, SAI Global Limited.

Standards Australia Limited (2007) AS 3798:2007, *Guidelines on earthworks for commercial and residential developments*, SAI Global Limited.

APPENDIX B

Site Layout & Geotechnical Testing Plan



Key:

Approximate borehole and DCP test location

Approximate borehole and DCP test location (MA, 2020)

Indicative site boundary

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	WB	SITE LAYOUT AND GEOTECHNICAL TESTING PLAN 723-727 Warringah Road, Forestville, NSW (Source: CMS, 2013)	Drawing No: **FIGURE 1**
Approved:	SK		
Date:	26.10.2021		
Scale:	NA		Project No: P2007886JR01V03

APPENDIX C

Test Borehole Logs

CLIENT	Child and Associates	COMMENCED	17/09/2021	COMPLETED	17/09/2021	REF **BH201**
PROJECT	Geotechnical Assessment	LOGGED	RJK	CHECKED	SK	Sheet 1 OF 2
SITE	723-727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Nil	PROJECT NO. P2007888
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	151.21298	RL SURFACE	125.2 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 8.85 m depth	LATITUDE	-33.78077	ASPECT	North	SLOPE: <10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	H	Not Observed		125.15	0.0-0.05/8/1 D 0.00-0.05 m				FILL: ASPHALT.			FILL
	L				0.3-0.5/8/1 D 0.30-0.50 m			SP	FILL: SAND; pale yellow; with gravels; trace silt and clay.	M	MD	
			1	0.70 124.50	0.8-1.0/8/1 D 0.80-1.00 m SPT 1.00 m 5,8/100 mm N= Refusal			CI	CLAY; medium plasticity; grey; trace sand.	M (<PL)	St	RESIDUAL SOIL
	H			1.30 1.45	1.1-1.2/8/1 D 1.10-1.20 m 1.4-1.45/8/1 D 1.40-1.45 m				SANDSTONE; medium grained; brown, red - brown, red; highly weathered; inferred low strength. Continued as Cored Borehole			WEATHERED ROCK
			2									
			3									
			4									
			5									
			6									
			7									
			8									
			9									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Child and Associates	COMMENCED	17/09/2021	COMPLETED	17/09/2021	REF	BH201
PROJECT	Geotechnical Assessment	LOGGED	RJK	CHECKED	SK	Sheet	2 OF 2
SITE	723-727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Nil	PROJECT NO. P2007888	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	151.21296	RL SURFACE	125.2 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 8.85 m depth	LATITUDE	-33.76077	ASPECT	North	SLOPE	<10%

Drilling | **Field Material Description** | **Defect Information**

METHOD	WATER	TCR	RQD (SCR)	DEPTH (metres)	DEPTH RL	GRAPHIC LOG	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $I_{s(50)}$ MPa	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm)
				1	1.45		Continuation from non-cored borehole				
NMLC	Not Observed	100	87 (95)	2	123.75		SANDSTONE; medium to coarse grained, brown, red - brown red and pale grey	MW		1.45-1.50: CS 1.50-1.51: DS, Clayey Sand 1.57: JT, 5°, CN, UN, Ro 1.73-1.89: BPSet 2, 0°, CN, Pl, Ro 1.95: JT, 5°, CN, UN, Ro 2.00: HB 2.15-2.88: JTSet 3, 0 - 5°, CN, UN, Ro, 190-220mm spacing 2.75: DB 2.82: BP, 0°, CN, Pl, Sm 3.00: HB 3.48-3.53: JTSet 2, 5°, CT, UN, Ro, Carbonaceous 4.00: HB 4.37-4.94: BPSet 2, 0°, CN, Pl, Sm 5.00: HB	
		100	94 (100)	3, 4, 5	5.10						
					120.10		Pale grey.	SW		5.05-5.15: BPSet 2, 0°, CN, Pl, Sm 5.41-5.43: JTSet 2, 0 - 5°, CN, UN, Ro, Carbonaceous 5.70: BP, 0°, CN, Pl, Sm 5.75: DB 6.00: HB 6.45: BP, 5°, CN, UN, Ro 7.00: HB	
		100	96 (100)	6, 7	7.44						
					117.71		SHALE; dark grey.			7.44-7.49: BPSet 2, 0°, CN, Pl, Sm	
				8			SANDSTONE; medium to coarse grained; pale grey.			7.47: JT, 0°, CN, UN, Ro 7.52: JT, 15°, CN, UN, Ro 7.56: BP, 5°, CN, Pl, Sm 8.00: HB 8.15: BP, 0°, CN, ST, Ro	
				9	8.85 116.35		Hole Terminated at 8.85 m (Target depth reached)				

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CLIENT	Child and Associates	COMMENCED	17/09/2021	COMPLETED	17/09/2021	REF BH202	
PROJECT	Geotechnical Assessment	LOGGED	RJK	CHECKED	SK	Sheet 1 OF 2	
SITE	723-727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Nil	PROJECT NO. P2007886	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	151.21327	RL SURFACE	124.8 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 6.25 m depth	LATITUDE	-33.76079	ASPECT	North	SLOPE	<5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADT	L	Not Observed		124.80				SM	FILL: Silty SAND; fine grained; pale brown; trace clay.	M	MD	FILL
				0.30 124.50				CI	Sandy CLAY; medium plasticity; dark grey, olive and orange; with sand and silt; trace gravels.	M (<PL)	F - St	
	H			0.70 124.10					SANDSTONE; medium grained; brown, red - brown, red; highly weathered; inferred low strength.			WEATHERED ROCK
				0.90					Continued as Cored Borehole			

Depth scale (metres): 1, 2, 3, 4, 5, 6, 7, 8, 9

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CLIENT	Child and Associates	COMMENCED	17/09/2021	COMPLETED	17/09/2021	REF BH202
PROJECT	Geotechnical Assessment	LOGGED	RJK	CHECKED	SK	Sheet 2 OF 2
SITE	723-727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Nil	PROJECT NO. P2007886
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE	151.21327	RL SURFACE	124.8 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 6.25 m depth	LATITUDE	-33.76079	ASPECT	North	SLOPE <5%

Drilling | **Field Material Description** | **Defect Information**

METHOD	WATER	TCR	RQD (SCR)	DEPTH / RL	ROCK / SOIL MATERIAL DESCRIPTION	WEATHERING	INFERRED STRENGTH $Is_{(50)}$ MPa	DEFECT DESCRIPTION & Additional Observations	AVERAGE DEFECT SPACING (mm)
				0.90	Continuation from non-cored borehole				
NMLC	Not Observed	100	85 (98)	123.90	SANDSTONE, medium to coarse grained, brown, red - brown red and pale grey.	MW		0.90-0.94: CS 1.00: HB 1.10-1.19: JTSet 2, 5°, CN, UN, Ro 1.54-1.66: BPSet 2, 5°, CN, Pl, Sm 2.00: HB 2.01-2.04: JTSet 2, 0 - 5°, CN, UN, Ro 2.32-2.33: DS, Clayey Sand 2.35-2.36: DS, Clayey Sand 2.88: BP, 0°, VNR, UN, Ro	
				3.00 / 121.80	Dark brown, red - brown and pale grey.			3.00: HB 3.08: JT, 0°, CN, UN, Ro 3.19: BP, 10°, CN, UN, Ro 3.29-3.32: CS 3.82-4.41: BPSet 2, 0°, CN, Pl, Sm 4.00: HB 4.19: BP, 0°, CN, Pl, Sm	
	Not Observed	100	93 (99)	4.45 / 120.35	Pale grey and dark grey.	SW		5.00: HB 5.08-5.45: BPSet 2, 5°, CN, Pl, Sm 5.11-5.12: DS, Clay 6.00: HB	
				6.25 / 118.55	Hole Terminated at 6.25 m				

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CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	**REF BH101**	
PROJECT	Geotechnical Investigation	LOGGED	AG	CHECKED	JF	Sheet 1 OF 1	
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	None	PROJECT NO. P2007886	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.2131	RL SURFACE	116.6 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.30 m depth	NORTHING	-33.7603	ASPECT	North	SLOPE	<5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L	Not Encountered		116.60 *0.10*					Brick pavers.			PAVEMENT
ADV	L	Not Encountered		116.50 *0.25*	0.2/S/1 D 0.20 m			SM	FILL: Silty SAND; fine to medium grained; brown; trace gravel.	D	MD	FILL
ADV	L	Not Encountered	0.5	116.35 *0.50*	0.3/S/2 D 0.30 m			SP	FILL: Gravelly SAND; medium to coarse grained; black to dark brown.	D	MD	
ADV	M	Not Encountered	1.0	116.10 *1.20*	0.6/S/3 D 0.60 m			SC	Clayey SAND; fine to medium grained; bluish grey to pale bluish grey; trace gravels.	M	D	RESIDUAL SOIL
ADT	R H R	Not Encountered		115.40 1.30	1.25/S/4 D 1.25 m				SANDSTONE, medium to coarse grained, white to pale grey, inferred low strength.	D		WEATHERED ROCK 1.20: V-bit refusal.
			1.5						Hole Terminated at 1.30 m			1.30: TC-bit refusal on inferred low to medium strength sandstone.
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	**REF BH102**
PROJECT	Geotechnical Investigation	LOGGED	AG	CHECKED	JF	Sheet 1 OF 1
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Grass	PROJECT NO. P2007886
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.2134	RL SURFACE	117 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 2.60 m depth	NORTHING	-33.7603	ASPECT	North	SLOPE 5 - 10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V	L			117.00 0.30				SC	TOPSOIL: Clayey SAND; fine to medium grained; dark brown to dark grey; trace silt.	M <<PL	L - MD	TOPSOIL
AD/V	L	Inflow	0.5 1.0	116.70 1.20	0.5/S/1 D 0.50 m			SC	Clayey SAND; fine to medium grained; pale yellow to pale olive.	M	MD D	RESIDUAL SOIL
AD/V	L		1.5	115.80 1.50	1.2/S/2 D 1.20 m				Becoming orange to grey; with gravels.		MD	
AD/V	M	Inflow	2.0	115.50 2.00	1.6/S/3 D 1.60 m			SM	Silty SAND; fine to medium grained; pale red to reddish orange; trace clay.		D VD	
AD/V	H			115.00 2.20	2.1/S/4 D 2.10 m			CL	Silty CLAY; low plasticity; white to pale grey; trace sand.	M (<PL)	H	
AD/T	R M H R		2.5	114.80 2.60					SANDSTONE; medium to coarse grained; white to pale grey; inferred low strength			WEATHERED ROCK 2.20: V-bit refusal.
			3.0 3.5 4.0 4.5						Hole Terminated at 2.60 m			2.60: TC-bit refusal on inferred low to medium strength sandstone.

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CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	REF	BH103
PROJECT	Geotechnical Investigation	LOGGED	SVK	CHECKED	JF	Sheet 1 OF 1	
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Nil	PROJECT NO. P2007886	
EQUIPMENT	Hand Auger	EASTING	151.2131	RL SURFACE	118 m	DATUM	AHD
EXCAVATION DIMENSIONS	⌀75 mm x 0.40 m depth	NORTHING	-33.7604	ASPECT	North	SLOPE	5 - 10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	M	Not Encountered		0.08					BRICK PAVERS.			PAVEMENT
				0.15				SP	FILL: Gravelly SAND; medium to coarse grained; red; trace silt and clay.	M	MD	FILL
				117.85 0.40	0.3-0.4/S/1 D 0.30 m			SP	SAND; fine to coarse grained; olive to grey; with silt; trace clay.	W	MD - D	RESIDUAL SOIL
			0.5						Hole Terminated at 0.40 m			0.40: Hand auger refusal on inferred very low to low strength sandstone (possible floater).
			1.0									
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

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CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	**REF BH104**	
PROJECT	Geotechnical Investigation	LOGGED	SVK	CHECKED	JF	Sheet 1 OF 1	
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Grass	PROJECT NO. P2007886	
EQUIPMENT	Hand Auger	EASTING	151.213	RL SURFACE	119.6 m	DATUM	AHD
EXCAVATION DIMENSIONS	ø75 mm x 0.50 m depth	NORTHING	-33.7605	ASPECT	North	SLOPE	15 - 20%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	M	Not Encountered		119.60	0.2/S/1 D 0.20-0.29 m			SC	TOPSOIL: Clayey SAND; fine to coarse grained; dark brown to dark grey; with silt.	M	L - MD	TOPSOIL
				0.30 119.30	0.3/S/2 D 0.30-0.50 m			SP	SAND; fine to coarse grained; olive to pale brown; with silt; trace clay.		MD	RESIDUAL SOIL
			0.5	0.50					Hole Terminated at 0.50 m			0.50: Hand auger refusal on inferred very low to low strength sandstone (possible floater).
			1.0									
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

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CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	**REF BH105**	
PROJECT	Geotechnical Investigation	LOGGED	AG	CHECKED	JF	Sheet 1 OF 1	
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	None	PROJECT NO. P2007886	
EQUIPMENT	Hand Auger	EASTING	151.136	RL SURFACE	118.6 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø75 mm x 0.60 m depth	NORTHING	-33.7605	ASPECT	North	SLOPE	5 - 10%

Drilling					Sampling		Field Material Description						
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	L	Not Encountered		118.60 / *0.15*				SC	TOPSOIL: Clayey SAND; fine to medium grained; dark brown to dark grey; trace silt.	M (<PL)	D - MD	TOPSOIL
HA	H	Not Encountered		118.45 / *0.30*	0.2/S/1 D 0.20 m			SC	FILL: Clayey SAND; fine to medium grained; grey to brown; with ironstone gravel; trace silt.		MD	FILL
HA	H	Not Encountered	0.5	118.30 / *0.60*	0.5/S/2 D 0.50 m			SC	Clayey SAND; fine to medium grained; orange to grey; trace roots.	M	MD and D	RESIDUAL SOIL
			1.0 – 4.5						Hole Terminated at 0.60 m			0.60: Hand auger refusal on inferred very low to low strength sandstone (possible floater).

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CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	REF BH106
PROJECT	Geotechnical Investigation	LOGGED	AG	CHECKED	JF	Sheet 1 OF 1
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Pavement	PROJECT NO. P2007886
EQUIPMENT	Hand Auger	EASTING	151.2131	RL SURFACE	120.8 m	DATUM: AHD
EXCAVATION DIMENSIONS	⌀75 mm x 0.60 m depth	NORTHING	-33.7606	ASPECT	North	SLOPE: 20 - 25%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	L	Not Encountered		120.80 0.10 120.70				SC	TOPSOIL: Clayey SAND; fine to medium grained; dark brown to dark grey; trace silt.	M (<PL)	VL - L	TOPSOIL
					0.3/S/1 D 0.30 m			SC	Clayey SAND; fine to medium grained; brown to pale brown; trace silt; trace roots.	M	MD and D	RESIDUAL SOIL
	M-H		0.5	0.45 120.35 0.60	0.5/S/2 D 0.50 m 0.6/S/3 D 0.55 m				Becoming white to pale grey.			
			1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5						Hole Terminated at 0.60 m			0.60: Hand auger refusal on inferred very low to low strength sandstone (possible floater).

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	REF BH107
PROJECT	Geotechnical Investigation	LOGGED	SVK	CHECKED	JF	Sheet 1 OF 1
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Trees & Shrubs	PROJECT NO. P2007886
EQUIPMENT	Hand Auger	EASTING	151.213	RL SURFACE	123.6 m	DATUM AHD
EXCAVATION DIMENSIONS	⌀75 mm x 0.90 m depth	NORTHING	-33.761	ASPECT	North	SLOPE <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	M-H	Not Encountered	0.5	123.60	0.3/S/1 D 0.30 m			SC	FILL: Clayey SAND; fine to coarse grained; dark grey to dark brown; with silt; trace concrete gravel; poorly compacted; poorly graded.	M	MD	FILL
				0.70 122.90 0.90	0.9/S/2 D 0.80 m			CL-CI	FILL: CLAY; low to medium plasticity; dark grey to dark brown; with silt; trace sand and concrete gravel and ash; poorly compacted; poorly graded.	M (<PL)	St	
			1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5						Hole Terminated at 0.90 m			0.90: Hand auger refusal on inferred very low to low strength sandstone (possible floater).

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Engineering Log - BOREHOLE

CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	**REF BH108**	
PROJECT	Geotechnical Investigation	LOGGED	SVK	CHECKED	JF	Sheet 1 OF 1	
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Nil	PROJECT NO. P2007886	
EQUIPMENT	Hand Auger	EASTING	151.2131	RL SURFACE	124 m	DATUM	AHD
EXCAVATION DIMENSIONS	⌀75 mm x 1.30 m depth	NORTHING	-33.7607	ASPECT	North	SLOPE	<5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA		Not Encountered		0.06					BRICK PAVERS.			PAVEMENT
	L			0.11 123.89				SP	FILL: SAND; fine to coarse grained; pale brown; trace silt and clay; with orange damp proof membrane at base; moderately compacted; poorly graded.	M	MD	FILL
	M		0.5		0.5/S/1 D 0.50 m			CI	FILL: CLAY; medium plasticity; grey, dark grey, orange and olive; with sand and silt; trace fine to coarse gravel of sandstone; moderately compacted; poorly graded.	M (>PL)	F	
			1.0		1.0/S/2 D 1.00 m							
				1.30					Hole Terminated at 1.30 m			1.30: Hand auger refusal on inferred very low to low strength sandstone (possible floater).
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

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Engineering Log - BOREHOLE

CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	**REF BH109**
PROJECT	Geotechnical Investigation	LOGGED	AG	CHECKED	JF	Sheet 1 OF 1
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Grass	PROJECT NO. P2007886
EQUIPMENT	Hand Auger	EASTING	151.2131	RL SURFACE	120.2 m	DATUM: AHD
EXCAVATION DIMENSIONS	ø75 mm x 0.30 m depth	NORTHING	-33.7603	ASPECT	Northwest	SLOPE: <5%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
HA	L	Not Encountered		120.20 0.15				SC	TOPSOIL: Clayey SAND; fine to medium grained; dark brown to dark grey; trace silt.	M	VL - L	TOPSOIL
	H			120.05 0.30	0.2/S/1 D 0.20 m			CL	Silty CLAY; low plasticity; orange to dark grey; sandstone cobble and boulders.	(<PL)	H	RESIDUAL SOIL
									Hole Terminated at 0.30 m			0.30: Hand auger refusal on inferred very low to low strength sandstone (possible floater).

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	REF	BH111
PROJECT	Geotechnical Investigation	LOGGED	AG	CHECKED	JF	Sheet 1 OF 1	
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	None	PROJECT NO. P2007888	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.21336	RL SURFACE	122.8 m	DATUM	AHD
EXCAVATION DIMENSIONS	⌀100 mm x 2.10 m depth	NORTHING	-33.7607	ASPECT	Northwest	SLOPE	10 - 15%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	H	Not Encountered		122.80 0.15					CONCRETE PAVEMENT DRIVEWAY.			PAVEMENT
AD/V	M		0.5	122.65 0.56	SPT 0.35-0.80 m 6,4,4 N=8 0.36/S/1 0.36 m			SC	Clayey SAND; fine to medium grained; orange to pale brown; (with small layer of iron indurated low strength sandstone).	M		RESIDUAL SOIL
			1.0 1.5	122.24	1.0/S/2 D 1.00 m			SP	SAND; fine to medium grained; pale brown to brown; trace silt.		MD - D	
				1.70 121.10					Becoming pale red to pink.			
	H		2.0	1.80 121.00 2.10	1.8/S/3 D 1.80 m				grading to extremely weathered sandstone.			
			2.5 3.0 3.5 4.0 4.5						Hole Terminated at 2.10 m			2.10: V-bit refusal on inferred low to medium strength sandstone.

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	REF BH112
PROJECT	Geotechnical Investigation	LOGGED	SVK	CHECKED	JF	Sheet 1 OF 1
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Nil	PROJECT NO. P2007886
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.213	RL SURFACE	125.2 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.70 m depth	NORTHING	-33.7608	ASPECT	North	SLOPE: 5 - 10%

METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/T	L	Inflow		0.05 / 125.15					ASPHALT; over concrete.			PAVEMENT
			0.5		SPT 0.30-0.75 m 4,5,3 N=8			GP	FILL: Sandy GRAVEL of black coal ash; fine to coarse, trace silt and clay.	M / W	MD	FILL
			1.0	0.70 / 124.50				CL-CI	CLAY; low to medium plasticity; olive; with silt; trace sand.	M	F to St	RESIDUAL SOIL
	R / H		1.5	1.42 / 123.78	SPT 1.42-1.72 m 3,3 HB N=3/150mm				SANDSTONE; medium to coarse grained; dark red; inferred low to medium strength; highly weathered.			WEATHERED ROCK
	R		2.0	1.70					Hole Terminated at 1.70 m			1.70: TC-bit refusal on inferred low to medium strength sandstone.
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

CLIENT	Child and Associates	COMMENCED	25/08/2020	COMPLETED	25/08/2020	REF **BH113**
PROJECT	Geotechnical Investigation	LOGGED	SVK	CHECKED	JF	Sheet 1 OF 1
SITE	723 - 727 Warringah Rd, Forestville, NSW	GEOLOGY	Hawkesbury Sandstone	VEGETATION	Grass	PROJECT NO. P2007888
EQUIPMENT	4WD truck-mounted hydraulic drill rig	EASTING	151.2132	RL SURFACE	125.2 m	DATUM: AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.80 m depth	NORTHING	-33.761	ASPECT	Northwest	SLOPE: 5 - 10%

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
ADV	L			125.20				SC	TOPSOIL: Clayey SAND; fine to medium grained; dark brown to dark grey; trace silt.	M	VL - L	TOPSOIL
				0.30 124.90				GP	FILL: Sandy GRAVEL; fine to coarse grained; grey; trace silt and clay.		L - MD	FILL
		Inflow	0.5	0.40 124.80				CL	Sandy CLAY; low plasticity; olive;	W	F - St	RESIDUAL SOIL
	M		1.0	0.90 124.30	SPT 1.00-1.45 m 5,7,13 N=20			CI	Silty CLAY; low to medium plasticity; pale grey to olive; with sand.	M	VSt - H	
ADT	R		1.5	1.70 123.50					SANDSTONE; medium to coarse grained; dark red; low to medium strength; highly weathered; iron indurated.			WEATHERED ROCK
	R			1.80					Hole Terminated at 1.80 m			1.80: TC-bit refusal on inferred low to medium strength sandstone.
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									

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Engineering Log - BOREHOLE

APPENDIX D

DCP “N” Counts

Dynamic Cone Penetrometer Test Log Summary

martens consulting engineers since 1989

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Site	723 - 727 Warringah Road, Forestville, NSW	DCP Group Reference	P2007886JS01V01
Client	Child and Associates	Log Date	25.08.2020
Logged by	AG / SVK / PS		
Checked by			
Comments	DCP commenced at 50 mm bgl.		

TEST DATA

Depth Interval (m)	DCP101	DCP102	DCP105					
0.15	Hammer Weight	3	2					
0.30	7	7	6					
0.45	2	3	4					
0.60	11 / 130 mm	3	14					
0.75	Double Bounce @ 0.63 m	3	8					
0.90		8	13 / 100 mm					
1.05		9	Double Bounce @ 0.90 m					
1.20		3						
1.35		4						
1.50		6						
1.65		7						
1.80		10						
1.95		14						
2.10		Double Bounce @ 2.15 m						

APPENDIX E

Rock Core Photos

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	WB	PHOTO OF ROCK CORE (BH201) Proposed Child Care Centre – 723-727 Warringah Road, Forestville, NSW	Drawing: **FIGURE 2**
Approved:	SK		
Date:	26.10.2021		
Scale:	NA		File No: P2007886JR01V01

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	WB	PHOTO OF ROCK CORE (BH202) Proposed Child Care Centre – 723-727 Warringah Road, Forestville, NSW	Drawing: **FIGURE 3**
Approved:	SK		
Date:	26.10.2021		
Scale:	NA		File No: P2007886JR01V01

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APPENDIX F

Laboratory Test Certificate

resource laboratories
AGGREGATE, ROCK, AND SOIL TESTING
ABN: 25 131 532 020
Sydney: 12/1 Boden Road Seven Hills NSW 2147 | PO Box 45 Pendle Hill NSW 2145
Ph: (02) 9674 7711 | Fax: (02) 9674 7755 | Email: info@resourcelab.com.au

Test Report

Customer: Martens & Associates Pty Ltd **Job number:** 21-0107
Project: P2007886 **Report number:** 1
Location: 723-727 Warringah Road, Forestville, NSW **Page:** 1 of 1

Point Load Strength Index

Sampling method: Tested as received **Test method(s):** AS 4133.4.1 Clause 3.2, 3.3

	Results				
Laboratory sample no.	25520	25521	25522	25523	25524
Customer sample no.	7886/BH201/ 1.8-1.9	7886/BH201/ 4.4-4.5	7886/BH201/ 8.3-8.4	7886/BH202/ 2.1-2.2	7886/BH202/ 6.1-6.2
Sample depth	1.8-1.9m	4.4-4.5m	8.3-8.4m	2.1-2.2m	6.1-6.2m
Date sampled	17/09/2021	17/09/2021	17/09/2021	17/09/2021	17/09/2021
Date tested	30/09/2021	30/09/2021	30/09/2021	30/09/2021	30/09/2021
Lithological description	SANDSTONE	SANDSTONE	SANDSTONE	SANDSTONE	SANDSTONE
Diametral					
Moisture content condition	Moist	Moist	Moist	Moist	Moist
Nature of weakness planes	Laminated	Laminated	Laminated	Laminated	Laminated
Specimen size					
Length (mm)	140.0	168.0	165.0	173.0	176.0
Diameter (mm)	51.3	50.5	51.5	51.1	51.5
I_s (MPa)	**0.41**	**0.34**	**1.2**	**0.34**	**0.84**
$I_{s(50)}$ (MPa)	**0.41**	**0.34**	**1.2**	**0.34**	**0.85**
Failure mode	Parallel to Laminae	Parallel to Laminae	Parallel to Laminae	Parallel to Laminae	Parallel to Laminae
Axial					
Moisture content condition	Moist	Moist	Moist	Moist	Moist
Nature of weakness planes	Laminated	Laminated	Laminated	Laminated	Laminated
Specimen size					
Height (mm)	49.8	40.7	36.5	40.3	43.3
Diameter (mm)	51.3	50.5	51.5	51.1	51.5
I_s (MPa)	**0.52**	**0.38**	**1.5**	**0.50**	**1.0**
$I_{s(50)}$ (MPa)	**0.55**	**0.39**	**1.5**	**0.51**	**1.0**
Failure mode	Perpendicular to Laminae	Perpendicular to Laminae	Perpendicular to Laminae	Perpendicular to Laminae	Perpendicular to Laminae

Notes:

Approved Signatory: C. Greely **Date:** 01/10/2021

NATA
ACCREDITED FOR TECHNICAL COMPETENCE
Accredited for compliance with ISO/IEC 17025 - Testing. NATA Accredited Laboratory Number: 17082

R77.v7 / 1 of 1

APPENDIX G

General Geotechnical Recommendations

Geotechnical Recommendations

Important Recommendations About Your Site (1 of 2)

martens consulting engineers

These general geotechnical recommendations have been prepared by Martens to help you deliver a safe work site, to comply with your obligations, and to deliver your project. Not all are necessarily relevant to this report but are included as general reference. Any specific recommendations made in the report will override these recommendations.

Batter Slopes

Excavations in soil and extremely low to very low strength rock exceeding 0.75 m depth should be battered back at grades of no greater than 1 Vertical (V) : 2 Horizontal (H) for temporary slopes (unsupported for less than 1 month) and 1 V : 3 H for longer term unsupported slopes.

Vertical excavation may be carried out in medium or higher strength rock, where encountered, subject to inspection and confirmation by a geotechnical engineer. Long term and short term unsupported batters should be protected against erosion and rock weathering due to, for example, stormwater run-off.

Batter angles may need to be revised depending on the presence of bedding partings or adversely oriented joints in the exposed rock, and are subject to on-site inspection and confirmation by a geotechnical engineer. Unsupported excavations deeper than 1.0 m should be assessed by a geotechnical engineer for slope instability risk.

Any excavated rock faces should be inspected during construction by a geotechnical engineer to determine whether any additional support, such as rock bolts or shotcrete, is required.

Earthworks

Earthworks should be carried out following removal of any unsuitable materials and in accordance with AS3798 (2007). A qualified geotechnical engineer should inspect the condition of prepared surfaces to assess suitability as foundation for future fill placement or load application.

Earthworks inspections and compliance testing should be carried out in accordance with Sections 5 and 8 of AS3798 (2007), with testing to be carried out by a National Association of Testing Authorities (NATA) accredited testing laboratory.

Excavations

All excavation work should be completed with reference to the *Work Health and Safety (Excavation Work) Code of Practice (2015)*, by Safe Work Australia. Excavations into rock may be undertaken as follows:

1. Extremely low to low strength rock - conventional hydraulic earthmoving equipment.
2. Medium strength or stronger rock - hydraulic earthmoving equipment with rock hammer or ripping tyne attachment.

Exposed rock faces and loose boulders should be monitored to assess risk of block / boulder movement, particularly as a result of excavation vibrations.

Fill

Subject to any specific recommendations provided in this report, any fill imported to site is to comprise approved material with maximum particle size of two thirds the final layer thickness. Fill should be placed in horizontal layers of not more than 300 mm loose thickness, however, the layer thickness should be appropriate for the adopted compaction plant.

Foundations

All exposed foundations should be inspected by a geotechnical engineer prior to footing construction to confirm encountered conditions satisfy design assumptions and that the base of all excavations is free from loose or softened material and water. Water that has ponded in the base of excavations and any resultant softened material is to be removed prior to footing construction.

Footings should be constructed with minimal delay following excavation. If a delay in construction is anticipated, we recommend placing a concrete blinding layer of at least 50 mm thickness in shallow footings or mass concrete in piers / piles to protect exposed foundations.

A geotechnical engineer should confirm any design bearing capacity values, by further assessment during construction, as necessary.

Shoring - Anchors

Where there is a requirement for either soil or rock anchors, or soil nailing, and these structures penetrate past a property boundary, appropriate permission from the adjoining land owner must be obtained prior to the installation of these structures.

Shoring - Permanent

Permanent shoring techniques may be used as an alternative to temporary shoring. The design of such structures should be in accordance with the findings of this report and any further testing recommended by this report. Permanent shoring may include [but not be limited to] reinforced block work walls, contiguous and semi contiguous pile walls, secant pile walls and soldier pile walls with or without reinforced shotcrete infill panels. The choice of shoring system will depend on the type of structure, project budget and site specific geotechnical conditions.

Permanent shoring systems are to be engineer designed and backfilled with suitable granular

Important Recommendations About Your Site (2 of 2)

material and free-draining drainage material. Backfill should be placed in maximum 100 mm thick layers compacted using a hand operated compactor. Care should be taken to ensure excessive compaction stresses are not transferred to retaining walls.

Shoring design should consider any surcharge loading from sloping / raised ground behind shoring structures, live loads, new structures, construction equipment, backfill compaction and static water pressures. All shoring systems shall be provided with adequate foundation designs.

Suitable drainage measures, such as geotextile enclosed 100 mm agricultural pipes embedded in free-draining gravel, should be included to redirect water that may collect behind the shoring structure to a suitable discharge point.

Shoring - Temporary

In the absence of providing acceptable excavation batters, excavations should be supported by suitably designed and installed temporary shoring / retaining structures to limit lateral deflection of excavation faces and associated ground surface settlements.

Soil Erosion Control

Removal of any soil overburden should be performed in a manner that reduces the risk of sedimentation occurring in any formal stormwater drainage system, on neighbouring land and in receiving waters. Where possible, this may be achieved by one or more of the following means:

1. Maintain vegetation where possible
2. Disturb minimal areas during excavation
3. Revegetate disturbed areas if possible

All spoil on site should be properly controlled by erosion control measures to prevent transportation of sediments off-site. Appropriate soil erosion control methods in accordance with Landcom (2004) shall be required.

Trafficability and Access

Consideration should be given to the impact of the proposed works and site subsurface conditions on trafficability within the site e.g. wet clay soils will lead to poor trafficability by tyred plant or vehicles.

Where site access is likely to be affected by any site works, construction staging should be organised such that any impacts on adequate access are minimised as best as possible.

Vibration Management

Where excavation is to be extended into medium or higher strength rock, care will be required when using a rock hammer to limit potential structural distress from excavation-induced vibrations where nearby structures may be affected by the works.

To limit vibrations, we recommend limiting rock hammer size and set frequency, and setting the hammer parallel to bedding planes and along defect planes, where possible, or as advised by a geotechnical engineer. We recommend limiting vibration peak particle velocities (PPV) caused by construction equipment or resulting from excavation at the site to 5 mm/s (AS 2187.2, 2006, Appendix J).

Waste – Spoil and Water

Soil to be disposed off-site should be classified in accordance with the relevant State Authority guidelines and requirements.

Any collected waste stormwater or groundwater should also be tested prior to discharge to ensure contaminant levels (where applicable) are appropriate for the nominated discharge location.

MA can complete the necessary classification and testing if required. Time allowance should be made for such testing in the construction program.

Water Management - Groundwater

If the proposed works are likely to intersect ephemeral or permanent groundwater levels, the management of any potential acid soil drainage should be considered. If groundwater tables are likely to be lowered, this should be further discussed with the relevant State Government Agency.

Water Management – Surface Water

All surface runoff should be diverted away from excavation areas during construction works and prevented from accumulating in areas surrounding any retaining structures, footings or the base of excavations.

Any collected surface water should be discharged into a suitable Council approved drainage system and not adversely impact downslope surface and subsurface conditions.

All site discharges should be passed through a filter material prior to release. Sump and pump methods will generally be suitable for collection and removal of accumulated surface water within any excavations.

Contingency Plan

In the event that proposed development works cause an adverse impact on geotechnical hazards, overall site stability or adjacent properties, the following actions are to be undertaken:

1. Works shall cease immediately.
2. The nature of the impact shall be documented and the reason(s) for the adverse impact investigated.
3. A qualified geotechnical engineer should be consulted to provide further advice in relation to the issue.

APPENDIX G

Geotechnical Explanatory Notes

Information

Important Information About Your Report (1 of 2)

These notes have been prepared by Martens to help you interpret and understand the limitations of your report. Not all are necessarily relevant to all reports but are included as general reference.

Engineering Reports - Limitations

The recommendations presented in this report are based on limited investigations and include specific issues to be addressed during various phases of the project. If the recommendations presented in this report are not implemented in full, the general recommendations may become inapplicable and Martens & Associates accept no responsibility whatsoever for the performance of the works undertaken.

Occasionally, sub-surface conditions between and below the completed boreholes or other tests may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact Martens & Associates.

Relative ground surface levels at borehole locations may not be accurate and should be verified by on-site survey.

Engineering Reports – Project Specific Criteria

Engineering reports are prepared by qualified personnel. They are based on information obtained, on current engineering standards of interpretation and analysis, and on the basis of your unique project specific requirements as understood by Martens. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the Client.

Where the report has been prepared for a specific design proposal (e.g. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (e.g. to a twenty storey building). Your report should not be relied upon, if there are changes to the project, without first asking Martens to assess how factors, which changed subsequent to the date of the report, affect the report's recommendations. Martens will not accept responsibility for problems that may occur due to design changes, if not consulted.

Engineering Reports – Recommendations

Your report is based on the assumption that site conditions, as may be revealed through selective point sampling, are indicative of actual conditions throughout an area. This assumption often cannot be substantiated until project implementation has commenced. Therefore your site investigation report recommendations should only be regarded as preliminary.

Only Martens, who prepared the report, are fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report, there is a risk that the report will be misinterpreted and Martens cannot be held responsible for such misinterpretation.

Engineering Reports – Use for Tendering Purposes

Where information obtained from investigations is provided for tendering purposes, Martens recommend 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.

Martens would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Engineering Reports – Data

The report as a whole presents the findings of a site assessment and should not be copied in part or altered in any way.

Logs, figures, drawings etc are customarily included in a Martens report and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel), desktop studies and laboratory evaluation of field samples. These data should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Engineering Reports – Other Projects

To avoid misuse of the information contained in your report it is recommended that you confer with Martens before passing your report on to another party who may not be familiar with the background and purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Subsurface Conditions - General

Every care is taken with the report in relation to interpretation of subsurface conditions, discussion of geotechnical aspects, relevant standards and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions - the potential will depend partly on test point

Information

Important Information About Your Report (2 of 2)

(eg. excavation or borehole) spacing and sampling frequency, which are often limited by project imposed budgetary constraints.

- Changes in guidelines, standards and policy or interpretation of guidelines, standards and policy by statutory authorities.
- The actions of contractors responding to commercial pressures.
- Actual conditions differing somewhat from those inferred to exist, because no professional, no matter how qualified, can reveal precisely what is hidden by earth, rock and time.

  The actual interface between logged materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions.

f these conditions occur, Martens will be pleased to ıssist with investigation or providing advice to esolve the matter.

ıubsurface Conditions - Changes

Natural processes and the activity of man create ubsurface conditions. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Reports are based on conditions which existed at the time of he subsurface exploration / assessment.

Decisions should not be based on a report whose adequacy may have been affected by time. If an extended period of time has elapsed since the eport was prepared, consult Martens to be advised now time may have impacted on the project.

ıubsurface Conditions - Site Anomalies

n the event that conditions encountered on site during construction appear to vary from those that were expected from the information contained in he report, Martens requests that it immediately be notified. Most problems are much more readily esolved at the time when conditions are exposed, ather than at some later stage well after the event.

Report Use by Other Design Professionals

To avoid potentially costly misinterpretations when other design professionals develop their plans based on a Martens report, retain Martens to work with other project professionals affected by the eport. This may involve Martens explaining the eport design implications and then reviewing plans and specifications produced to see how they have ncorporated the report findings.

Subsurface Conditions – Geo-environmental Issues

Your report generally does not relate to any findings, conclusions, or recommendations about the potential for hazardous or contaminated materials existing at the site unless specifically required to do so as part of Martens' proposal for works.

Specific sampling guidelines and specialist equipment, techniques and personnel are typically used to perform geo-environmental or site contamination assessments. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Martens for information relating to such matters.

Responsibility

Geo-environmental reporting relies on interpretation of factual information based on professional judgment and opinion and has an inherent level of uncertainty attached to it and is typically far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded.

To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Martens to other parties but are included to identify where Martens' responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Martens closely and do not hesitate to ask any questions you may have.

Site Inspections

Martens will always be pleased to provide engineering inspection services for aspects of work to which this report relates. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site. Martens is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction.

Soil Data

Explanation of Terms (1 of 3)

Definitions

In engineering terms, soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material does not exhibit any visible rock properties and can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

The methods of description and classification of soils and rocks used in this report are typically based on Australian Standard 1726 and the Unified Soil Classification System (USCS) – refer Soil Data Explanation of Terms (2 of 3). In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

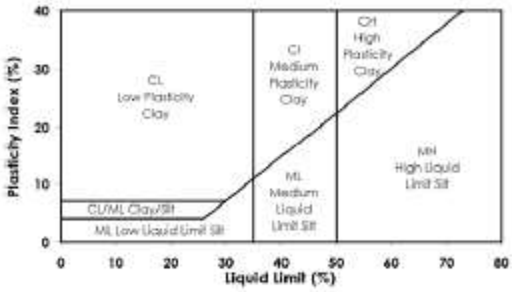
Particle Size

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy CLAY). Unless otherwise stated, particle size is described in accordance with the following table.

Division	Subdivision	Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2.36 to 6
SAND	Coarse	0.6 to 2.36
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
SILT		0.002 to 0.075
CLAY		< 0.002

Plasticity Properties

Plasticity properties of cohesive soils can be assessed in the field by tactile properties or by laboratory procedures.



Moisture Condition

Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.
Moist	Soil feels cool and damp and is darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist but with free water forming on hands when handled.

Consistency of Cohesive Soils

Cohesive soils refer to predominantly clay materials.

Term	C_u (kPa)	Approx. SPT "N"	Field Guide
Very Soft	<12	2	A finger can be pushed well into the soil with little effort. Sample extrudes between fingers when squeezed in fist.
Soft	12 - 25	2 – 4	A finger can be pushed into the soil to about 25mm depth. Easily moulded in fingers.
Firm	25 - 50	4 – 8	The soil can be indented about 5mm with the thumb, but not penetrated. Can be moulded by strong pressure in the figures.
Stiff	50 - 100	8 – 15	The surface of the soil can be indented with the thumb, but not penetrated. Cannot be moulded by fingers.
Very Stiff	100 - 200	15 – 30	The surface of the soil can be marked, but not indented with thumb pressure. Difficult to cut with a knife. Thumbnail can readily indent.
Hard	> 200	> 30	The surface of the soil can be marked only with the thumbnail. Brittle. Tends to break into fragments.
Friable	-	-	Crumbles or powders when scraped by thumbnail.

Density of Granular Soils

Non-cohesive soils are classified on the basis of relative density, generally from standard penetration test (SPT) or Dutch cone penetrometer test (CPT) results as below:

Relative Density	%	SPT 'N' Value* (blows/300mm)	CPT Cone Value (q_c MPa)
Very loose	< 15	< 5	< 2
Loose	15 - 35	5 - 10	2 - 5
Medium dense	35 - 65	10 - 30	5 - 15
Dense	65 - 85	30 - 50	15 - 25
Very dense	> 85	> 50	> 25

* Values may be subject to corrections for overburden pressures and equipment type.

Minor Components

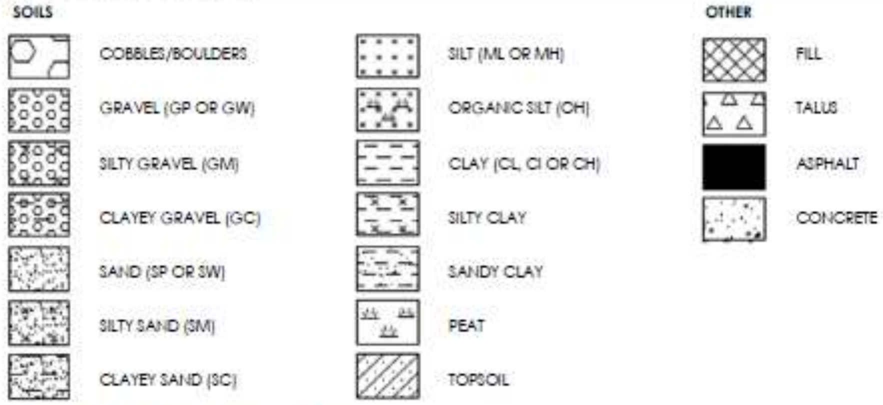
Minor components in soils may be present and readily detectable, but have little bearing on general geotechnical classification. Terms include:

Term	Assessment	Proportion of Minor component In:
Trace of	Presence just detectable by feel or eye. Soil properties little or no different to general properties of primary component.	Coarse grained soils: < 5 % Fine grained soils: < 15 %
With some	Presence easily detectable by feel or eye. Soil properties little different to general properties of primary component.	Coarse grained soils: 5 – 12 % Fine grained soils: 15 – 30 %

Soil Data

Explanation of Terms (2 of 3)

Symbols for Soils and Other



Unified Soil Classification Scheme (USCS)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)					USCS	Primary Name
COARSE GRAINED SOILS More than 50 % of material less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.0 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Gravel
				Predominantly one size or a range of sizes with more intermediate sizes missing	GP	Gravel
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	Silty Gravel
				Plastic fines (for identification procedures see CL below)	GC	Clayey Gravel
		SANDS More than half of coarse fraction is smaller than 2.0 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of intermediate sizes missing.	SW	Sand
				Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Sand
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty Sand
				Plastic fines (for identification procedures see CL below)	SC	Clayey Sand

IDENTIFICATION PROCEDURES ON FRACTIONS < 0.2 MM							
		DRY STRENGTH (Crushing Characteristics)	DILATANCY	TOUGHNESS	DESCRIPTION	USCS	Primary Name
FINE GRAINED SOILS More than 50 % of material less than 63 mm is smaller than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	None to Low	Quick to Slow	None	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	ML	Silt
		Medium to High	None	Medium	Inorganic clays of low to medium plasticity [1], gravely clays, sandy clays, silty clays, lean clays	CL [2]	Clay
		Low to Medium	Slow to Very Slow	Low	Organic silts and organic silty clays of low plasticity	OL	Organic Silt
		Low to Medium	Slow to Very Slow	Low to Medium	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	MH	Silt
		High	None	High	Inorganic clays of high plasticity, fat clays	CH	Clay
		Medium to High	None	Low to Medium	Organic clays of medium to high plasticity	OH	Organic Silt
HIGHLY ORGANIC SOILS		Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat

Notes:

1. Low Plasticity – Liquid Limit W_L < 35 %   Medium Plasticity – Liquid limit W_L 35 to 50 %   High Plasticity - Liquid limit W_L > 50 %.
2. CI may be adopted for clay of medium plasticity to distinguish from clay of low plasticity.

Soil Data

Explanation of Terms (3 of 3)

Soil Agricultural Classification Scheme

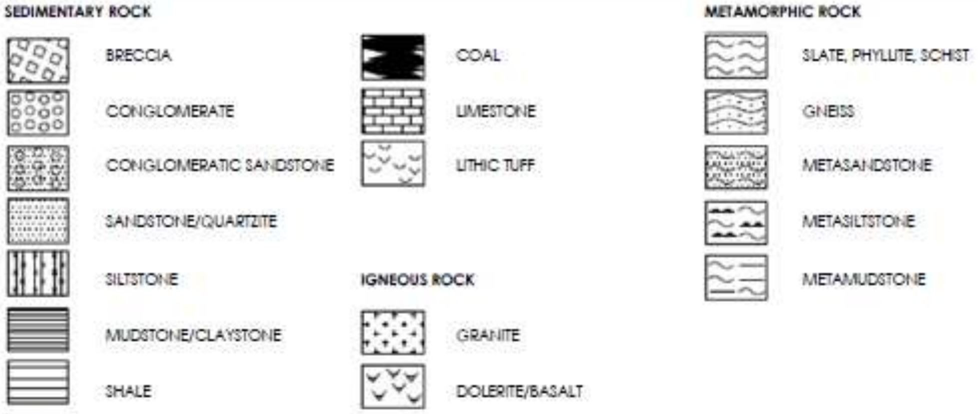
In some situations, such as where soils are to be used for effluent disposal purposes, soils are often more appropriately classified in terms of traditional agricultural classification schemes. Where a Martens report provides agricultural classifications, these are undertaken in accordance with descriptions by Northcote, K.H. (1979) *The factual key for the recognition of Australian Soils,* Rellim Technical Publications, NSW, p 26 - 28.

Symbol	Field Texture Grade	Behaviour of moist bolus	Ribbon length	Clay content (%)
S	Sand	Coherence nil to very slight; cannot be moulded; single grains adhere to fingers	0 mm	< 5
LS	Loamy sand	Slight coherence; discolours fingers with dark organic stain	6.35 mm	5
CLS	Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with clay stain	6.35mm - 1.3cm	5 - 10
SL	Sandy loam	Bolus just coherent but very sandy to touch; dominant sand grains are of medium size and are readily visible	1.3 - 2.5	10 - 15
FSL	Fine sandy loam	Bolus coherent; fine sand can be felt and heard	1.3 - 2.5	10 - 20
SCL-	Light sandy clay loam	Bolus strongly coherent but sandy to touch, sand grains dominantly medium size and easily visible	2.0	15 - 20
L	Loam	Bolus coherent and rather spongy; smooth feel when manipulated but no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present	2.5	25
Lfsy	Loam, fine sandy	Bolus coherent and slightly spongy; fine sand can be felt and heard when manipulated	2.5	25
SiL	Silt loam	Coherent bolus, very smooth to silky when manipulated	2.5	25 + > 25 silt
SCL	Sandy clay loam	Strongly coherent bolus sandy to touch; medium size sand grains visible in a finer matrix	2.5 - 3.8	20 - 30
CL	Clay loam	Coherent plastic bolus; smooth to manipulate	3.8 - 5.0	30 - 35
SiCL	Silty clay loam	Coherent smooth bolus; plastic and silky to touch	3.8 - 5.0	30- 35 + > 25 silt
FSCL	Fine sandy clay loam	Coherent bolus; fine sand can be felt and heard	3.8 - 5.0	30 - 35
SC	Sandy clay	Plastic bolus; fine to medium sized sands can be seen, felt or heard in a clayey matrix	5.0 - 7.5	35 - 40
SiC	Silty clay	Plastic bolus; smooth and silky	5.0 - 7.5	35 - 40 + > 25 silt
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing	5.0 - 7.5	35 - 40
LMC	Light medium clay	Plastic bolus; smooth to touch, slightly greater resistance to shearing than LC	7.5	40 - 45
MC	Medium clay	Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture, some resistance to shearing	> 7.5	45 - 55
HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; firm resistance to shearing	> 7.5	> 50

Rock Data

Explanation of Terms (1 of 2)

Symbols for Rock



Definitions

Descriptive terms used for Rock by Martens are based on AS1726 and encompass rock substance, defects and mass.

Rock Substance In geotechnical engineering terms, rock substance is any naturally occurring aggregate of minerals and organic matter which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Rock substance is effectively homogeneous and may be isotropic or anisotropic.

Rock Defect Discontinuity or break in the continuity of a substance or substances.

Rock Mass Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

Degree of Weathering

Rock weathering is defined as the degree of decline in rock structure and grain property and can be determined in the field.

Term	Symbol	Definition
Residual soil[1]	Rs	Soil derived from the weathering of rock. The mass structure and substance fabric are no longer evident. There is a large change in volume but the soil has not been significantly transported.
Extremely weathered[1]	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly weathered[2]	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decrease compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original rock substance is no longer recognisable.
Moderately weathered[2]	MW	Rock substance affected by weathering to the extent that staining extends throughout the whole of the rock substance and the original colour of the fresh rock is no longer recognisable.
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh	FR	Rock substance unaffected by weathering

Notes:
1 The term "Distinctly Weathered" (DW) may be used to cover the range of substance weathering between EW and SW.
2 Rs and EW material is described using soil descriptive terms.

Rock Strength

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

Term	Is (50) MPa	Field Guide	Symbol
Very low	>0.03 ≤0.1	May be crumbled in the hand. Sandstone is 'sugary' and friable.	VL
Low	>0.1 ≤0.3	A piece of core 150mm long x 50mm diameter may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.	L
Medium	>0.3 ≤1.0	A piece of core 150mm long x 50mm diameter can be broken by hand with considerable difficulty. Readily scored with a knife.	M
High	>1 ≤3	A piece of core 150mm long x 50mm diameter cannot be broken by unaided hands, can be slightly scratched or scored with a knife.	H
Very high	>3 ≤10	A piece of core 150mm long x 50mm diameter may be broken readily with hand held hammer. Cannot be scratched with pen knife.	VH
Extremely high	>10	A piece of core 150mm long x 50mm diameter is difficult to break with hand held hammer. Rings when struck with a hammer.	EH

Rock Data

Explanation of Terms (2 of 2)

Degree of Fracturing

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

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

Rock Core Recovery

TCR = Total Core Recovery

$$= \frac{\text{Length of core recovered}}{\text{Length of core run}} \times 100\%$$

SCR = Solid Core Recovery

$$= \frac{\sum \text{Length of cylindrical core recovered}}{\text{Length of core run}} \times 100\%$$

RQD = Rock Quality Designation

$$= \frac{\sum \text{Axial lengths of core} > 100\text{ mm long}}{\text{Length of core run}} \times 100\%$$

Rock Strength Tests

- ▼ Point load strength Index (Is50) - axial test (MPa)
- ▶ Point load strength Index (Is50) - diametral test (MPa)
- ● Unconfined compressive strength (UCS) (MPa)

Defect Type Abbreviations and Descriptions

Defect Type (with inclination given)

BP	Bedding plane parting
FL	Foliation
CL	Cleavage
JT	Joint
FC	Fracture
SZ/SS	Sheared zone/ seam (Fault)
CZ/CS	Crushed zone/ seam
DZ/DS	Decomposed zone/ seam
FZ	Fractured Zone
IS	Infilled seam
VN	Vein
CO	Contact
HB	Handling break
DB	Drilling break

Planarity

Pl	Planar
Cu	Curved
Un	Undulating
St	Stepped
Ir	Irregular
Dis	Discontinuous

Roughness

Pol	Polished
Sl	Slickensided
Sm	Smooth
Ro	Rough
VR	Very rough

Thickness

Zone	> 100 mm
Seam	> 2 mm < 100 mm
Plane	< 2 mm

Coating or Filling

Cn	Clean
Sn	Stain
Ct	Coating
Vnr	Veneer
Fe	Iron Oxide
X	Carbonaceous
Qz	Quartzite
MU	Unidentified mineral

Inclination

Inclination of defect is measured from perpendicular to and down the core axis.
Direction of defect is measured clockwise (looking down core) from magnetic north.

Test, Drill and Excavation Methods

Explanation of Terms (1 of 3)

Sampling

Sampling is carried out during drilling or excavation to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling or excavation provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples may be taken by pushing a thin-walled sampling tube, e.g. U_{50} (50 mm internal diameter thin walled tube), into soils and withdrawing a soil sample in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Other sampling methods may be used. Details of the type and method of sampling are given in the report.

Drilling / Excavation Methods

The following is a brief summary of drilling and excavation methods currently adopted by the Company and some comments on their use and application.

Hand Excavation - in some situations, excavation using hand tools, such as mattock and spade, may be required due to limited site access or shallow soil profiles.

Hand Auger - the hole is advanced by pushing and rotating either a sand or clay auger, generally 75-100 mm in diameter, into the ground. The penetration depth is usually limited to the length of the auger pole; however extender pieces can be added to lengthen this.

Test Pits - these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils and, if it is safe to descend into the pit, collection of bulk disturbed samples. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (e.g. Pengo) - the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling (Push Tube) - the hole is advanced by pushing a 50 - 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength etc. is only marginally affected.

Continuous Spiral Flight Augers - the hole is advanced using 90 - 115 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface or, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling - the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling - similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling - a continuous core sample is obtained using a diamond tipped core barrel of usually 50 mm internal diameter. Provided full core recovery is achieved (not always possible in very weak or fractured rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

In-situ Testing and Interpretation

Cone Penetrometer Testing (CPT)
Cone penetrometer testing (sometimes referred to as Dutch Cone) described in this report has been carried out using an electrical friction cone penetrometer.

The test is described in AS 1289.6.5.1-1999 (R2013). In the test, a 35 mm diameter rod with a cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system.

Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the push rod centre to an amplifier and recorder unit mounted on the control truck. As penetration occurs (at a rate of approximately 20 mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

(i) Cone resistance (q_c) - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa.

(ii) Sleeve friction (q_f) - the frictional force of the sleeve divided by the surface area, expressed in kPa.

(iii) Friction ratio - the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower (A) scale (0 - 5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main (B) scale (0 - 50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1 % - 2 % are commonly encountered in sands and very soft clays rising to 4 % - 10 % in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

q_c (MPa) = (0.4 to 0.6) N (blows/300 mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:

q_c = (12 to 18) C_u

Test, Drill and Excavation Methods

Explanation of Terms (2 of 3)

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Standard Penetration Testing (SPT)
Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample.

The test procedure is described in AS 1289.6.3.1-2004. The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm penetration depth increments and the 'N' value is taken as the number of blows for the last two 150 mm depth increments (300 mm total penetration). In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued. The test results are reported in the following form:

(i) Where full 450 mm penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows:

as 4, 6, 7
N = 13

(ii) Where the test is discontinued, short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm

as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

Dynamic Cone (Hand) Penetrometers
Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150mm increments of penetration. Normally, there is a depth limitation of 1.2m but this may be extended in certain conditions by the use of extension rods. Two relatively similar tests are used.

Perth sand penetrometer (PSP) - a 16 mm diameter flat ended rod is driven with a 9 kg hammer, dropping 600 mm. The test, described in AS 1289.6.3.3-1997 (R2013), was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

Cone penetrometer (DCP) - sometimes known as the Scala Penetrometer, a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm. The test, described in AS 1289.6.3.2-1997 (R2013), was developed initially for pavement sub-grade investigations, with correlations of the test results with California Bearing Ratio published by various Road Authorities.

Pocket Penetrometers
The pocket (hand) penetrometer (PP) is typically a light weight spring hand operated device with a stainless steel loading piston, used to estimate unconfined compressive strength, q_u, (UCS in kPa) of a fine grained soil in field conditions. In use, the free end of the piston is pressed into the soil at a uniform penetration rate until a line, engraved near the piston tip, reaches the soil surface level. The reading is taken from a gradation scale, which is attached to the piston via a built-in spring mechanism and calibrated to kilograms per square centimetre (kPa) UCS. The UCS measurements are used to evaluate consistency of the soil in the field moisture condition. The results may be used to assess the undrained shear strength, C_u, of fine grained soil using the approximate relationship:

$q_u = 2 \times C_u$.

It should be noted that accuracy of the results may be influenced by condition variations at selected test surfaces. Also, the readings obtained from the PP test are based on a small area of penetration and could give misleading results. They should not replace laboratory test results. The use of the results from this test is typically limited to an assessment of consistency of the soil in the field and not used directly for design of foundations.

Test Pit / Borehole Logs

Test pit / borehole log(s) presented herein are an engineering and / or geological interpretation of the subsurface conditions. Their reliability will depend to some extent on frequency of sampling and methods of excavation / drilling. Ideally, continuous undisturbed sampling or excavation / 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 test pit / borehole logs 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 test pits / boreholes, the frequency of sampling and the possibility of other than 'straight line' variation between the test pits / boreholes.

Laboratory Testing

Laboratory testing is carried out in accordance with AS 1289 Methods of Testing Soil for Engineering Purposes. Details of the test procedure used are given on the individual report forms.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly, or perhaps not at all during the time it 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 prior weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations 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.

Test, Drill and Excavation Methods

Explanation of Terms (3 of 3)

DRILLING / EXCAVATION METHOD

HA	Hand Auger	RD	Rotary Blade or Drag Bit	NQ	Diamond Core - 47 mm
AD/V	Auger Drilling with V-bit	RT	Rotary Tricone bit	NMLC	Diamond Core – 51.9 mm
AD/T	Auger Drilling with TC-Bit	RAB	Rotary Air Blast	HQ	Diamond Core – 63.5 mm
AS	Auger Screwing	RC	Reverse Circulation	HMLC	Diamond Core – 63.5 mm
HSA	Hollow Stem Auger	CT	Cable Tool Rig	DT	Diatube Coring
S	Excavated by Hand Spade	PT	Push Tube	NDD	Non-destructive digging
BH	Tractor Mounted Backhoe	PC	Percussion	PQ	Diamond Core - 83 mm
JET	Jetting	E	Tracked Hydraulic Excavator	X	Existing Excavation

SUPPORT

Nil	No support	S	Shotcrete	RB	Rock Bolt
C	Casing	Sh	Shoring	SN	Soil Nail
WB	Wash bore with Blade or Bailer	WR	Wash bore with Roller	T	Timbering

WATER

▽ Water level at date shown
▷ Water inflow
◁ Partial water loss
◀ Complete water loss

GROUNDWATER NOT OBSERVED (NO)	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED (NX)	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

PENETRATION / EXCAVATION RESISTANCE

L	Low resistance: Rapid penetration possible with little effort from the equipment used.
M	Medium resistance: Excavation possible at an acceptable rate with moderate effort from the equipment used.
H	High resistance: Further penetration possible at slow rate & requires significant effort equipment.
R	Refusal/ Practical Refusal. No further progress possible without risk of damage/ unacceptable wear to digging implement / machine.

These assessments are subjective and dependent on many factors, including equipment power, weight, condition of excavation or drilling tools, and operator experience.

SAMPLING

D	Small disturbed sample	W	Water Sample	C	Core sample
B	Bulk disturbed sample	G	Gas Sample	CONC	Concrete Core

U63 Thin walled tube sample - number indicates nominal undisturbed sample diameter in millimetres

TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11	4,7,11 = Blows per 150mm.
N=18	'N' = Recorded blows per 300mm penetration following 150mm seating
DCP	Dynamic Cone Penetration test to AS1289.6.3.2-1997. 'n' = Recorded blows per 150mm penetration

Notes:

RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB 30/80mm	Hammer double bouncing on anvil after 80 mm penetration
N=18	Where practical refusal occurs, report blows and penetration for that interval

CPT	Static cone penetration test
CPTu	CPT with pore pressure (u) measurement
PP	Pocket penetrometer test expressed as instrument reading (kPa)
FP	Field permeability test over section noted
VS	Field vane shear test expressed as uncorrected shear strength (sv = peak value, sr = residual value)
PM	Pressuremeter test over section noted
PID	Photoionisation Detector reading in ppm
WPT	Water pressure tests

SOIL DESCRIPTION

Density		Consistency		Moisture	
VL	Very loose	VS	Very soft	D	Dry
L	Loose	S	Soft	M	Moist
MD	Medium dense	F	Firm	W	Wet
D	Dense	St	Stiff	Wp	Plastic limit
VD	Very dense	VSt	Very stiff	Wl	Liquid limit
		H	Hard		

ROCK DESCRIPTION

Strength		Weathering	
VL	Very low	EW	Extremely weathered
L	Low	HW	Highly weathered
M	Medium	MW	Moderately weathered
H	High	SW	Slightly weathered
VH	Very high	FR	Fresh
EH	Extremely high		