Northern River Schools Cluster

Geotechnical Investigation Report – Broadwater Public School

ADCO Construction Pty Ltd

Reference: SYDGE319200AG Rev.2
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NORTHERN RIVER SCHOOLS CLUSTER

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1. INTRODUCTION

This report presents the results of geotechnical site investigation carried out by Tetra Tech Coffey (Coffey) at Broadwater Public School as part of the Northern River Schools Cluster (Stage 3-8) project. The geotechnical investigation was commissioned by ADCO Construction Pty Ltd (ADCO) and completed in general accordance with our fee proposal (Ref: SYDGE319200AA dated 16 March 2023).

The geotechnical investigation comprised the drilling of two geotechnical boreholes within the proposed building footprint and two environmental boreholes for contamination investigation purposes.

This report presents the results of geotechnical investigation and provide advice and recommendations for the proposed school development including the followings:

- Site description.
- Investigation procedure and methodology.
- Regional geology, subsurface conditions, and geotechnical model for the site.
- Groundwater conditions.
- Earthworks and site preparation.
- Suitability of exposure of soils to construction traffic.
- Modulus of Subgrade Reaction and Young's modulus for slabs on ground design.
- Temporary and permanent batter slopes.
- Design parameters for retaining wall design.
- Allowable bearing capacities and footing design options including high level pad or raft.
- Recommendations on suitable building footing systems including screw piles and driven piles, and relevant geotechnical design parameters.
- Design CBR values for pavements.
- Estimated long-term movement of ground due to ground water table variations.
- Classification of the site in accordance with AS 2870 based on reactivity of soil.
- Parameters for Earthquake design according to AS1170.4.
- Aggressivity of soil to concrete and steel structures.
- Any construction difficulties and solutions.

Contamination investigation results are provided in a separate report (Ref: SYDGE319200R03 dated 21 July 2023 / ADCO Ref: BRO-CI-PP-RPT-0001). The available geotechnical information from Douglas Partners' report (Ref: 216628.00.R.002.Rev0 dated 21 October 2022) has been incorporated to this report. For convenience, the available borehole logs from the previous geotechnical investigation report by Douglas Partners are included in Appendix D (refer to Douglas Partners report for further information).

2. SITE DESCRIPTION

Broadwater Public School is located at 9 Byrnes Street, Broadwater, New South Wales. The school campus is located on a generally level site, as confirmed by the available site survey information. The site comprises single and double storey school buildings, playgrounds, recreational areas, and a grass playing field. The existing buildings and structures appeared to be damaged and were enclosed in temporary fencing.

Mature and juvenile trees surrounded the perimeter of the site with the Richmond River located approximately 100m to the west from the centre of the school.

3. REGIONAL GEOLOGY

Based on the NSW seamless geology map, the Broadwater Public School site is primarily composed of Quaternary alluvium (Q_al), which consists of “fluvially deposited fine to medium grained lithic to quartz-rich sand, silt, clay”.

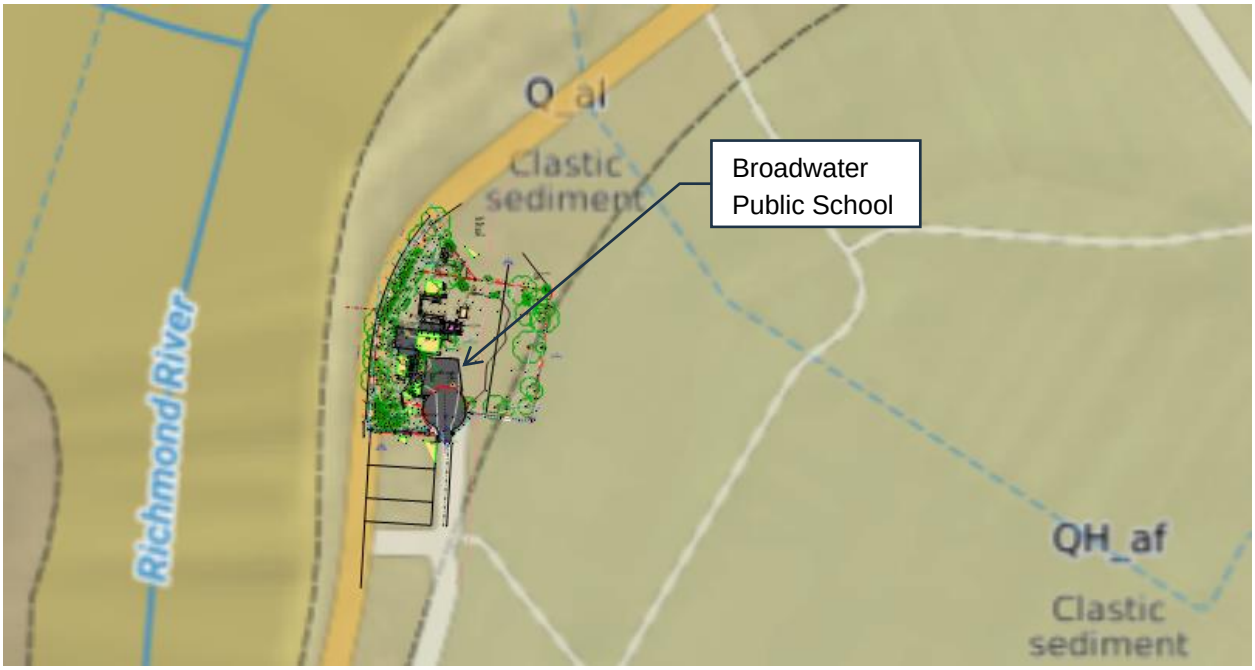


Figure 1 – Local geology condition at Broadwater Public School

4. INVESTIGATION METHODS

4.1 FIELD INVESTIGATION

The fieldwork was carried out by Coffey on 3 July 2023, comprising the following:

- Drilling of two deep boreholes BRO-C-BH1 and BRO-C-BH2 to a depth of 9.45m (refusal) and 12.2m respectively below the existing ground surface.
- Drilling of two shallow boreholes (BRO-C-BH3 and BRO-C-BH4) to 1m depth for soil contamination testing purposes.

Borehole BRO-C-BH1 was terminated at depth of 9.45m due to auger refusal on bedrock. Borehole BRO-C-BH2 was terminated at 12.2m and beyond the target depth of 10m. The borehole was drilled well into the medium dense sand to confirm this layer. The approximately borehole locations are shown in the location plan in Appendix A.

Prior to any ground penetration, a Before You Dig Australia (BYDA) request was made for the subject site. Each borehole location was compared with the DBYD plans and services located by an accredited service locator.

The boreholes were drilled using a truck mounted drilling rig. Solid flight augers were used for drilling in soils up to maximum depth of 5.75m depth and continued using washbore techniques to a maximum depth of 12.2m. Standard Penetration Tests (SPT) were carried out at selected depths to assess soil strength and to obtain samples for logging. On completion of drilling, boreholes were backfilled with cuttings to the initial ground surface.

Coffey geotechnical engineers were present throughout the drilling operation to sample, record test results and log material encountered. The Engineering Borehole Logs are presented in Appendix C together with Coffey soil explanation sheets.

4.2 LABORATORY TESTING

On completion of fieldwork, selected soil samples from the boreholes were sent to the NATA accredited laboratory for laboratory testing. Table 1 below provides the testing schedule that Coffey submitted.

Table 1: Geotechnical laboratory testing schedule

Laboratory Test	Quantity	Method
Moisture Content	3	AS 1289.2.1.1
Atterberg Limits	1	AS 1289.3.1.1 / 2.1
Linear Shrinkage	1	AS 1289.3.4.1
Particle Size Distribution	1	AS 1289.3.6.1
CBR	2	AS 1289.6.1.1
Soil aggressivity suite	4	Inorg-001, Inorg-002 and Inorg-081

Additional samples were collected from the investigation locations for the purposes of contamination assessment, which is presented in a separate Coffey Report (Ref: SYDGE319200R03 dated 21 July 2023 / ADCO Ref: BRO-CI-PP-RPT-0001).

5. RESULTS OF INVESTIGATION

5.1 ENCOUNTERED GROUND CONDITIONS

General ground conditions

The encountered subsurface ground profile at the site was consistent with the published and anticipated geology. At the proposed new school building locations, the encountered ground profile typically comprises relatively shallow loose sandy alluvium up to 0.6m thick overlying very soft to firm clay (about 2.6m thick) and very loose to loose sand (about 2.3m thick) followed by medium dense to dense sand below approximately 5m to 5.5m depth. Dense silty gravel was encountered at 8.6m depth in borehole BRO-C-BH1. This gravel layer of dense consistency was not encountered in other boreholes in the vicinity of the proposed new buildings.

Groundwater

The observed groundwater encountered in the boreholes are noted on the engineering borehole logs in Appendix C. During auger drilling of boreholes, groundwater was observed at depths between 1.9m and 2.8m below the current ground surface levels (estimated between RL 0 to RL -0.9m AHD).

5.2 GEOTECHNICAL MODEL

Using the subsurface information from the geotechnical investigation, the encountered ground conditions have been characterised into the geotechnical units presented in Table 2 below. A typical geotechnical cross section has been created showing the subsurface geotechnical model and the geotechnical unit distribution with depth and elevation. The typical section location plan and the associated geotechnical section are

included in Appendix B. The approximate location of the proposed new school building has been shown in the geotechnical section.

Table 2: Summary of site geotechnical model

Unit / Material	Description	Typical Unit Thickness (m)	Typical Soil Consistency
Unit 2 – Fill (localised)	Silty Sand with gravels (loose)	0 – 0.5	-
Unit 3A – Alluvium	Sandy Clay, Clay, Silt, medium to high plasticity clay, low liquid limit silt	2.4 – 2.6	Very Soft to Firm
Unit 3C – Alluvium	Silty Sand, Sand, fine to medium grained	2.2 – 2.3	Very Loose to Loose
Unit 3D – Alluvium	Silty Sand, Sand, fine to coarse grained	3.3 – 7.2	Medium Dense to Dense
Unit 3E – Alluvium	Silty Gravel, fine to coarse grained, sub-rounded to sub-angular, with fine to coarse sand	>0.8	Dense

5.3 GROUNDWATER

A summary of the groundwater levels observed during the investigation are summarised in Table 3. However, it is expected that groundwater level varies at this site in response to climatic conditions and tidal influences due to the proximity to Richmond River. Those responses may not be immediate. In the absent of groundwater level monitoring data, it is recommended that a groundwater table at RL 1.0m to 1.5 mAHD be considered in the design.

Table 3: Summary of site geotechnical model

Location	Ground Surface Elevation (mAHD)	Groundwater Level Observed	
		(mBGL)	(mAHD)
BRO-C-BH1	1.9	1.9	0
BRO-C-BH2	1.9	2.8	-0.9
BH1 (Douglas Partners)	2.1	2.4	-0.3
BH2 (Douglas Partners)	2.2	2.1	0.1
BH3 (Douglas Partners)	2.2	2.3	-0.1

5.4 LABORATORY TESTING RESULTS

A summary of the results is provided in Table 4 to Table 6. The laboratory certificates are included in Appendix E.

Table 4: California Bearing Ratio and compaction test results

Location	Details		Soaked CBR and Compaction Test				
	Depth (m)	Material	MC before soaking (%)	DD before soaking (t/m^3)	DD after soaking (t/m^3)	Swell (%)	CBR (%)
BRO-C-BH1	0.5 – 1	Sandy Clay	25.3	1.52	1.54	-1.0	3.0
BRO-C-BH2	0.5 - 1	Sandy Clay	33.3	1.37	1.38	-0.5	8.0

Notes to Table 4: **MC**: Moisture Content, **DD**: Dry Density, **CBR**: California Bearing Ratio

Table 5: Geotechnical soil classification test results

Location	Details		Particle Size Distribution			Atterberg Limits and Linear Shrinkage				
	Depth (m)	Material	Gravel (%)	Sand (%)	Clay (%)	MC (%)	LL (%)	PL (%)	PI (%)	LS (%)
BRO-C-BH1	6.8 – 7.25	Silty Sand	-	-	-	20.2	-	-	-	-
BRO-C-BH2	1.0 – 1.25	Clay	-	-	-	34.5	74	28	46	19
BRO-C-BH2	2.3 – 2.75	Clay	-	-	-	70	-	-	-	-
BRO-C-BH2	5.3 – 5.75	Sand	0	95	5	-	-	-	-	-

Notes to Table 5: **MC**: Moisture Content, **LL**: Liquid Limit, **PL**: Plastic Limit, **PI**: Plasticity Index, **LS**: Linear Shrinkage

Table 6: Moisture content and soil Aggressivity test results

Location	Details		Moisture Content (%)	Soil Aggressivity			Corrosion Classification	
	Depth (m)	Material		pH	Sulphate as SO4 (mg/kg)	Chloride (mg/kg)	Exposure – Concrete Piles	Exposure – Steel Piles
BRO-C-BH1	1.0 – 1.45	Clay	35.3	5.4	60	20	Mild	Non-Aggressive
BRO-C-BH1	5.3 – 5.75	Sand	17.5	4.2	90	20	Severe	Mild
BRO-C-BH2	3.8 – 4.0	Silty Sand	18.5	4.4	210	10	Severe	Mild
BRO-C-BH2	6.8 – 7.25	Sand	19.4	5.5	20	<10	Moderate	Non-Aggressive

6. DISSCUSSION AND RECOMMENDATIONS

6.1 EARTHWORKS

6.1.1 Subgrade Preparation

It is expected that a sandy material of approximately 0.3 - 0.5m thick of Units 2 or Unit 3C below the existing ground surface distributed over the site. Clayey material of Unit 3A is at 0.5m depth bellow the existing ground surface. Prior to the construction of subgrade layers (by engineered fill), topsoil, the existing hard stand and the underlying fill should be removed and stockpiled separately for appropriate reuse. The exposed subgrade material should be proof rolled with at least four passes of a non-vibratory smooth drum roller of minimum 12 tonne dead weight. Any soft or heaving areas should be excavated and replaced with engineered fill.

It is expected that trafficability in clayey materials (Unit 3A) for wheeled vehicles can be difficult during and following rainfall due to surface heaving and / or rutting. Granular fill is recommended for area underlain by clayey subgrade to improve trafficability.

6.1.2 Engineering Fill Compaction

For bulk earthworks using conventional earthmoving plant, fill material should be placed in layers not exceeding 300mm loose thickness and moisture conditioned to Standard Optimum Moisture Content (SOMC) ± 2%.

All engineered fill should be compacted to achieve a minimum dry density ratio of 98% SMDD (Standard Maximum Dry Density and moisture conditioned to SOMC ± 2% at the time of compaction.

Earthworks construction should be constructed under Level 1 geotechnical inspection and testing as defined in AS3798-2007.

6.1.3 Re-use of Material

Unit 2 –Silty Sand with gravel fill is uncontrolled fill and may be reused as general fill material. Unit 2 cannot be used as structural fill under structure foundation/subgrade unless further testing be undertaken. Unit 3C – Sandy soils would be suitable for re-use as general fill subject to meeting minimum placement and compaction requirement. Units 2 and 3C were described as fine to medium grained sand and hence it is relatively difficult to compact the fine to medium sand material to the required density index of 75 – 85%.

Unit 3A – Clayey soil is highly compressible and potential Acid Sulphate Soil (ASS) and cannot be used as general fill unless a form of soil treatment be applied. An ASS management plan is likely be required if excavation and removal of Unit 3A material is undertaken.

6.2 EXCAVATIONS CONDITIONS

It is understood that no basements are proposed for the school site. Excavations may be required for installation of underground services, shallow footing construction, lift pit, or to achieve design levels. Excavation of lift pit may be up to 2m below the existing ground surface and well within the soft to firm clay soil (Units 2, 3A and 3C). Hydrostatic uplift forces for lift pit should be designed using the recommended groundwater level (i.e., at RL 1.0m to 1.5 mAHD). Shallow excavation (less than 1.5 to 2m depth) will typically encounter Unit 2, 3A and 3C, and they can be readily excavated using conventional hydraulic excavator with bucket.

6.3 UNSUPPORTED EXCAVATIONS

Due to potential of shallow groundwater table and loose/soft condition of soil units within 2m – 3m depth below the existing ground surface, unsupported excavation is not recommended for excavation greater than 1m depth.

For excavation less than 1m depth, batter slopes may be possible where excavations are set back sufficiently from adjacent structures and boundary (i.e., minimum 4m clearance distance). The batter slopes should be scaled following excavation to remove all loose materials which could slide or topple from the face during construction and hence pose a risk to construction personnel.

Table 7 provides a summary of the recommended batter slopes within 1m depth for each geotechnical units without subject to flood inundation and rapid drawdown. Excavation of permanent batters is not recommended due to the presence of shallow ground table at this school site.

Temporary batter stability must be observed regularly. Works must be stopped, and advice be sought if sign of batter instability be observed.

Table 7: Recommended batter slopes for geotechnical units

Unit / Material	Short Term Batter Slope (Up to 2 months)
Unit 2 – Fill	1.5H:1V
Unit 3A – Alluvium (Firm)	1.5H:1V
Unit 3A – Alluvium (Very soft to soft)	2H:1V
Unit 3C – Alluvium (Very loose to loose)	3H:1V

6.4 RETAINING WALL DESIGN

Where unsupported, open excavation are impracticable, a temporary retaining wall, such as cantilever or sheetpile walls, can be considered during site construction. Table 8 presents recommended design parameters for the design of the temporary retaining wall where there is a level retained ground surface. Retaining wall analyses will need to consider surcharges, footing loads from adjacent structures and hydrostatic pressure.

Table 8: Recommended geotechnical model and relevant parameters

Geological Unit	Description	γ (kN/m^3)	S_u (kPa)	c' (kPa)	φ' (°)	E_u (MPa)	E' (MPa)	K_a	K_p	K_0	*v*
Unit 2 – Fill	Silty Sand with gravel (soft or loose)	17	5	0	25	-	8	0.41	2.46	0.54	0.3
Unit 3A – Alluvium	Sandy Clay/Clay (firm)	18	40	2	26	8	4	0.39	2.56	0.55	0.3
Unit 3A – Alluvium	Sandy Clay/Clay (very soft to soft)	17	20	1	21	3	1	0.47	2.12	0.65	0.3
Unit 3C – Alluvium	Silty Sand/Sand (very loose to loose)	16	-	0	26	-	7	0.39	2.56	0.55	0.3
Unit 3D – Alluvium	Silty Sand/Sand (medium dense to dense)	18	-	0	34	-	40	0.28	3.54	0.45	0.3
Unit 3E – Alluvium	Silty Gravel (dense)	18	-	0	36	-	50	0.26	3.85	0.50	0.3

Notes for Table 8: *Eu, E'* are undrained and drained Young's soil modulus respectively; S_u is undrained shear strength; c' drained cohesion; φ' is drained friction angle; K_a is coefficient of Active Earth pressure; K_p is coefficient of Passive Earth pressure; K_0 is initial horizontal stress ratio.

6.5 BUILDING FOUNDATIONS

6.5.1 Shallow Footings & Slab on Ground

Shallow footing is not suitable for the proposed new school building due to the presence of highly compressible soil layers (Unit 3A and 3C) up to more than 5m depth within the site. Long term (creep) settlement of Unit 3A may occur over time. Any additional load or filling over the existing ground will also cause long term ground settlement due to the soft/loose soil layers. An allowable bearing capacity of 50kPa can be adopted for the subgrade design for paved footpath over re-compacted Units 2 and 3C subgrade within 0.1m – 1m depth below the existing ground surface. Where subgrade bearing capacity in excess of 50kPa is required, it is likely that over excavation and replacement with compacted gravel fill is recommended as subgrade treatment for pavement and hard stand construction over the site. Table 9 below provides a summary of the modulus of subgrade reaction and Young's modulus for slab on ground design.

Table 9: Summary of modulus of subgrade reaction and Young's modulus for slab on ground design

Geological Unit	Description	Undrained Young's Modulus, E_u (MPa)	Drained Young's Modulus, E' (MPa)	Constrained Soil Modulus, *M* MPa	Modulus of Subgrade Reaction (MN/m^3)
Unit 2 – Fill	Silty Sand with gravels (loose)	-	8	8	4

Geological Unit	Description	Undrained Young's Modulus, E_u (MPa)	Drained Young's Modulus, E' (MPa)	Constrained Soil Modulus, M MPa	Modulus of Subgrade Reaction (MN/m^3)
Unit 3A – Alluvium	Sandy Clay/Clay (firm)	8	6	7	2
Unit 3C – Alluvium	Silty Sand/Sand (very loose to loose)	-	7	7	3

Notes for Table 9: *Eu, E'* are undrained and drained Young's soil modulus respectively; M is constrained soil modulus.

6.5.2 Piled Foundation

It is understood that project structural engineers are preferred to use driven pile (pre-cast concrete) or screw pile foundation at the site. Piles should be founded in Unit 3D of medium dense to dense sand. A summary of each pile type is given below.

6.5.2.1 Driven Piles

For driven piles, the pile geotechnical capacity can be calculated depending on the pile shaft and base cross section areas. There are a number of key geotechnical factors that need to be taken into consideration when designing for pile geotechnical capacity:

- Geotechnical compression, tension, and lateral capacity.
- Conical uplift capacity or cone pull out failure.
- Drivability of driven steel piles.
- Strength reduction factors.
- Pile foundation defection.
- Pile spacing.
- Seismic actions.
- Negative friction from soft clay unit.

Geotechnical capacity contribution of the soil layer within the top depth of 1.5 times the pile diameter below the finished ground surface should be ignored in accordance with AS 2159 – Pile Design and Installation. Negative skin friction from Unit 3A would likely impact on the pile settlement. Shaft resistance from Unit 3A should not be considered as the capacity contribution to the pile axial capacity.

Preliminary recommended geotechnical parameters for pile foundation design are provided in Table 10.

Table 10: Recommended geotechnical parameters for driven pile foundation design

Geological Unit	Description	Ultimate End Bearing (4) (kPa)	Ultimate Shaft (1) Adhesion (kPa)	Ultimate Lateral Capacity (kPa)	Lateral Subgrade Reaction (2) (MPa/m^3)
Unit 2 – Fill	Silty Sand with gravels (loose)	80	-	80	4 / dp
Unit 3A – Alluvium	Sandy Clay/Clay (firm)	125	25	125	2 / dp
Unit 3A – Alluvium	Sandy Clay/Clay (very soft to soft)	50	15(3)	50	0.5 / dp
Unit 3C – Alluvium	Silty Sand/Sand (very loose to loose)	60	5	60	4 / dp

Geological Unit	Description	Ultimate End Bearing (4) (kPa)	Ultimate Shaft (1) Adhesion (kPa)	Ultimate Lateral Capacity (kPa)	Lateral Subgrade Reaction (2) (MPa/m3)
Unit 3D – Alluvium	Silty Sand/Sand (medium dense to dense)	4000	80	1700	18 / d_p
Unit 3E – Alluvium	Silty Gravel (dense)	5000	100	2000	25 / d_p

Notes: (1) ultimate shaft capacity under compression load, a load factor of 0.7 be applied to obtain ultimate shaft capacity under tension load; (2) lateral reaction modulus for a single pile with diameter of d_p in metre; (3) shaft resistance from Unit 3A is provided for negative skin friction design of pile foundation. Shaft resistance from Unit 3A should not be considered as part of pile axial capacity. (4) Ultimate end bearing value requires a minimum pile embedment of 1.5 times pile diameter or 1.5 m depth in to the soil unit whichever is longer.

For cone pull-out failure calculation, the inverted cone can be calculated using the angle of pull-out of approximately 0.5 times the soil angle of friction.

For limit state design of piles, the design ultimate geotechnical pile capacity is derived by applying a geotechnical strength reduction factor (Φg) to the ultimate geotechnical pile capacity assessed using the ultimate shaft resistance and end bearing values shown in Table 10. In accordance with AS2159- 2009, Φg is dependent on an Average Risk Rating (ARR) which considers various geotechnical uncertainties, foundation system redundancy, construction supervision, quantity and type of pile testing. Based on the available information, we suggest Φg of 0.45 could be adopted for pile design. For uplift loads a Φg of 0.4 should be adopted and shaft adhesion values presented in Table 10 above should be multiplied by 0.7. The final Φg should be reviewed by Coffey at the detailed design stage.

The use of limit state design also requires assessment of the serviceability performance of the foundation system. This should be carried out by an experienced geotechnical professional using well-established and soundly based methods. The elastic modulus value given in Table 10 may be adopted but it should be noted that the accuracy of settlement prediction is dependent on construction methods as well as material stiffness, both of which can involve degree of uncertainty.

6.5.2.2 Screw Piles

Screw piles may be a viable option for this school site. The use of steel screw piles, including multi-helix piles with optional head fin attachments for increased lateral support if needed, along with a pile cap, would be suitable for lightly loaded structures requiring minimal lateral resistance, as expected in this case. Steel screw pile capacity depends on the foundation's density, strength consistency, and depth. Designing steel screw piles with a helix diameter of 0.6 m and multi-helix can be accomplished using an allowable bearing pressure of 800 kPa when founded at a minimum depth of 7m in the underlying medium dense to dense sand (Unit 3D) (i.e., minimum 1.5m depth into Unit 3D).

It is crucial to carefully control the installation of steel screw piles in the field to ensure they do not encounter refusal before reaching their termination depth, especially if refusing on dense gravels or rock. In such scenarios, the pile's advancement will cease, leading to over rotation and disturbance of the overburden soils above the helix. This issue often arises when steel screw piles encounter an underlying harder stratum, significantly reducing toe penetration compared to the string rotation, thereby substantially reducing the bearing capacity for the helix and possibly incurring pile movements.

The actual capacity of steel screw piles depends not only on soil conditions but also on structural considerations, such as the strength of the helix and the helix/shaft joint. Both the structural section capacity and geotechnical capacity should be taken into account, especially when the required load-carrying capacity of individual steel screw piles exceeds, say, 600 kN. Measurement of installation torque should not be solely relied upon to indicate pile capacity, as documented evidence shows significantly misleading results can be

obtained. Therefore, piling contractors would be responsible for assessing the actual pile capacities for their piles.

It is essential to check the structural capacity of the steel screw pile and account for inclined or eccentric loads and possible corrosion effects.

To increase the lateral capacity of steel screw piles, concrete pile caps can be constructed, or proprietary head attachments can be used, which are dragged into the soil to provide additional lateral resistance at the pile head. However, it should be noted that the lateral support is generally limited and suitable for non-critical structures that can accommodate some lateral movement, such as light poles, signs, and small towers.

The ultimate geotechnical strength ($R_{d,ug}$) of steel screw piles in uplift can be calculated using the weight of the enclosing cylinder of soil above the helix, together with friction developed on the walls of this cylinder, using an average buoyant soil density of 7 kN/m^3 (assuming a high groundwater table in the worst case), while ignoring friction.

Regarding the compressive load testing of piles, (AS 2159, 2009) requires it to be undertaken to a test load of E_d/Φ_g. For a geotechnical strength reduction factor (Φ_g) of 0.45, this test load is twice the design action effect (Ed). However, the results of steel screw pile load tests typically indicate that plastic deformation of the helix can occur when a screw pile is loaded to only approximately 1.5 times E_d, especially for piles with a helix outstand to plate thickness ratio greater than about 10. Therefore, failure can occur before reaching the required test load for such piles.

Although the test load nominated by (AS 2159, 2009) is unlikely to be achieved for piles with insufficient helix plate thickness, failure would not be expected to occur at normal serviceability loads. To achieve the nominated test load, steel screw piles should be designed with a helix outstand to plate thickness ratio of no greater than about 10.

For proper understanding of subsurface conditions, it is imperative to provide a specialist screw piling contractor with a full copy of this report.

6.6 DESIGN CBR VALUES AND PAVEMENT DESIGN

It is expected that new pavement will be constructed at, or near existing ground surface level. Therefore, it is likely that the subgrade will be Sandy Clay.

The results of the CBR tests conducted on selected samples of subgrade material indicate CBR values between 3% (sandy clay) and 8% (sandy clay). It is recommended that a CBR value of 3% be adopted for the clayey subgrade.

Pavements should be protected by adequate surface and subsoil drainage to reduce the risk of water ingress and subgrade softening. Pavement subgrade should be prepared in accordance with the site preparation requirements presented in Section 6.1.1.

Groundwater was observed at depths between 1.9m and 2.8m below the current ground surface levels during auger drilling of boreholes. As a result, there is no likelihood of permanent uplift forces acting on the conventional slab to be constructed at or near the ground surface. During the flood events, only buoyancy load arising from the submerged slab should be considered.

It is also understood that the lift pit will be more than 2m depth below the existing ground level and fully tanked. Therefore, permanent uplift pressure on the lift pit must be considered. The predicated uplift pressure is approximately 20 kPa when design groundwater level between RL 1.0m to 1.5 mAHD is adopted.

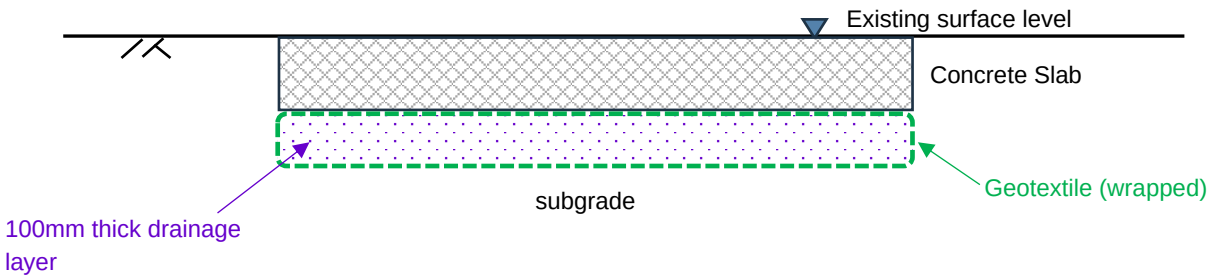


Figure 2: Sketch for proposed drainage layer under pavement

6.7 ESTIMATE LONG-TERM MOVEMENT OF GROUND DUE TO GROUNDWATER VARITIONS.

Groundwater table between RL 1.0m and 1.5 mAHD is recommend in the design. For long-term settlement calculations, the maximum groundwater table at RL 2.5m AHD has been considered to account for potential groundwater variations. The anticipated maximum long-term settlement of the ground is approximately 35mm for every 1m drop in the groundwater table.

6.8 SITE CLASSIFICATION

Additional soil classification testing has been conducted for clayey soil in borehole BRO-C-BH2 between 1m and 1.25m depth. Soil classification testing results are also available for the clayey soil between 0.7 to 1.5m depth as provided in Douglas Partners' investigation report (Ref: 216628.00.R.002.Rev0 dated 21 October 2022). The testing results are summarised in Table 11 together with the correlated approximate range of shrink swell index I_{ps}. Coffey recommends adopting a shrink well index of 2% for this site. Assuming that Unit 3A will not be excavated and removed from the site, the estimated characteristic ground surface movement is approximately 50mm – 80mm, which is corresponding with site Class E in accordance with AS 2870.

Table 11: Recommended geotechnical model and relevant parameters

Geological Unit	Description	BH	Depth m	LL%	PL%	PI%	LS%	WPI%	Clay/Silt %	Correlated(1) I_{ps} %
Unit 3A - Alluvium	Clay (firm)	BRO-C-BH2	1.0-1.25	74	28	46	19	-	-	3.5 – 4
Unit 3A – Alluvium	Clay (firm)	BH1	1.5	30	16	14	9.5	1330	58	0.5 – 1
Unit 3B - Alluvium	Clay (stiff)	BH4	0.7	23	6	17	5.5	1547	41	0.5 – 1

Notes: (1) approximate shrink swell index is correlated with the provided soil classification test results.
LL: Liquid Limit, **PL**: Plastic Limit, **PI**: Plasticity Index, **LS**: Linear Shrinkage, **WPI:** % passing 0.425mm sieve x PI.

6.9 EARTHQUAKE DESIGN

We recommend that a Hazard Factor (Z) of 0.09 and probability factor (Kp) of 1.5 would be appropriate for the proposed site in accordance with AS 1170.4-2007 Part 4 Earthquake Actions in Australia. The site be classified as Class De (Deep soil site).

6.10 SOIL AGGRESSIVITY

The soil aggressivity test results were compared with the exposure classifications defined in Australian Standard AS2159-2009 Piling – "Design and Installation". The chemical test results indicate ***"Mild-Aggressive"*** to ***"Severe-Aggressive"*** ground conditions to buried concrete element and ***"Non-Aggressive"*** to ***"Mild-Aggressive"*** ground conditions to buried steel elements.

IMPORTANT INFORMATION ABOUT YOUR TETRA TECH COFFEY REPORT

As a client of Tetra Tech Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Tetra Tech Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Tetra Tech Coffey and applies only to the site investigated. 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. Your report should not be used if there are any changes to the project without first asking Tetra Tech Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Tetra Tech Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Tetra Tech Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between 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. For this reason, owners should retain the services of Tetra Tech Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Tetra Tech Coffey, who prepared the report, is 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 Tetra Tech Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Tetra Tech Coffey before passing your report on to another party who may not be familiar with the background and the 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.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Tetra Tech Coffey to work with other project design professionals who are affected by the report. Have Tetra Tech Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. 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 Tetra Tech Coffey for information relating to geoenvironmental issues.

Rely on Tetra Tech Coffey for additional assistance

Tetra Tech Coffey 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. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Tetra Tech Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is 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 Tetra Tech Coffey to other parties but are included to identify where Tetra Tech Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Tetra Tech Coffey closely and do not hesitate to ask any questions you may have.

APPENDIX A: BOREHOLE LOCAITON PLAN

LEGEND

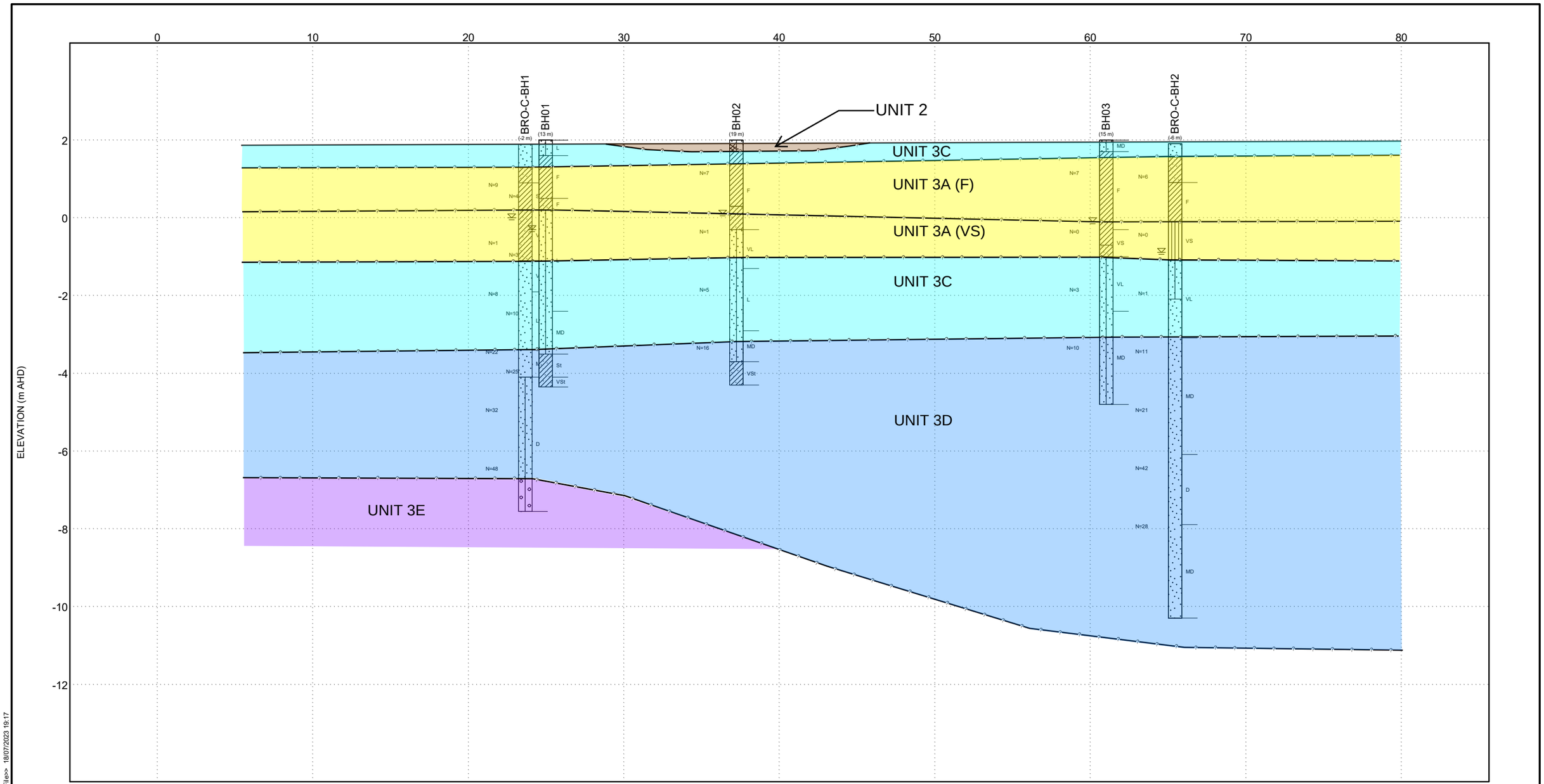
- 2022 Geotechnial boreholes by DP
- 2023 Geotechnical boreholes by Coffey
- 2023 Environmental boreholes by Coffey

drawn	IG
approved	VN
date	18/07/2023
scale	NTC
original size	A4

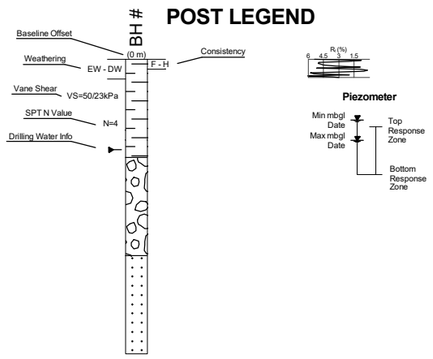
TETRA TECH COFFEY

client:	**ADCO Construction Pty Ltd**
project:	**Northern River School Cluster** **Broadwater Public School**
title:	**Borehole Location Plan**
project no:	**SYDGE319200**
figure no:	1

APPENDIX B: GEOTECHNICAL SECTIONS



POST LEGEND



MATERIAL GRAPHIC

- SAND
- SANDY CLAY
- CLAY
- SILTY SAND
- SILTY GRAVEL
- SILT

H 1:250
0 2 4 6 8 10m
V 1:100
0 1 2 3 4 5m
Coord.System: MGA94 Height Datum: AHD

PROJECT UNIT

- UNIT 1 - TOPSOIL
- UNIT 2 - FILL
- UNIT 3A - ALLUVIUM (CLAY/SANDY CLAY: VS-S)
- UNIT 3B - ALLUVIUM (CLAY/SANDY CLAY: ST-VST)
- UNIT 3C - ALLUVIUM (SILTY SAND/CLAYEY SAND: VL-L)
- UNIT 3D - ALLUVIUM (SILTY SAND/CLAYEY SAND: MD-D)
- UNIT 4 - RESIDUAL SOIL (SANDY CLAY - VST-H)
- UNIT 5 - EXTREMELY WEATHERED MATERIAL

drawn	IG
approved	VN
date	18/07/2023
scale	H 1:250 V 1:100
original size	A3

TETRA TECH COFFEY

client: ADCO Construction Pty Ltd

project: Northern River School Cluster

title: **BROADWATER PUBLIC SCHOOL - SECTION A-A**

project no: SYDGE319200 | fig no: | rev:

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APPENDIX C: ENGINEERING BOREHOLE LOGS

SOIL DESCRIPTION EXPLANATION SHEET

DEFINITION:

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 can be remoulded or disaggregated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with AS 1726:2017 as shown in the table on Sheet 2.

PARTICLE SIZE DEFINITIONS

Components	Subdivision	Size (mm)
Boulders Cobbles		>200 63 - 200
Gravel	Coarse Medium Fine	19 - 63 6.7 - 19 2.36 - 6.7
Sand	Coarse Medium Fine	0.6 - 2.36 0.210 - 0.6 0.075 - 0.21
Silt Clay		0.002 – 0.075 < 0.002

MOISTURE CONDITION

Coarse Grained Soil

Dry (D)	Non-cohesive and free-running
Moist (M)	Soil feels cool, darked in colour. Soil tends to stick together.
Wet (W)	As for moist, with free water forming when handled.

Fine Grained Soil

Moist, dry of plastic limit ($w<W_P$)	Hard and friable or powdery
Moist, near plastic limit ($w\approx W_P$)	Can be moulded at a moisture content approximately equal to the plastic limit.
Moist, wet of plastic limit ($w>W_P$)	Soils usually weakened and free water forms on hands when handling.
Wet, near liquid limit ($w\approx W_L$)	Near liquid limit.
Wet, wet of liquid limit ($w>W_L$)	Wet of liquid limit.

CONSISTENCY OF COHESIVE SOILS

Term (Abbreviation)	Indicative undrained shear strength s_u (kPa)	Field guide
Very Soft (VS)	<12	Soil exudes between fingers when squeezed in hand.
Soft (S)	12 – 25	Soil can be moulded by light finger pressure.
Firm (F)	25 – 50	Soil can be moulded by strong finger pressure.
Stiff (St)	50 – 100	Soil cannot be moulded by fingers.
Very Stiff (VSt)	100 – 200	Soil can be indented by thumb nail.
Hard (H)	>200	Soil can be indented with difficulty by thumb nail.
Friable (Fb)	–	Soil can be easily crumbled or broken into small pieces by hand.

RELATIVE DENSITY OF NON-COHESIVE SOILS

Term (Abbreviation)	Density index (%)
Very Loose (VL)	Less than 15
Loose (L)	15 – 35
Medium Dense (MD)	35 – 65
Dense (D)	65 – 85
Very Dense (VD)	Greater than 85

MINOR COMPONENTS

Term	Assessment Guide	Proportion of minor component in:
Trace	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: Fines - <5%, Accessory coarse fraction - <15% Fine grained soils: sand/gravel <15%
With	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: Fines - 5 to 12%, Accessory coarse fraction – 15 to 30% Fine grained soils: sand/gravel 15 to 30%

SOIL STRUCTURE AND CEMENTATION

Zoning		Cementation	
Layer	Zone is continuous across exposure or sample.	Weakly cemented	Easily disaggregated by hand in air or water.
Lense	Discontinuous layer of different material, with lenticular shape.	Moderately cemented	Effort is required to disaggregate the soil by hand in air or water.
Pocket	Irregular inclusion of different material.		

GEOLOGICAL ORIGIN

Residual soil	Structure and fabric of parent rock not visible.
Extremely weathered material	Structure and/or fabric of parent rock is visible.
Alluvial soil	Deposited by streams and rivers.
Estuarine soil	Deposited in coastal estuaries, including sediments carried by inflowing rivers and streams, or tidal currents.
Marine soil	Deposited in a marine environment
Lacustrine soil	Deposited in freshwater lakes
Aeolian soil	Carried and deposited by wind
Colluvial soil	Deposited on slopes (transported downslope by gravity, with or without assistance of water).
Topsoil	Mantle of surface or near surface material, often defined by high levels of organic material.
Fill	Any material which has been placed by anthropogenic processes. Fill may be significantly more variable between tested locations than naturally occurring soils.

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 63 mm and basing fractions on estimated mass)						GROUP SYMBOL	SOIL NAME
COARSE GRAINED SOIL: More than 65% of materials 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)	GRAVEL: More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVEL (Fines less than 5%)	Wide range in grain size and substantial amounts of all intermediate particle sizes, not enough fines to bind coarse grains, no dry strength.		GW	GRAVEL
				Predominantly one size or a range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength.		GP	GRAVEL
			GRAVEL with FINES (Fines greater than 12%)	'Dirty' materials with excess of non-plastic fines (for identification procedures see ML below).		GM	Silty GRAVEL
				'Dirty' materials with excess of plastic fines (for identification procedures see CL below).		GC	Clayey GRAVEL
		SAND: More than half of coarse fraction is smaller than 2.36	CLEAN SAND (Fines less than 5%)	Wide range in grain sizes and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength.		SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength.		SP	SAND
			SAND with FINES (Fines greater than 12%r)	'Dirty' materials with excess of non-plastic fines (for identification procedures see ML below).		SM	Silty SAND
				'Dirty' materials with excess of plastic fines (for identification procedures see CL below).		SC	Clayey SAND
FINE GRAINED SOIL: More than 35% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm				
		SILT & CLAY: Liquid limit less	DRY STRENGTH	DILATANCY	TOUGHNESS		
			None to low	Slow to rapid	Low	ML	SILT
			Medium to high	None to slow	Medium	CL, CI	CLAY
			Low to medium	Slow	Low	OL	Organic SILT
		SILT & CLAY: Liquid limit	Low to medium	None to slow	Low to medium	MH	SILT
			High to very high	None	High	CH	CLAY
			Medium to high	None to very slow	Low to medium	OH	Organic CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			PT	Peat

● Low plasticity – Liquid Limit W_L less than 35%. ● Medium plasticity –W_L between 35% and 50%. ● High plasticity – W_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
Parting	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (e g. bedding). May be open or closed.	
Fissure	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. May include desiccation cracks.	
Sheared Seam	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
Sheared Surface	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect	

TERM	DEFINITION	DIAGRAM
Softened Zone	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere	
Tube	Tubular cavity. May occur singly or as one of a large number of separate or interconnected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter. Origins include root holes, animal burrows, tunnel erosion.	
Tube cast	An infilled tube. The infill may be uncemented or weakly cemented soil or have rock properties.	
Infilled Seam	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open defects.	

TETRA TECH COFFEY

Engineering Log - Borehole

Borehole ID.	***BRO-C-BH1***
sheet:	1 of 2
project no.	***SYDGE319200***
client:	***ADCO Construction Pty Ltd***
date started:	***03 Jul 2023***
principal:	***NSW Department of Education***
date completed:	***03 Jul 2023***
project:	***Northern River School Cluster***
logged by:	***WS***
location:	***Boardwater Public School***
checked by:	***VN***

position: E: 542607; N: 6791617 (MGA94) | surface elevation: 1.90 m (AHD) | angle from horizontal: 90°

drill model: GOT2008, Truck mounted | drilling fluid: Water | casing diameter : HW

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	soil origin, structure and additional observations
AD, HW casing				1				**SAND**: fine to medium grained, brown-grey, trace rootlets.	M			**TOPSOIL/ALLUVIUM**
								Sandy CLAY: medium plasticity, brown-grey, fine to coarse sand, trace rootlets.	~Wp			
			SPT 2, 3, 6 N=9		1.0		CH	**CLAY**: high plasticity, brown mottled orange, trace fine to mediusm sand.		St	X	**ALLUVIUM** HP 220 kPa
		03/07/23		0			CL	**Sandy CLAY**: low plasticity, brown grey, fine to coarse sand.	>Wp	VS		
			SPT 0, 1, 0 N=1	-1	2.0							
					3.0		SP	**SAND**: fine to coarse grained, pale grey, mottled pale yellow.	M	VL		
			SPT 2, 3, 5 N=8	-2	4.0					L		
				-3	5.0							
			SPT 2, 7, 15 N=22	-4						MD		
W					6.0		SM	**SILTY SAND**: fine to coarse grained, brown yellow.	W	D		
			SPT 12, 15, 17 N=32	-5	7.0							
				-6								

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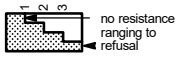
method
- DT diatube
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- RR rock roller

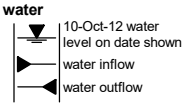
* bit shown by suffix e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration



water



samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

soil group symbol & material description based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

TETRA TECH COFFEY

Engineering Log - Borehole

Borehole ID.	***BRO-C-BH1***
sheet:	2 of 2
project no.	***SYDGE319200***
client:	***ADCO Construction Pty Ltd***
date started:	***03 Jul 2023***
principal:	***NSW Department of Education***
date completed:	***03 Jul 2023***
project:	***Northern River School Cluster***
logged by:	***WS***
location:	***Boardwater Public School***
checked by:	***VN***

position: E: 542607; N: 6791617 (MGA94) | surface elevation: 1.90 m (AHD) | angle from horizontal: 90°

drill model: GOT2008, Truck mounted | drilling fluid: Water | casing diameter : HW

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	soil origin, structure and additional observations
W			SPT 7, 20, 28 N=48	-7	9.0		SM	**SILTY SAND**: fine to coarse grained, brown yellow. *(continued)* 8.3 m: becoming orange brown	W	D		**ALLUVIUM**
							GM	**SILTY GRAVEL**: fine to coarse grained, sub-rounded to sub-angular, orange brown, with fine to coarse sand.	M			
				-8 -9 -10 -11 -12 -13 -14	10.0 11.0 12.0 13.0 14.0 15.0			Borehole BRO-C-BH1 terminated at 9.45 m Refusal				

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method
DT diatube
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore
RR rock roller

* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud
C casing
N nil

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remouded (kPa)
R refusal
HB hammer bouncing

soil group symbol & material description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

TETRA TECH COFFEY

Engineering Log - Borehole

Borehole ID.	***BRO-C-BH2***
sheet:	1 of 2
project no.	***SYDGE319200***
client:	***ADCO Construction Pty Ltd***
date started:	***03 Jul 2023***
principal:	***NSW Department of Education***
date completed:	***03 Jul 2023***
project:	***Northern River School Cluster***
logged by:	***WS***
location:	***Boardwater Public School***
checked by:	***VN***

position: E: 542618; N: 6791657 (MGA94) | surface elevation: 1.91 m (AHD) | angle from horizontal: 90°

drill model: GOT2008, Truck mounted | drilling fluid: Water | casing diameter : HW

drilling information | **material substance**

method & support	penetration	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (SOIL NAME: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa)	soil origin, structure and additional observations
HW casing					0.0			**SAND**: fine to medium grained, brown, mottled pale yellow, trace rootlets.	D			**TOPSOIL/ALLUVIUM**
							CI-CH	**Sandy CLAY**: medium to high plasticity, brown, fine to medium sand, trace rootlets.	<Wp			
			SPT 2, 2, 4 N=6	1	1.0		CI	**CLAY**: medium plasticity, brown mottled orange, trace fine to medium sand.		F	×	**ALLUVIUM** HP 210 kPa
				0	2.0		ML	**SILT**: low liquid limit, grey-brown.	>Wp	VS		
AD		03/07/23	SPT 0, 0, 0 N=0	-1	3.0		SM	**SILTY SAND**: fine to medium grained, grey-brown.	W	VL		
			SPT 0, 0, 1 N=1	-2	4.0		SP	**SAND**: fine to medium grained, grey-brown.				
				-3	5.0				M	MD		
W			SPT 2, 5, 6 N=11	-4	6.0		SP	**SAND**: fine to medium grained, grey, trace silt.				
			SPT 8, 9, 12 N=21	-5	7.0							
				-6								

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method

DT	diatube
AD	auger drilling*
AS	auger screwing*
HA	hand auger
W	washbore
RR	rock roller
*	bit shown by suffix
e.g.	AD/T
B	blank bit
T	TC bit
V	V bit

support

M	mud
C	casing
N	nil

penetration

1 2 3 — no resistance ranging to refusal

water

10-Oct-12 water level on date shown

water inflow

water outflow

samples & field tests

B	bulk disturbed sample
D	disturbed sample
E	environmental sample
SS	split spoon sample
U##	undisturbed sample ##mm diameter
HP	hand penetrometer (kPa)
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
VS	vane shear; peak/remoulded (kPa)
R	refusal
HB	hammer bouncing

soil group symbol & material description based on AS 1726:2017

moisture condition

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

TETRA TECH COFFEY

Engineering Log - Borehole

Borehole ID.	***BRO-C-BH2***
sheet:	2 of 2
project no.	***SYDGE319200***
client:	***ADCO Construction Pty Ltd***
date started:	***03 Jul 2023***
principal:	***NSW Department of Education***
date completed:	***03 Jul 2023***
project:	***Northern River School Cluster***
logged by:	***WS***
location:	***Boardwater Public School***
checked by:	***VN***

position: E: 542618; N: 6791657 (MGA94) | surface elevation: 1.91 m (AHD) | angle from horizontal: 90°

drill model: GOT2008, Truck mounted | drilling fluid: Water | casing diameter : HW

drilling information						material substance						
method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description **SOIL NAME**: plasticity or particle characteristics, colour, secondary and minor components	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	soil origin, structure and additional observations
W			SPT 8, 13, 29 N=42	-7	9.0		SP	**SAND**: fine to medium grained, grey, trace silt. *(continued)*	M	D		**ALLUVIUM**
			SPT 8, 11, 17 N=28	-8	10.0					MD		
				-9	11.0							
				-10	12.0							
				-11	13.0			Borehole BRO-C-BH2 terminated at 12.20 m Target depth				
				-12	14.0							
				-13	15.0							
				-14								

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method
DT diatube
AD auger drilling*
AS auger screwing*
HA hand auger
W washbore
RR rock roller

* bit shown by suffix
e.g. AD/T
B blank bit
T TC bit
V V bit

support
M mud
C casing
N nil

penetration
1 2 3 no resistance ranging to refusal

water
10-Oct-12 water level on date shown
water inflow
water outflow

samples & field tests
B bulk disturbed sample
D disturbed sample
E environmental sample
SS split spoon sample
U## undisturbed sample ##mm diameter
HP hand penetrometer (kPa)
N standard penetration test (SPT)
N* SPT - sample recovered
Nc SPT with solid cone
VS vane shear; peak/remoulded (kPa)
R refusal
HB hammer bouncing

soil group symbol & material description
based on AS 1726:2017

moisture condition
D dry
M moist
W wet
Wp plastic limit
Wl liquid limit

consistency / relative density
VS very soft
S soft
F firm
St stiff
VSt very stiff
H hard
Fb friable
VL very loose
L loose
MD medium dense
D dense
VD very dense

TETRA TECH COFFEY

Engineering Log - Borehole

Borehole ID.	***BRO-C-BH3***
sheet:	1 of 1
project no.	***SYDGE319200***
client:	***ADCO Construction Pty Ltd***
date started:	***03 Jul 2023***
principal:	***NSW Department of Education***
date completed:	***03 Jul 2023***
project:	***Northern River School Cluster***
logged by:	***WS***
location:	***Boardwater Public School***
checked by:	***VN***

position: E: 542615; N: 6791652 (MGA94) | surface elevation: 2.01 m (AHD) | angle from horizontal: 90°

drill model: GOT2008, Truck mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	soil origin, structure and additional observations
AD		Not Encountered		2			SW	**SAND**: fine to coarse grained, brown-grey, trace rootlets.	M	L		**TOP SOIL/FILL**
								SAND: fine to coarse grained, grey brown.				**ALLUVIUM**
				1	1.0		CL	**Sandy CLAY**: low plasticity, grey brown, fine to coarse sand.	<Wp	S		
								Borehole BRO-C-BH3 terminated at 1.0 m Target depth				
				0	2.0							
				-1	3.0							
				-2	4.0							
				-3	5.0							
				-4	6.0							
				-5	7.0							

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method
- DT diatube
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- RR rock roller

* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration
1 2 3 — no resistance ranging to refusal

water
- 10-Oct-12 water level on date shown
- water inflow
- water outflow

samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

soil group symbol & material description based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density
- VS very soft
- S soft
- F firm
- St stiff
- VSt very stiff
- H hard
- Fb friable
- VL very loose
- L loose
- MD medium dense
- D dense
- VD very dense

TETRA TECH COFFEY

Engineering Log - Borehole

Borehole ID.	***BRO-C-BH4***
sheet:	1 of 1
project no.	***SYDGE319200***
client:	***ADCO Construction Pty Ltd***
date started:	***03 Jul 2023***
principal:	***NSW Department of Education***
date completed:	***03 Jul 2023***
project:	***Northern River School Cluster***
logged by:	***WS***
location:	***Boardwater Public School***
checked by:	***VN***

position: E: 542615; N: 6791627 (MGA94) | surface elevation: 1.94 m (AHD) | angle from horizontal: 90°

drill model: GOT2008, Truck mounted | drilling fluid: N/A | hole diameter : 100 mm

drilling information | **material substance**

method & support	penetration 1 2 3	water	samples & field tests	RL (m)	depth (m)	graphic log	soil group symbol	material description (**SOIL NAME**: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency / relative density	hand penetrometer (kPa) 100 200 300 400	soil origin, structure and additional observations
AD		Not Encountered		1	1.0		SW	**SAND**: fine to coarse grained, brown mottled pale yellow, trace rootlets.	M	L		**TOP SOIL/FILL**
								SAND: fine to coarse grained, grey brown.				**ALLUVIUM**
							Cl	**Sandy CLAY**: low plasticity, grey brown, fine to coarse sand.	<Wp	S		
				0	2.0			Borehole BRO-C-BH4 terminated at 1.0 m Target depth				
				-1	3.0							
				-2	4.0							
				-3	5.0							
				-4	6.0							
				-5	7.0							
				-6								

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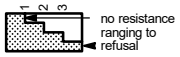
method
- DT diatube
- AD auger drilling*
- AS auger screwing*
- HA hand auger
- W washbore
- RR rock roller

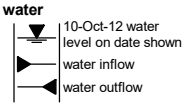
* bit shown by suffix, e.g. AD/T
- B blank bit
- T TC bit
- V V bit

support
- M mud
- C casing
- N nil

penetration



water



samples & field tests
- B bulk disturbed sample
- D disturbed sample
- E environmental sample
- SS split spoon sample
- U## undisturbed sample ##mm diameter
- HP hand penetrometer (kPa)
- N standard penetration test (SPT)
- N* SPT - sample recovered
- Nc SPT with solid cone
- VS vane shear; peak/remouded (kPa)
- R refusal
- HB hammer bouncing

soil group symbol & material description
based on AS 1726:2017

moisture condition
- D dry
- M moist
- W wet
- Wp plastic limit
- Wl liquid limit

consistency / relative density

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

APPENDIX D: BOREHOLE LOGS FROM PREVIOUS GEOTECHNICAL INVESTIGATION (DOUGLAS PARTNERS)

BOREHOLE LOG

CLIENT: NSW Department of Education
PROJECT: Proposed Schools Flood Recovery
LOCATION: Broadwater Public School

SURFACE LEVEL: 2.1 AHD
EASTING: 542593
NORTHING: 6791620
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 216628.00
DATE: 22/9/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 100mm)
2.0	0.1	TOPSOIL/FILL/Silty SAND (SM): fine sand, dark brown, moist, appeared poorly compacted							
	0.5	Silty SAND (SM): fine sand, grey, moist, loose, alluvial							
	0.9	CLAY (CH): high plasticity, brown with grey, w>PL, firm, alluvial							
1.0		- grey with orange							
	1.6				1.5				
	1.9	Sandy CLAY (CI); medium plasticity, grey, trace fine gravel and sand, w>PL, very moist, firm, alluvial		S			2,2,2 N = 4		
0.0		Silty SAND (SM): fine sand, grey with orange, wet, loose, alluvial			1.95			▼	
	2.4	- dark grey							
-1.0	3.0	- grey-brown		S	3.0		2,2,1 N = 3		
					3.45				
-2.0	4.5	- medium dense		S	4.5		2,4,6 N = 10		
					4.95				
-3.0	5.1	- brown							
	5.6	Sandy CLAY (CI): medium plasticity, grey with orange, w>PL, stiff, residual			6.0				
-4.0	6.2	- w<PL, very stiff		S			5,11,14 N = 25		
	6.45	Bore discontinued at 6.45m. Limit of Investigation			6.45				

RIG: Christie Soil Rig **DRILLER:** Geoserve **LOGGED:** MM/AB **CASING:** Uncased

TYPE OF BORING: Auger

WATER OBSERVATIONS: No free groundwater encountered during investigation

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: NSW Department of Education
PROJECT: Proposed Schools Flood Recovery
LOCATION: Broadwater Public School

SURFACE LEVEL: 2.2 AHD
EASTING: 542589
NORTHING: 6791633
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 216628.00
DATE: 21/9/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 100mm)
	0.1	TOPSOIL/FILL/Silty SAND (SM): fine sand, dark brown, moist, appeared poorly compacted							
	0.5	FILL/Silty SAND (SM): fine sand, dark brown, trace fine to coarse gravel, moist, appeared poorly compacted							
		CLAY (CH): high plasticity, brown with grey, w>PL, firm, alluvial							
	1.0	- grey with orange		S	1.0		2,3,4 N = 7		
					1.45				
	1.9	Sandy CLAY (CI): medium plasticity, grey with orange, fine sand, w>PL, very moist, firm, alluvial						▼	
	2.1	- dark grey, w<LL, wet							
	2.5	Silty SAND (SM): fine sand, dark grey, wet, very loose, alluvial		S	2.5		1,0,1 N = 1		
					2.95				
	3.5	- grey-brown, loose							
				S	4.0		1,2,3 N = 5		
					4.45				
	5.1	- medium dense							
				S	5.5		4,6,10 N = 16		
	5.9	Sandy CLAY (CL): low plasticity, grey with orange, fine sand, w>PL, very stiff, residual			5.95				
	6.5	Bore discontinued at 6.5m. Limit of Investigation							

RIG: Christie Soil Rig **DRILLER:** Geoserve **LOGGED:** MM/AB **CASING:** Uncased

TYPE OF BORING: Auger

WATER OBSERVATIONS: Free groundwater observed at 2.1 m during investigation

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: NSW Department of Education
PROJECT: Proposed Schools Flood Recovery
LOCATION: Broadwater Public School

SURFACE LEVEL: 2.2 AHD
EASTING: 542596
NORTHING: 6791656
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 216628.00
DATE: 21/9/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 100mm)
2	0.1	TOPSOIL/FILL/Silty SAND (SM): fine sand, dark brown, moist, appeared poorly compacted							
	0.2	Silty SAND (SM): fine sand, brown, moist, loose, alluvial							
	0.5	- dark brown, medium dense							
1	1.0	CLAY (CH): high plasticity, brown with grey, w>PL, firm, alluvial							
		- grey with orange		S	1.0		2,3,4 N = 7		
					1.45				
	1.7	- very moist						▼	
0	2.5	- dark grey, wet, w<LL, very soft		S	2.5		0,0,0 N = 0		
	2.9	Sandy CLAY (CL): low plasticity, dark grey, fine sand, w<LL, very soft, alluvial			2.95				
-1	3.2	Silty SAND (SM): fine sand, grey, wet, very loose, alluvial							
	3.9	- grey-brown		S	4.0		0,1,2 N = 3		
-2					4.45				
	4.6	- medium dense							
-3				S	5.5		4,5,5 N = 10		
					5.95				
-4									
-5									
-6									
-7	7.0	Bore discontinued at 7.0m. Limit of Investigation							

RIG: Christie Soil Rig **DRILLER:** Geoserve **LOGGED:** MM/AB **CASING:** Uncased

TYPE OF BORING: Auger

WATER OBSERVATIONS: Free groundwater observed at 2.3 m during investigation

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: NSW Department of Education
PROJECT: Proposed Schools Flood Recovery
LOCATION: Broadwater Public School

SURFACE LEVEL: 2.8 AHD
EASTING: 542542
NORTHING: 6791618
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 216628.00
DATE: 21/9/2022
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 100mm)
	0.1	TOPSOIL/FILL/Silty SAND (SM): fine sand, dark brown, moist, appeared poorly compacted							
	0.4	FILL/Silty SAND (SM): fine sand, brown, moist, appeared poorly compacted							
	0.8	CLAY (CH): high plasticity, brown with grey, w>PL, stiff, large tree roots in clay, alluvial		D	0.7				
	1.2	Sandy CLAY (CI): medium plasticity, orange with grey, fine sand, w>PL, stiff, residual			1.0				
		- pale grey with orange, w<PL, very stiff		S	1.5		8,16,30/30mm		
	1.83	Bore discontinued at 1.83m. Refusal on inferred very low strength (or stronger) rock. Limit of Investigation			1.83				

RIG: Christie Soil Rig **DRILLER:** Geoserve **LOGGED:** MM/AB **CASING:** Uncased

TYPE OF BORING: Auger

WATER OBSERVATIONS: No free groundwater encountered during investigation

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

APPENDIX E: LABORATORY TESTING RESULTS

CERTIFICATE OF ANALYSIS

Work Order	: **EB2320992**	Page	: 1 of 7
Client	: **TETRA TECH COFFEY PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: Viet Nguyen	Contact	: Khaleda Ataei
Address	: Level 3, 101 Sussex Street Sydney	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: + 61 2 8784 8555
Project	: NRSC 754-SYDGE319200	Date Samples Received	: 11-Jul-2023 23:47
Order number	: ----	Date Analysis Commenced	: 12-Jul-2023
C-O-C number	: ----	Issue Date	: 17-Jul-2023 16:45
Sampler	: RUBY FRITZ, WILL SHU		
Site	:		
Quote number	: EN/222		
No. of samples received	: 22		
No. of samples analysed	: 22		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Corrosion assessment for Concrete and Steel piles in soil per Australian Standard AS2159-2009 uses a combination of soil and groundwater data (Tables 6.4.2 C & 6.5.2 C). In the absence of groundwater data, assessment has been made against soil criteria only. Refer to AS2159-2009 section 6.4 for further interpretation of corrosion assessment. ALS is not NATA accredited for Corrosion Assessment comments
- EA167: Soil Condition A – High permeability soils (e.g. sands and gravels) which are in groundwater
- EA167: Soil Condition B – Low permeability soils (e.g. silts and clays) or all soils above groundwater

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Blakebrook C-BH1_0.8-1.25	Blakebrook C-BH1_3.8-4.25	Blakebrook C-BH2_0.8-1.25	Blakebrook C-BH2_5.3-5.75	Blakebrook C-BH3_3.8-4.25
			Sampling date / time	07-Jul-2023 00:00	07-Jul-2023 00:00	10-Jul-2023 00:00	10-Jul-2023 00:00	10-Jul-2023 00:00
Compound	CAS Number	LOR	Unit	EB2320992-001	EB2320992-002	EB2320992-003	EB2320992-004	EB2320992-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.3**	**5.1**	**5.3**	**5.2**	**4.5**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**10**	**23**	**10**	**15**	**142**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**29.9**	**37.6**	**29.9**	**40.9**	**36.4**
EA080: Resistivity								
Resistivity at 25°C	----	1	ohm cm	**100000**	**43500**	**100000**	**66700**	**7040**
EA167: Corrosion Classification (per AS2159-2009)								
Ø Exposure Classification - Concrete Piles Soil Condition A	----	-	-	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Severe**
Ø Exposure Classification - Concrete Piles Soil Condition B	----	-	-	**Mild**	**Mild**	**Mild**	**Mild**	**Moderate**
Ø Exposure Classification - Steel Piles Soil Condition A	----	-	-	**Non Aggressive**	**Non Aggressive**	**Non Aggressive**	**Non Aggressive**	**Mild**
Ø Exposure Classification - Steel Piles Soil Condition B	----	-	-	**Non Aggressive**	**Non Aggressive**	**Non Aggressive**	**Non Aggressive**	**Non Aggressive**
ED040S: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	**20**	<10	**20**	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**20**	**30**	**20**	**20**	**100**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Blakebrook C-BH3_8.3-8.75	Blakebrook C-BH4_3.8-4.25	Blakebrook C-BH4_6.8-7.25	Broadwater C-BH1_1.0-1.45	Broadwater C-BH1_5.3-5.75
			Sampling date / time	10-Jul-2023 00:00	07-Jul-2023 00:00	07-Jul-2023 00:00	03-Jul-2023 00:00	03-Jul-2023 00:00
Compound	CAS Number	LOR	Unit	EB2320992-006	EB2320992-007	EB2320992-008	EB2320992-009	EB2320992-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.4	5.1	6.1	5.4	4.2
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	22	19	14	42	52
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	39.8	36.0	31.1	35.3	17.5
EA080: Resistivity								
Resistivity at 25°C	----	1	ohm cm	45400	52600	71400	23800	19200
EA167: Corrosion Classification (per AS2159-2009)								
Ø Exposure Classification - Concrete Piles Soil Condition A	----	-	-	Moderate	Moderate	Mild	Moderate	Severe
Ø Exposure Classification - Concrete Piles Soil Condition B	----	-	-	Mild	Mild	Non Aggressive	Mild	Moderate
Ø Exposure Classification - Steel Piles Soil Condition A	----	-	-	Non Aggressive	Non Aggressive	Non Aggressive	Non Aggressive	Mild
Ø Exposure Classification - Steel Piles Soil Condition B	----	-	-	Non Aggressive	Non Aggressive	Non Aggressive	Non Aggressive	Non Aggressive
ED040S: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	20	20	20	60	90
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	30	20	10	20	20

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Broadwater C-BH2_3.8-4.00	Broadwater C-BH2_6.8-7.25	Empire Vale C-BH1_3.9-4.25	Empire Vale C-BH1_12.8-13.25	Empire Vale C-BH2_0.8-1.1
			Sampling date / time	03-Jul-2023 00:00	03-Jul-2023 00:00	05-Jul-2023 00:00	05-Jul-2023 00:00	06-Jul-2023 00:00
Compound	CAS Number	LOR	Unit	EB2320992-011	EB2320992-012	EB2320992-013	EB2320992-014	EB2320992-015
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	4.4	5.5	9.0	9.4	5.8
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	97	8	619	1080	567
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	18.5	19.4	40.5	36.5	30.8
EA080: Resistivity								
Resistivity at 25°C	----	1	ohm cm	10300	125000	1620	926	1760
EA167: Corrosion Classification (per AS2159-2009)								
Ø Exposure Classification - Concrete Piles Soil Condition A	----	-	-	Severe	Moderate	Mild	Mild	Mild
Ø Exposure Classification - Concrete Piles Soil Condition B	----	-	-	Moderate	Mild	Non Aggressive	Non Aggressive	Non Aggressive
Ø Exposure Classification - Steel Piles Soil Condition A	----	-	-	Mild	Non Aggressive	Moderate	Severe	Moderate
Ø Exposure Classification - Steel Piles Soil Condition B	----	-	-	Non Aggressive	Non Aggressive	Mild	Moderate	Mild
ED040S: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	210	20	210	170	380
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	<10	1190	2230	1040

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Empire Vale C-BH2_12.8-13.25	Wardell C-BH1_2.3-2.75	Wardell C-BH2_0.8-1.0	Wardell C-BH2_5.3-5.45	Wardel C-BH2_2.3-2.75m
			Sampling date / time	06-Jul-2023 00:00	04-Jul-2023 00:00	04-Jul-2023 00:00	04-Jul-2023 00:00	04-Jul-2023 00:00
Compound	CAS Number	LOR	Unit	EB2320992-016	EB2320992-017	EB2320992-019	EB2320992-020	EB2320992-021
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**9.3**	**4.9**	**5.5**	**6.5**	**4.8**
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1220**	**33**	**19**	**17**	**48**
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**39.0**	**20.0**	**11.8**	**22.2**	**20.7**
EA080: Resistivity								
Resistivity at 25°C	----	1	ohm cm	**820**	**30300**	**52600**	**58800**	**20800**
EA167: Corrosion Classification (per AS2159-2009)								
Ø Exposure Classification - Concrete Piles Soil Condition A	----	-	-	**Mild**	**Moderate**	**Moderate**	**Mild**	**Moderate**
Ø Exposure Classification - Concrete Piles Soil Condition B	----	-	-	**Non Aggressive**	**Mild**	**Mild**	**Non Aggressive**	**Mild**
Ø Exposure Classification - Steel Piles Soil Condition A	----	-	-	**Severe**	**Mild**	**Non Aggressive**	**Non Aggressive**	**Mild**
Ø Exposure Classification - Steel Piles Soil Condition B	----	-	-	**Moderate**	**Non Aggressive**	**Non Aggressive**	**Non Aggressive**	**Non Aggressive**
ED040S: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**170**	**80**	**30**	**30**	**120**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**2760**	<10	<10	**10**	<10

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Empire C-BH2_1.1-2.75m	Empire C-BH1_3.8-3.9m	----	----	----
			Sampling date / time	04-Jul-2023 00:00	04-Jul-2023 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB2320992-022	EB2320992-023	--------	--------	--------
				Result	Result	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.8**	**9.1**	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**455**	**648**	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	**30.5**	**35.2**	----	----	----
EA080: Resistivity								
Resistivity at 25°C	----	1	ohm cm	**2200**	**1540**	----	----	----
EA167: Corrosion Classification (per AS2159-2009)								
Ø Exposure Classification - Concrete Piles Soil Condition A	----	-	-	**Mild**	**Mild**	----	----	----
Ø Exposure Classification - Concrete Piles Soil Condition B	----	-	-	**Non Aggressive**	**Non Aggressive**	----	----	----
Ø Exposure Classification - Steel Piles Soil Condition A	----	-	-	**Mild**	**Moderate**	----	----	----
Ø Exposure Classification - Steel Piles Soil Condition B	----	-	-	**Non Aggressive**	**Mild**	----	----	----
ED040S: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**320**	**200**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**800**	**1240**	----	----	----

Brisbane Laboratory

Coffey Testing Pty Ltd
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Phone: +61 7 3569 8920

Material Test Report

Report No: BRIS23S-03746-1
Issue No: 1

Client: Tetra Tech Coffey Pty Ltd (Brisbane)
level 5, 12 Creek Street
Brisbane QLD 4000

Principal:
Project No.: TESTBRIS00394AA
Project Name: NRSC
Lot No.: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

Approved Signatory: Ben Herron
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 21/07/2023

Sample Details

Sample ID:	BRIS23S-03746
Date Sampled:	03/07/2023
Source:	On site
Material:	Clay
Specification:	No Specification
Sampling Method:	Submitted by client*
Project Location:	Broadwater, NSW
Sample Location:	BH2 2.3-2.75m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	70.0	
Date Tested		13/07/2023	

Comments

*Results relate only to the items tested or sampled.

Document Set ID: 1908309
Version: 1, Version Date: 26/02/2024

Brisbane Laboratory

Coffey Testing Pty Ltd
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Material Test Report

Report No: BRIS23S-03747-1
Issue No: 1

Client: Tetra Tech Coffey Pty Ltd (Brisbane)
level 5, 12 Creek Street
Brisbane QLD 4000

Principal:
Project No.: TESTBRIS00394AA
Project Name: NRSC
Lot No.: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

Approved Signatory: Ben Herron
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 21/07/2023

Sample Details

Sample ID: BRIS23S-03747
Date Sampled: 03/07/2023
Source: On site
Material: Clay
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: Broadwater, NSW
Sample Location: BH2
1.0-1.25m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	34.5	
Date Tested		12/07/2023	
Sample History	AS 1289.1.1	Oven-Dried	
Preparation	AS 1289.1.1	Dry-Sieved	
Linear Shrinkage (%)	AS 1289.3.4.1	19.0	
Mould Length (mm)		249.9	
Crumbling		No	
Curling		No	
Cracking		Yes	
Liquid Limit (%)	AS 1289.3.1.1	74	
Method		Four Point	
Plastic Limit (%)	AS 1289.3.2.1	28	
Plasticity Index (%)	AS 1289.3.3.1	46	
Date Tested		20/07/2023	

Comments

*Results relate only to the items tested or sampled.

Document Set ID: 1908309
Version: 1, Version Date: 26/02/2024

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Material Test Report

Report No: BRIS23S-03748-1
Issue No: 1

Client: Tetra Tech Coffey Pty Ltd (Brisbane)
level 5, 12 Creek Street
Brisbane QLD 4000

Principal:
Project No.: TESTBRIS00394AA
Project Name: NRSC
Lot No.: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

Approved Signatory: Ben Herron
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 21/07/2023

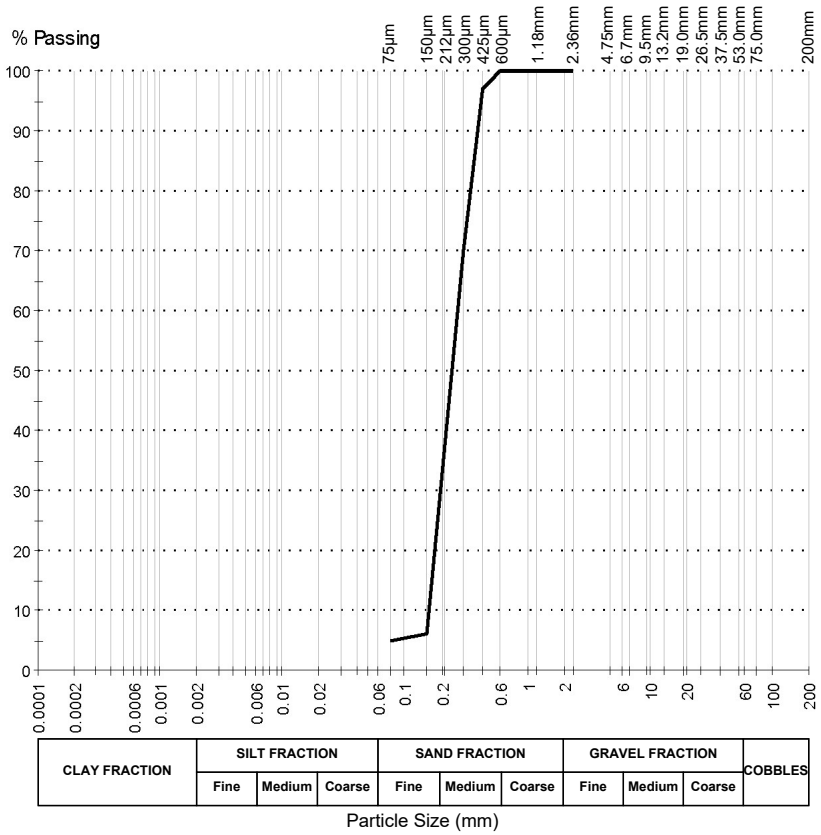
Sample Details

Sample ID: BRIS23S-03748
Date Sampled: 03/07/2023
Source: On site
Material: In Situ
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: Broadwater, NSW
Sample Location: BH2
5.3-5.75m

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying By: Oven
Date Tested: 19/07/2023

Note: Sample Washed

Sieve Size	% Passing	Limits
2.36mm	100	
1.18mm	100	
600µm	100	
425µm	97	
300µm	70	
150µm	6	
75µm	5	

Comments

*Results relate only to the items tested or sampled.

Document Set ID: 1908309
Version: 1, Version Date: 26/02/2024

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Report No: BRIS23S-03763-1
Issue No: 1

Material Test Report

Client: Tetra Tech Coffey Pty Ltd (Brisbane)
level 5, 12 Creek Street
Brisbane QLD 4000

Principal:
Project No.: TESTBRIS00394AA
Project Name: NRSC
Lot No.: **TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

Approved Signatory: Ben Herron
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 21/07/2023

Sample Details

Sample ID: BRIS23S-03763
Date Sampled: 03/07/2023
Source: On site
Material: Silty Sand
Specification: No Specification
Sampling Method: Submitted by client*
Project Location: Broadwater, NSW
Sample Location: BH1
6.8-7.25m

Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	20.2	
Date Tested		12/07/2023	

Comments

*Results relate only to the items tested or sampled.

Document Set ID: 1908309
Version: 1, Version Date: 26/02/2024

Brisbane Laboratory

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Material Test Report

Report No: BRIS23S-03749-1
Issue No: 1

Client:	Tetra Tech Coffey Pty Ltd (Brisbane) level 5, 12 Creek Street Brisbane QLD 4000
Principal:	
Project No.:	TESTBRIS00394AA
Project Name:	NRSC
Lot No.:	**TRN:**

Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

Approved Signatory: Warren O'Connor
(General Manager - Southern Queensland Region)
NATA Accredited Laboratory Number:431
Date of Issue: 28/07/2023

Sample Details

Sample ID:	BRIS23S-03749
Date Sampled:	03/07/2023
Source:	On site
Material:	In Situ
Specification:	No Specification
Sampling Method:	Submitted by client*
Project Location:	Broadwater, NSW
Sample Location:	BH1 0.5-1.0m

Other Test Results

Description	Method	Result	Limits
Moisture Content (%)	AS 1289.2.1.1	22.9	
Date Tested		21/07/2023	
Standard MDD (t/m³)	AS 1289.5.1.1	**1.52**	
Standard OMC (%)		**25.0**	
Retained Sieve (mm)		19	
Oversize Material (%)		0	
Curing Time (h)		44	
Date Tested		21/07/2023	
CBR at 5.0mm (%)	AS 1289.6.1.1	**3.0**	
Dry Density before Soaking (t/m³)		1.52	
Density Ratio before Soaking (%)		100.0	
Moisture Content before Soaking (%)		25.3	
Moisture Ratio before Soaking (%)		100.5	
Dry Density after Soaking (t/m³)		1.54	
Density Ratio after Soaking (%)		101.5	
Swell (%)		-1.0	
Moisture Content of Top 30mm (%)		22.5	
Moisture Content of Remaining Depth (%)		22.4	
Compaction Hammer Used		Standard	
Surcharge Mass (kg)		4.50	
Period of Soaking (Days)		4	
Retained on 19 mm Sieve (%)		0	
CBR Moisture Content Method		AS 1289.2.1.1	
Sample Curing Time (h)		48	
Plasticity Method		Visual/Tactile Assessment	
Sample Moisture Content		AS 1289.2.1.1	
Date Tested		23/07/2023	

Particle Size Distribution

Chart

Comments

*Results relate only to the items tested or sampled.

Document Set ID: 1908309
Version: 1, Version Date: 26/02/2024

Brisbane Laboratory

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California Bearing Ratio Test Report

Report No: CBR:BRIS23S-03749
Issue No: 1

Client:	Tetra Tech Coffey Pty Ltd (Brisbane) level 5, 12 Creek Street Brisbane QLD 4000
Principal:	
Project No.:	TESTBRIS00394AA
Project Name:	NRSC
Lot No.:	**TRN:**

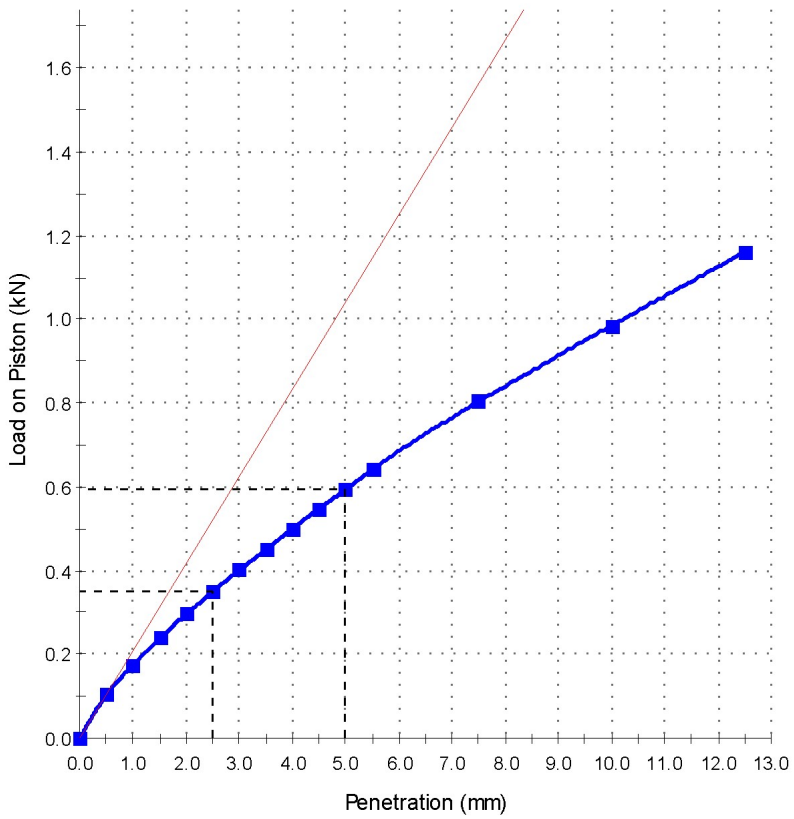
Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

Approved Signatory: Warren O'Connor
(General Manager - Southern Queensland Region)
NATA Accredited Laboratory Number:431
Date of Issue: 28/07/2023

Sample Details

Sample ID:	BRIS23S-03749	**Sampling Method:**	Submitted by client*
Client ID:		**Material:**	In Situ
Date Sampled:	3/07/2023	**Source:**	On site
Date Submitted:	11/07/2023	**Specification:**	No Specification
Date Tested:	23/07/2023		
Project Location:	Broadwater, NSW		
Sample Location:	BH1, 0.5-1.0m		

Load vs Penetration



Test Results

	AS 1289.6.1.1
CBR at 5.0mm (%):	**3.0**
Dry Density before Soaking (t/m³):	1.52
Density Ratio before Soaking (%):	100.0
Moisture Content before Soaking (%):	25.3
Moisture Ratio before Soaking (%):	100.5
Dry Density after Soaking (t/m³):	1.54
Density Ratio after Soaking (%):	101.5
Swell (%):	-1.0
Moisture Content of Top 30mm (%):	22.5
Moisture Content of Remaining Depth (%):	22.4
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	48
Plasticity Determination Method:	Visual/Tactile

Comments

Document Set ID: 1908309
Version: 1, Version Date: 26/02/2024

Brisbane Laboratory

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California Bearing Ratio Test Report

Report No: CBR:BRIS23S-03750
Issue No: 1

Client:	Tetra Tech Coffey Pty Ltd (Brisbane) level 5, 12 Creek Street Brisbane QLD 4000
Principal:	
Project No.:	TESTBRIS00394AA
Project Name:	NRSC
Lot No.:	**TRN:**

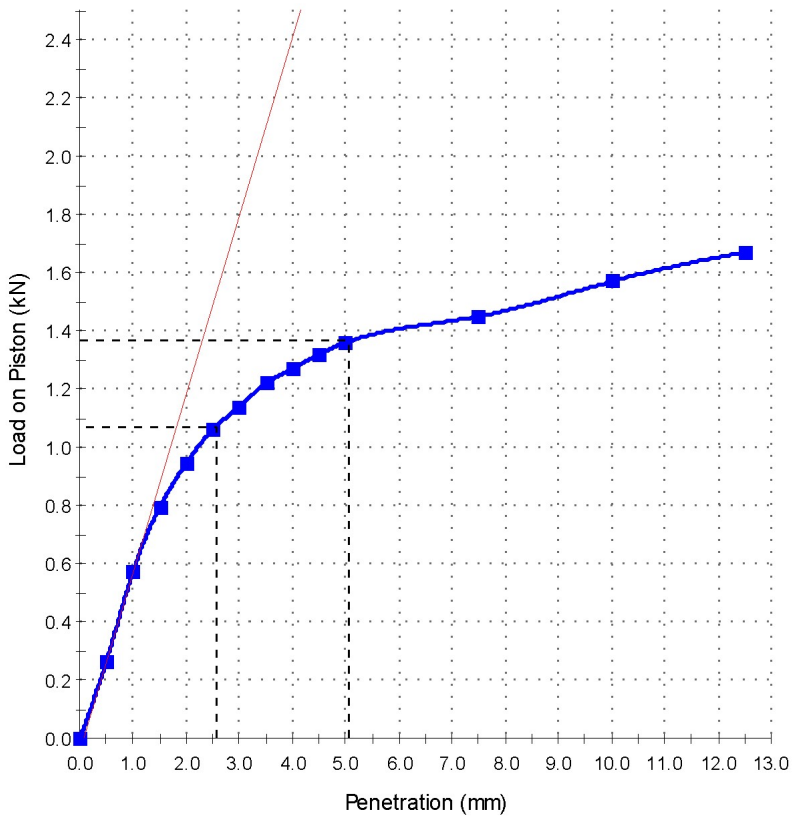
Accredited for compliance with ISO/IEC 17025 - Testing. NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates

Approved Signatory: Warren O'Connor
(General Manager - Southern Queensland Region)
NATA Accredited Laboratory Number:431
Date of Issue: 28/07/2023

Sample Details

Sample ID:	BRIS23S-03750	**Sampling Method:**	Submitted by client*
Client ID:		**Material:**	In Situ
Date Sampled:	3/07/2023	**Source:**	On site
Date Submitted:	11/07/2023	**Specification:**	No Specification
Date Tested:	23/07/2023		
Project Location:	Broadwater, NSW		
Sample Location:	BH2, 0.5-1.0m		

Load vs Penetration



Test Results

	AS 1289.6.1.1
CBR at 2.5mm (%):	**8**
Dry Density before Soaking (t/m³):	1.37
Density Ratio before Soaking (%):	101.0
Moisture Content before Soaking (%):	33.3
Moisture Ratio before Soaking (%):	99.5
Dry Density after Soaking (t/m³):	1.38
Density Ratio after Soaking (%):	101.5
Swell (%):	-0.5
Moisture Content of Top 30mm (%):	33.6
Moisture Content of Remaining Depth (%):	31.3
Compaction Hammer Used:	Standard AS 1289.5.1.1
Surcharge Mass (kg):	4.50
Period of Soaking (Days):	4
Retained on 19 mm Sieve (%):	0
CBR Moisture Content Method:	AS 1289.2.1.1
Sample Curing Time (h):	24
Plasticity Determination Method:	Visual/Tactile

Comments

Document Set ID: 1908309
Version: 1, Version Date: 26/02/2024