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Report on
Geotechnical Investigation

Proposed Gungahlin Tennis Facility
Part Block 4 Section 109, Amaroo

Prepared for
Stantec Australia Pty Ltd

Project 220131.00
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1. Introduction

This report presents the results of a geotechnical investigation undertaken for the proposed Gungahlin Tennis Facility at Part Block 4 Section 109, Amaroo. The investigation was commissioned in an email dated 28 March 2023 by Faraz Khan of Stantec Australia Pty Ltd and was undertaken in accordance with Douglas Partners' proposal 220131.00.P.001.Rev0 dated 30 January 2023.

It is understood that the proposed development of the site includes an access road extension from Amaroo Playing Fields, a bridge crossing, car parking, a pavilion, ten (10) full sized tennis courts and two (2) smaller “hot shot” courts.

It is further understood that a preliminary geotechnical investigation was completed by Cardno Pty Ltd in October 2018 (Cardno, 2018) for concept design purposes, which covered the tennis facilities area of the block only.

As part of preparations for a detailed design, a geotechnical investigation was required for the proposed tennis facility and access road (and bridge) to the proposed site, on the block. The aim of the investigation was to assess the subsurface soil and groundwater conditions at the investigation locations to provide comments on:

- The presence and thickness of uncontrolled fill;
- Depth to the underlying rock (if encountered);
- Site classification;
- Site preparation measures and earthworks;
- Excavation conditions;
- Pavement design parameters for access roadway and car parking;
- Retaining wall design parameters;
- The performance of suitable foundation systems and likely allowable bearing pressures for both the pavilion and bridge/culvert structures;
- Soil aggressivity; and
- Possible geotechnical constraints and risk mitigation measures.

The investigation included the excavation of fifteen (15) test pits, the drilling of two (2) boreholes and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the items listed above.

This report must be read in conjunction with the notes “About this Report” which are included in Appendix A.

2. Proposed Development

A new development that is to be known as Gungahlin Tennis Facility is proposed in the northern portion of Amaroo Block 4 Section 109. The proposed development includes an access road extension from Amaroo Playing Fields, car parking, a bridge crossing over a tributary creek of Ginninderra Creek, an overflow carpark, ten (10) full sized courts, two (2) smaller "hot shots" courts, a hitting wall, LED flood lighting, car parking and a pavilion.

The proposed site development is separated into two portions (north and south) by a proposed bridge in the middle. The northern portion of the site generally falls from the east to the west, and the southern portion of the site generally falls from southeast to northwest towards Ginninderra Creek.

It is understood that the northern portion of the proposed site is located in a flood catchment area, which is sacrificial to a 20-year flooding event and inundation of Ginninderra Creek is expected. Based on the current preliminary design, the site will be subject to ~0.4 m fill and ~0.9 m cut (up to ~0.7 m cut in tennis court area) to achieve the design levels. The proposed tennis courts and car parks (including access road) will be surfaced with flexible pavement of 400 mm and 300 mm total thickness respectively. The overall proposed development is shown on Drawing 1 and existing site contours and design levels are shown on Drawings 2 and 3 all located in Appendix B.

3. Previous Investigation

A previous geotechnical investigation has been undertaken by Cardno (NSW/ACT) Pty Ltd in September 2018 (Cardno, 2018) within the proposed tennis court, pavilion and car parking areas. The investigation comprised the excavation of 8 test pits (Pits TP1 – TP8) to depths of 1.5 – 2.5 m using a 6-tonne excavator fitted with a 450 mm wide toothed bucket. The approximate test locations are shown on Drawing 1 in Appendix B. The investigation report is included in Appendix C. The investigation results are summarised below:

- TOPSOIL: generally low to medium sandy clay and silty sand topsoil to depths of 0.3 – 0.5 m;
- ALLUVIUM: generally medium plasticity sandy clay, silty clay, gravelly clay and clayey silt, firm to hard, below the topsoil to depths of 1.4 – 2.2 m. Pits TP1, TP5, TP6 and TP8 terminated in this stratum at the target depths of 2.0 – 2.2 m;
- SILTSTONE: generally medium strength siltstone rock underlying alluvium in Pits TP2, TP3, TP4 and TP7 from depths of 1.4 – 2.1 m to target depth/refusal depths of 1.5 – 2.2 m.

Groundwater seepages (variably slow to fast inflow) were observed in all the pits except TP7 at depths of 1.4 – 2.1 m.

4. Site Description

The overall site is located in a low-lying area in the northern portion of Block 4 Section 109 in Amaroo. The proposed site development is separated into two portions (north and south) by a proposed bridge in the middle. The northern portion of the site generally falls from the east to the west, and the southern portion of the site generally falls from southeast to northwest towards Ginninderra Creek.

At the time of the site investigation, the northern portion of the site (where new tennis courts, pavilion and car parking are proposed) was surrounded by Ginninderra Creek and its tributary creek lines in the north, west and south directions. The site was heavily grass vegetated with sporadic trees located in the middle of the proposed site, as well as long the eastern boundary. The site was bounded immediately to the north by a water quality pond then Bernard Heinze Avenue, immediately to the west by Ginninderra Creek then Jorgensen Street, immediately to the south by a tributary creek line of Ginninderra Creek and to the east by Horse Park Drive, which was located on a road embankment up to ~2 m in height. A sewer easement is aligned through the middle of the north portion of the site (to the west of the proposed Pavilion) in a northeast-southwest direction, and a secondary sewer line runs from the main sewer line to the northwest, along the proposed car parking at the southwestern corner of the northern portion of the site. A number of sewer manholes were present on site. A wired fence was observed on site running parallel to the sewer main in approximately 15 m distance to the west.

The southern portion of the site (where the access road extension and overflow carpark are proposed) was located in an open space to the north of the existing Amaroo Playing Fields, with concrete paved Bicentennial National Trail running in a southwest-east direction within the open space. A tributary creek of Ginninderra Creek was located to the north of the Bicentennial National Trail running in an east-west direction, which connected to a stone pitched drain towards Horse Park Drive. The proposed access road area was generally grass vegetated with trees along the Bicentennial National Trail. The proposed overflow car parking area was moderately to heavily grass vegetated, with tufts of sedge grasses which is generally indicative of water logged or previously water logged soil.

Figures 1 – 5 below show the general site conditions at the time of service locating and site investigations.

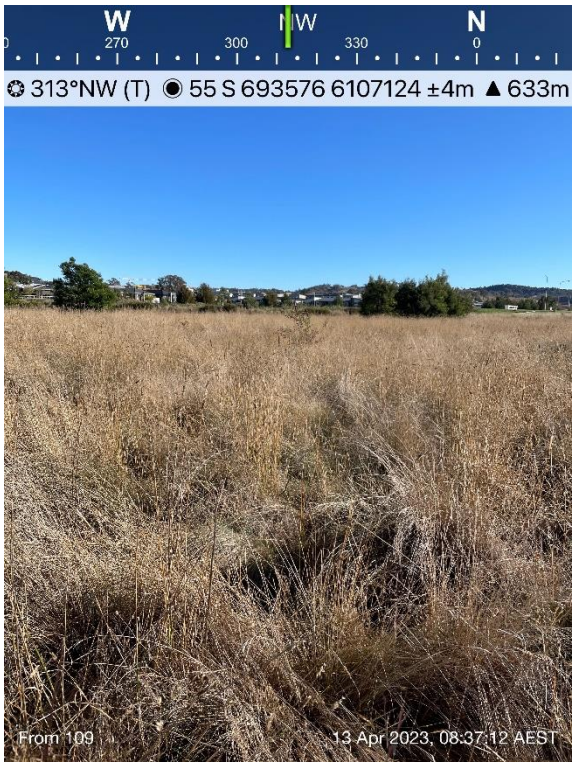

Figure 1: General view of the northern portion of the site from Pit 109 towards Jorgensen Street.

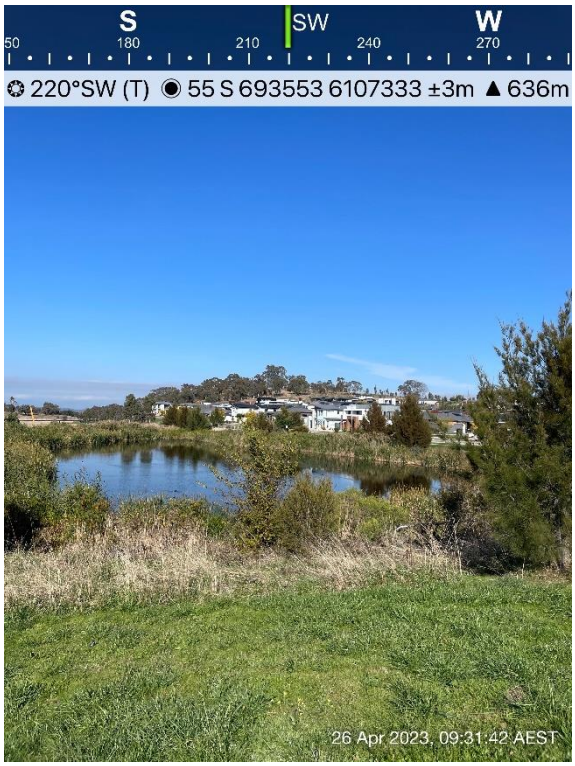

Figure 2: View of a water quality pond located to the northwest of the proposed site.

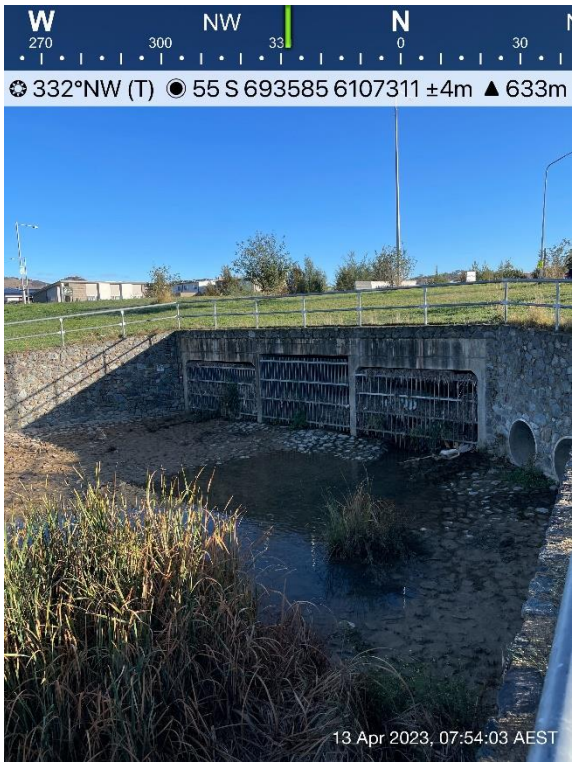

Figure 3: Stone pitched culvert drain located at the southwestern corner of the intersection of Horse Park Drive and Bernard Heinze Avenue.

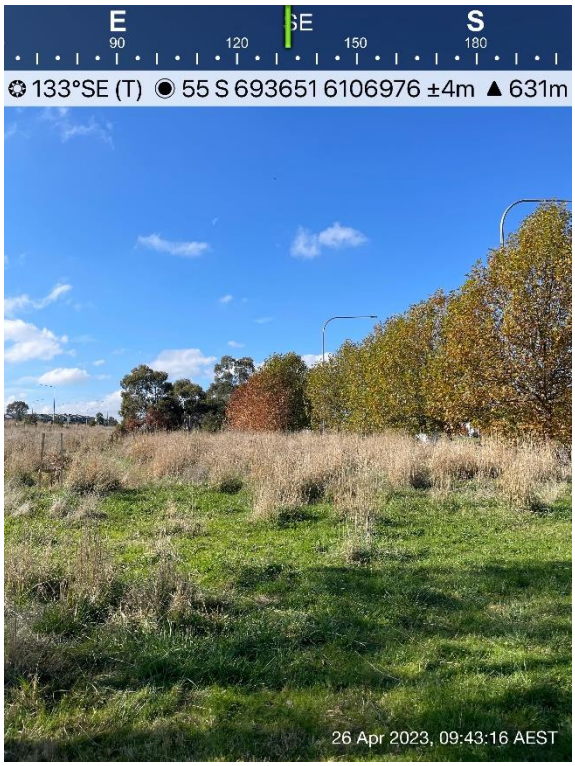

Figure 4: General view of the proposed overflow car parking area from the southern end of the proposed access road.

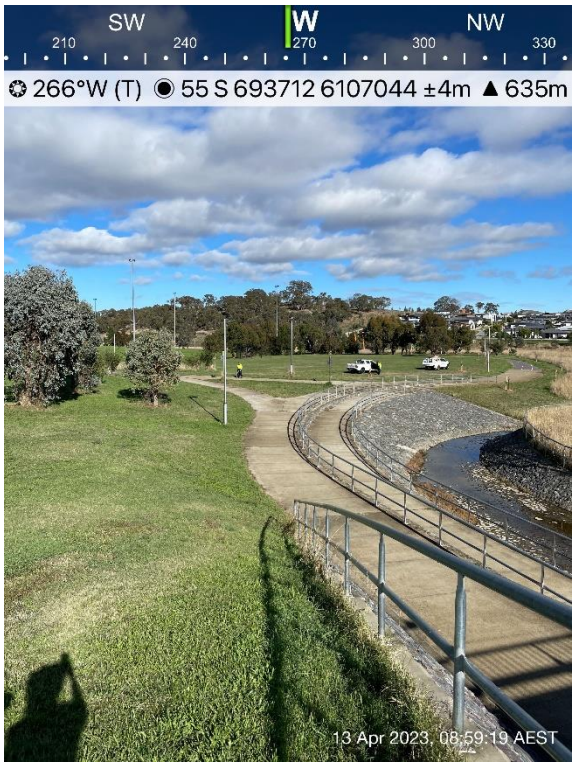

Figure 5: General view of the southern portion of the site, from the eastern end of the Bicentennial National Trail with a rock pitching drain.

5. Regional Geology

BMR (1992) indicates that the site is underlain by rock units of the Canberra Formation, which typically comprises mudstone, siltstone, minor sandstone, limestone, hornfels, dacitic ignimbrite volcaniclastics, minor agglomerate and lithic tuff.

The geotechnical investigation has confirmed the presence of siltstone underlying the site.

6. Field Work

6.1 Field Work Methods

The field work comprises the excavation of fifteen (15) test pits (Pits 101 – 115) and drilling of two (2) boreholes (Bores 201 and 202). The test pits and boreholes were logged on site by a geotechnical engineer who also collected disturbed and bulk samples to assist in strata identification and for laboratory testing.

Fifteen (15) test pits (Pits 101 – 115) were excavated using a CAT 306 CR mini-excavator (~ 7 tonne) fitted with a 450 mm wide toothed bucket to the limit of investigation/refusal depths of 1.0 – 3.0 m. Dynamic cone penetrometer (DCP) tests (AS 1289 6.3.2:1997) were also undertaken from the surface adjacent to each test pit location to provide an indication of the in-situ strength profile of the upper ~1 m of the site soils.

Two (2) boreholes (Bores 201 and 202) were drilled using a Hanjin D&B 8D tracked drilling rig. The boreholes were drilled through overburden soils using 110 mm diameter solid flight augers into the top of weathered rock to depths of 2.6 and 1.4 m respectively, then continued in the weathered rock using NMLC diamond core drilling equipment to the limit of investigation depths of 6.3 and 5.1 m, respectively.

Standard penetration tests (SPT's, AS 1289.6.3.1:1997) were carried out from 1.0 m depth then nominally at 1.5 m test depth intervals to provide information on the strength of the overburden soils and samples for logging purposes. The SPT procedure is given in the notes included in Appendix D and the penetration N values are shown on the borehole logs.

The recovered core samples were photographed prior to point load strength index testing being undertaken by the geotechnical engineer.

The approximate test location coordinates and surface levels provided on each log were determined on site using a Emlid Reach RS2 dGPS and are accurate to ± 0.5 m.

The approximate test locations and site boundary are shown on Drawing 1 in Appendix B.

6.2 Field Work Results

The subsurface conditions encountered at the test locations are summarised below. The test pits and borehole logs are given in Appendix D together with notes that define classification methods and descriptive terms.

- TOPSOIL FILL: generally low plasticity silty clay topsoil fill in Pits 106, 114 and 115 to depths of 0.15 – 0.25 m;
- FILL: variably low plasticity to medium/high plasticity clayey fill below topsoil fill in Pits 106, 114 and 115 to depths of 0.3 – 0.6 m;
- TOPSOIL: generally low plasticity silty clay or sandy clay topsoil from surface to 0.15 – 0.3 m depth at all test locations except Pits 106, 114 and 115. In Pit 106, low plasticity clayey silt topsoil was encountered from 0.3 – 0.6 m depth below the fill materials;
- NATURAL SOILS: soft to hard, low to high plasticity clayey material with various amounts of sand, gravel and silt, and medium dense to very dense sandy gravel/silty gravel/silty sand in all testing locations from depths of 0.15 – 0.6 m to depths of 1.0 – 2.6 m. Pits 102 – 104, 107, 109, 110 – 114 terminated in this stratum at the limit of investigation depths of 1.0 – 2.2 m. It should be noted that soft, wet sandy gravelly clay was encountered in Pit 104 from 1.9 m depth due to the groundwater seepages.
- WEATHERED ROCK: within the test pits, generally very low strength to medium strength, highly weathered to moderately weathered siltstone rock in Pits 101, 105, 106, 110 and 115 from depths of 0.7 – 2.3 m to the limit of investigation / refusal depths of 1.1 – 3.0 m; and within the boreholes, variably low to medium strength to high strength siltstone rock in Boreholes 201 and 202 from depths of 2.6 and 1.4 m to the limit of investigation depths of 6.3 and 5.1 m respectively.

Groundwater seepages were observed during the excavation of Pits 101 and 104 – 107 at depths of 1.2 – 2.3 m, and during the augering of Bore 201 at 2.0 m depth. No free groundwater was observed at the other testing locations. However, the immediate backfill of test pits after excavation and the use of rotary drilling equipment and water as a drilling fluid during core drilling precluded longer term monitoring of groundwater levels. Furthermore, it is noted that groundwater conditions rarely remain constant and can change seasonally due to variations in rainfall, temperature and soil permeability. For these reasons, it is noted that the moisture condition of the site soils may vary considerably from the time of the investigation compared to at the time of construction.

7. Laboratory Testing

Laboratory testing was performed on selected samples, and comprised the following:

- Four (4) Atterberg limits and linear shrinkage tests;
- Four (4) particle size distribution tests (coarse);
- Four (4) California bearing ratio (CBR) tests;
- Four (4) Emerson Crumb tests;
- Seven (7) field moisture contents; and

- 10 pH, chloride and sulfate content (aggressivity) tests.

The results of the laboratory testing are provided in detail in the test report sheets in Appendix E and are summarised in Sections 7.1 and 7.2 below. Chemical testing (pH, chloride and sulfate) was carried out by Envirolab Services Pty Ltd.

7.1 Mechanical Laboratory Testing

The plasticity testing confirms the logging of clay soils ranging from low (LL <35%) to high (LL >50%).

Table 1: Results of Laboratory Testing - Atterberg Limits, Linear Shrinkage and Grading (Coarse)

Pit No.	Depth (m)	Description	FMC (%)	LL (%)	PL (%)	PI (%)	LS (%)	Gravel (%)	Sand (%)	Silt and clay (%)
103	0.4 - 0.6	Clay	27.6	62	22	40	9.5	0	2	98
106	1.0	Silty Clay	15.4	48	22	26	10.5	2	2	96
107	1.0	Silty Clay	10.3	38	20	18	9.0	5	6	89
110	1.0	Silty Clay	11.3	32	19	13	7.5	19	26	55

Notes to table
FMC - Field Moisture Content
LL - Liquid Limit
PL - Plastic Limit
PI - Plasticity Index
LS - Linear Shrinkage

The CBR samples tested were compacted to about 100% modified maximum dry density ratio at close to optimum moisture content and soaked for four days under a surcharge loading of 4.5kg. The CBR test results indicated that the samples tested were 0.8 – 3.6% dry of OMC.

Table 2: Results of Laboratory Testing – CBR, Standard Compaction and Emerson Crumb Tests

Pit No.	Depth (m)	Description	FMC (%)	OMC (%)	SMDD (t/m^3)	CBR (%)	Swell During Soaking Phase (%)	Emerson Class No
103	0.4 - 0.6	Clay	27.6	29.5	1.48	1.0	0.5	4 *
110	0.4 - 0.6	Silty Clay	10.4	14.0	1.89	10	0.5	4 *
112	0.4 - 0.6	Silty Clay	13.3	16.5	1.79	6	1.0	4 *
114	0.4 - 0.6	Fill/Sandy Gravelly Clay	14.2	15.0	1.87	10	0.5	4 *

Notes to table
FMC - Field Moisture Content
OMC - Optimum Moisture Content (Standard)
SMDD - Maximum Dry Density (Standard)
CBR - California Bearing Ratio`
Emerson Class No (AS 1289.3.8.1)
* Carbonate and Gypsum mineral present

Selected samples of the rock core were tested for measurement of point load strength index ($Is_{[50]}$). The results are given on the borehole logs and indicate $Is_{[50]}$ values in the range 0.52 – 2.5 MPa reflecting medium to high strength of the rock. These values equate to uniaxial compressive strengths (UCS) of 10.4 – 50 MPa, adopting a correlation factor of 20.

7.2 Chemical Laboratory Testing

Table 3: Results of pH, Chloride and Sulfate Testing

Bore No.	Depth (m)	Material	pH	Chloride (mg/kg)	Sulfate, as SO^4 (mg/kg)	Electrical Conductivity* (µS/cm)	Resistivity (2) (ohm.cm)
201	2.0	Gravelly Sandy Clay	8.2	<10	10	30	33,333
201	3.1 – 3.2	Siltstone	9.0	<10	10	85	11,765
202	1.7 – 1.85	Siltstone	8.7	<10	<10	13	76,923
Criteria for "Non-aggressive" Soil Conditions (low permeability soils or soils above the groundwater table) (1)			>5.5 (concrete) >5.0 (steel)	<5,000 (steel)	<5,000 (concrete)	-	>5,000 (steel)

Note: *EC in 1:5 soil:water solution
(1) In accordance with AS 2159:2009
(2) Resistivity (ohm.cm) is the inverse of Electrical Conductivity (S/cm)

The results of the aggressivity testing indicate that based on the low permeability soils above the water table the exposure classification for concrete and steel piles is *Non-Aggressive*.

8. Comments

8.1 General

It must be recognised that the proposed Gungahlin Tennis Facility is located within a flood catchment area with highly variable soil deposits underlying the site. These site soils are variably low to high plasticity, with extensive groundwater seepages particularly in close proximity to the creek lines. Should periods of high rainfall precede construction, it must be expected that the subsurface moisture conditions would be extremely challenging. Design of the development must therefore take into consideration the potential for adverse soil and water conditions with contingency planning to address these conditions. It would be necessary to install permanent groundwater control measures early in site works to cut-off groundwater seepages and protect future works.

Further, to reduce the risk of construction delays due to wet subgrade soils, significant over-excavation of wet soils is likely to be required and construction haul roads may be required to be elevated above design levels, particularly in the low-lying areas of the western end of the site near Ginninderra Creek.

8.2 Geotechnical Constraints

Based on the proposed development details, the site investigation and the laboratory testing, the following are considered to be the main geotechnical considerations for the development, pending prior weathered conditions:

- Constructability: The proposed tennis courts are located in a low-lying area and surrounded by creek lines in the north, west and south directions. Due to the presence of the groundwater seepages, water softened soils and the variation of the subsurface conditions, it would be prudent to construct the tennis courts, pavilion and car parks (northern portion of the site) on an elevated pad of low plasticity granular fill (preferably weathered rock). This would also largely negate or significantly reduce the impact of the remaining constraints that are documented below.
- Presence of variable plasticity soils varying from low to high plasticity: The soils present at the site were variable in composition and when combined with widespread entry points for water ingress, would be highly susceptible to fluctuations in volume from shrink/swell behaviour. The impact would be the soils shrink and swell at different rates and different total amounts likely causing strain in the court pavement and surfacing.
- Presence of groundwater seepage: Groundwater seepages were observed at relatively shallow depths in 6 of the testing locations (generally near the creek lines) which would impact the shrink/swell behaviour of the clayey soils and reduce the strength of the site soils. Therefore, rock rafts (using quarry gravel and cobbles) should be considered in order to dissipate any excess pore water pressure to prevent possible uplifting effect on the footings and concrete pavement slabs.
- Inundation: Based on the preliminary design, the site will be subject to ~0.4 m fill and ~0.9 m cut to achieve the design levels. It is understood that the site would be sacrificial to a 20-year flooding event and inundation of the playing courts is expected in these events. To prevent the building-up of pore water pressure underneath the footings/playing courts; therefore shrink-swell movement and/or softening, a permeable subbase layer and rock drainage blanket would be required across the site, where tennis courts, pavilion and car parks are proposed. However, given the size of the proposed site, this is unlikely to be economically feasible. A more practical option might be to place/compact a selected material zone (SMZ), that can resist groundwater ingress however is low reactive in nature, similar to Transport for New South Wales (TfNSW) procedures for constructing roads over expansive clays.
- Presence of mature trees: The trees would be a contributing factor for potential cracking/court distress from potential tree root migration and additional soil moisture suction and drying effects. For future landscaping purposes, shrubs are recommended rather than trees and are set back outside the zone of influence (dictated by the plants height).
- Weather conditions before construction: Given the site conditions (low lying area with potential inundation), the construction should be carried out during a relatively dry period and in the warmer months of the year.
- Backfill of service trenches: Due to the presence of existing buried service trenches (i.e. sewer), poor/low strength subgrade conditions must be anticipated in those backfill zones.
- Over-excavation: Due to the type of soils present onsite and the preliminary design levels, over-excavation up to ~2.1 m depth and construction of Selected Material Zone (SMZ) and rock drainage blankets will be required for proposed tennis courts and car park. To minimise the over-excavation depth, it is highly recommended that the proposed tennis courts to be built above existing levels.

- Remediation cost: Due to the expected inundation of the site, future remediation costs (or reconstruction) should be taken into consideration of the current design.

8.3 Site Preparation and Earthworks

8.3.1 General

As indicated in the first dot point in Section 8.2 above, it is recommended that the playing courts be constructed on a low reactivity earth raft of at least 0.8 m thickness (assuming a 0.4 m thick pavement above). The raft is suggested to comprise pavement gravels overlying a selected material zone (SMZ – TfNSW) and possibly rock drainage layers or drains pending if groundwater is encountered at the stripped surface. Taking account of the depth of moisture impacted soils and groundwater seepage depths, it is recommended that site stripping/cutting be minimal and restricted to topsoil, fill and moisture impacted soil which generally should be no more than 0.5 m depth, though it will be deeper adjacent to the creek lines. This is likely to require fill depths of about 0.5 m above existing surface levels to achieve the recommended (DP recommended) 1.2 m thickness of a combination of low reactivity, earth raft and pavement gravels. It must be noted that DP has investigated numerous damaged playing courts across Canberra and largely the damage has been a result of shrink/swell behaviour (ie: thin pavement materials over variably shrink/swell reactive soils) in conjunction with poor drainage and planning of adjacent vegetation (ie: close proximity of mature trees).

8.3.2 Stripping

Site preparation for the proposed development will require the removal of any uncontrolled filling, topsoils, vegetation and any root affected soils, any sandy silty upper alluvium and any moisture weakened soil.

An average topsoil stripping depth of about 0.15 – 0.3 m can be at least anticipated. It is noted that topsoil to 0.6 m was observed in Pit 106 underlying existing fill material. It is also noted that part of the proposed tennis court areas contains some trees/shrubs and as such root affected soil will be encountered. Where trees are to be removed, the depth of root affected soils to be removed can only be determined during site earthworks.

The sandy silty upper alluvial deposit (e.g. in Pit 105) is often difficult to compact due to its high silt content and is readily susceptible to infiltration and saturation by water and therefore particularly prone to loss of strength. Allowance should be made for its removal in tennis courts and pavement areas or alternatively for the use of a bridging or replacement layer, if proposed fill depths exceed 1.5 m. Similarly, these soils may require at least partial if not full removal in controlled filling areas. This material is difficult to handle and compact upon, particularly if subject to water ingress and would require careful moisture control. The final depth of stripping will be heavily dependent on prior weather conditions. It is recommended that prior to any stripping of this material, inspection be undertaken by a suitably qualified geotechnical engineer to assess the extent of removal, or to advise on other remedial works that may be required (i.e. bridging layers and/or geofabric layers).

Possible deep unsuitable soils as a result of alluvial deposition (e.g. firm, wet clay soils in Pit 101) should be anticipated, especially along the western boundary of the site near Ginninderra Creek and adjacent to any creek tributaries. Groundwater springs or seepages in stripped areas and/or seepages within

parts of trench excavations necessitating the need for gravel backfilling, rubble drains or drainage blankets are likely though cannot be determined until during construction.

To aid compliance with the afore-mentioned recommendations, all stripped and excavated surfaces on which controlled fill, pavements or buildings are to be constructed, should be progressively inspected by an experienced geotechnical engineer.

Pending prior weather conditions, the stripped surfaces in low lying areas or near the creek lines may require deeper stripping and/or the provision of rock bridging layers. This to some degree can be mitigated by the timing of works as stated above.

8.3.3 Site Trafficability

Given the site location and subsurface conditions encountered, following periods of wet weather, stripped or excavated surfaces in topsoil and upper silty alluvial materials would likely be boggy with reduced trafficability. Exposed surfaces in underlying soils would be slippery.

Some measures that would help reduce the impact of wet weather on earthworks are as follows:

- Retain vegetative cover wherever possible;
- Provide cut surfaces with a slight but even cross-gradient to assist surface drainage;
- “Seal” exposed soil surfaces at the end of each work day by running over them with a smooth drum roller;
- Armour temporary access roads with rockfill or recycled crushed concrete; and
- Form swale drains at upslope locations to help intercept and redirect surface and near-surface seepage water to outside the works area into existing drainage gullies or dams, or to a sediment retention pond.

The underlying upper silt and sand soils could be moist to saturated (depending on the preceding weather conditions at the time of construction) and effectively untrafficable to all but tracked machinery which would still sink into the silt/sand soil.

8.3.4 Excavation Conditions

Based on the preliminary design provided by the client, the site is proposed to be subject to ~ 0.4 m fill and ~ 0.9 m cut to achieve the design levels. The site soils can be excavated using conventional earthmoving plant and as such no difficulties are anticipated in the removal of the soil components, except under wet weather conditions.

Bulk excavation of the highly weathered, highly fractured, up to low strength rock can be achieved by a medium size excavator (20 – 40 tonne) fitted with a toothed bucket and single tyne ripper. Depending on the proposed excavation depth, if excavations into medium to high strength rock is required, large excavators with rock hammers, and single tyne rippers will be needed. Similarly, high torque specialist piling rigs would be required should piers into medium or higher strength rock be required.

It must be noted that the excavatability of rock will be largely dependent on the degree of fracturing within the rock mass.

Provided the SMZ layer doesn't comprise rock particles generally greater than 75 mm, pier drilling into suitable natural soils or weathered rock would be achievable for proposed bridge crossing, buildings and/or light poles.

Groundwater seepages from the creek lines into construction excavations via sandy gravelly layers, just above the weathered rock, the soil rock interface and from fractures in the rock must be anticipated, especially after rain periods. The seepage flows are likely to be persistent, but readily controllable by gravity draining to the nearby creek lines or a collection sump or pond.

8.3.5 Excavation Support

For temporary excavations, maximum batter slopes of 1H:1V and 0.5H:1V are suggested for natural soils and weathered rock respectively, in dry conditions but this should be re-assessed onsite by a geotechnical engineer at the time of construction. Where batters are not feasible due to space restrictions (or other reasons), structural support measures must be provided. Furthermore, any excavations that encounter groundwater seepages, must be inspected by an experienced geotechnical engineer for appropriate batter slopes or other support measures.

Permanent excavation batters should be formed no steeper than 3(H):1(V) in natural soil/up to low strength rock and not steeper 1(H):1(V) in the medium or greater strength rock (subject to inspection and joint defects). The surfaces of the batters should be stabilised by vegetation, stone pitching or other suitable means, and a lined surface drain constructed along the top of the batter to limit the amount of rainfall runoff directed onto the face. Rock batters may require stabilisation via draped and dowelled mesh if jointing is adverse.

Where excavation batters are not possible because of space restrictions or other reason, structural support measures must be provided. DP can provide advice for retaining systems and geotechnical design parameter values should supports be required.

8.3.6 Re-Use of Onsite Material

Topsoil, root-bound soil, sandy silty upper alluvium, and excessively wet soil are not suitable to be used in engineered filling including in trenches. The upper sandy silty soils can be difficult to properly moisture condition and compact, and in wet weather is prone to relatively rapid saturation and loss of strength. Blending of the non-organic sandy silty soils in small portions (<20% by volume) with the site clayey soils may produce a blended soil suitable for use in engineered fill but not in pavement or playing court areas unless it placed at depths greater than 1.5 m depth. Blending with the site weathered rock is not recommended and should be avoided as the weathered rock breaks down to mostly a sandy soil with minimum clay fines to bind the soils together. Alternatively, the sandy slopewash soil can be used in non-structural fills such as landscaping works.

The clayey soils (mainly alluvial, some residual) contained portions of high plasticity clayey soils (e.g. Pits 3 and 113), which would be highly susceptible to shrink-swell volume changes and should be avoided in pavement areas including playing courts and only used in controlled fill area (i.e. buildings) if shrink/swell nature has been taken into consideration into the structure(s) design.

Site excavated weathered rock of up to low strength (if encountered) is considered suitable for reuse in all areas of controlled fill or embankment fill subject to removal or breakdown under roller compaction of particles greater than about 75 mm in size.

8.3.7 Filling Placement and Compaction

In areas that require filling, the stripped surfaces must be test rolled in the presence of a geotechnical engineer. Areas exhibiting significant deflections under test rolling should be treated either by over-excavation and replacement with approved filling material, by placement of a bridging layer, or by other suitable remedial treatment.

All controlled fill in building areas, and subgrade fill in pavement areas, should be compacted to a minimum 100% standard maximum dry density. It is recommended that filling be placed in not thicker than 200 mm thick compacted layers with a maximum particle size of 75 mm. A few percent by volume of particles to a maximum 150 mm size would be acceptable, though approved by a geotechnical engineer.

Based on the results of the laboratory testing and on our visual assessment at the time of the field investigation, the site soils are wet of their plastic limit and therefore likely to require the drying of moisture to obtain an optimum moisture condition for compaction in areas of buildings.

Further comment on properties for fill material within the playing court and pavement areas is provided in Section 8.4 below.

To validate compaction levels within the controlled filling and the SMZ layer, field inspections and in-situ testing of future earthworks must be undertaken in order to satisfy the requirements of a Level 1 or Level 2 (with regular onsite visits by a geotechnical engineer) inspection and testing service as defined in AS 3798:2007.

For the proposed pavilion, if piled foundations are adopted, controlled filling under a Level 2 inspection and testing service as defined in AS 3798:2007 is considered suitable. If high-level foundations are preferred, Level 1 inspection and testing will be required.

8.4 Tennis Courts and Pavement Areas

8.4.1 Shrink/Swell Minimisation and Site Drainage

As stated above, minimisation of shrink/swell movements in the subgrade soils will be critical to reducing the risk of premature failure of the playing courts. It is recommended that a capping layer of pavement material and selected material zone (SMZ) fill (permeability < 5 x 10^{-7} cm/sec) be provided on the subgrade which is not less than 1.2 m. This is to reduce shrink-swell movements in the subgrade.

It is further understood that the site is sacrificial to a 20-year flooding event and inundation of the playing courts is expected during these events. The permeability of the SMZ material has been recommended (above) to reduce the risk of groundwater ingress into the pavement material and the underlying clayey subgrade soils whilst still providing a low reactivity cap to the more reactive clayey subgrade soil.

Material selection and construction of the SMZ is suggested to be in general accordance with Transport for New South Wales QA Specifications (TfNSW R44:2020 and TfNSW 3071:2020), though subject to review at the time of construction by an experienced geotechnical engineer for any acceptable modifications.

In the event during site preparation and earthworks that groundwater seepages or springs are encountered, rock drainage blankets or finger type drains will be required to intercept the flows and allow gravity drainage to the creek lines. Where drains are required, sufficient grade is required at the base of the drain in order to divert water away from the tennis courts to ensure that saturation of underlying soils does not occur.

The rock material used in any drainage blankets or finger drains should comprise a minimum 50 mm to maximum 150 mm/200 mm size durable quarry rock with minimal fines encapsulated with geotextile. The drainage rock should be tracked rolled sufficiently to create interlock between the rock particles.

The adopted treatment method would need to apply to the zone of influence of the access road formation or playing courts (ie: 45^{o} from the road embankment or playing court edge).

It is also recommended to extend the playing court pavement a minimum of 0.5 m past the fence line to reduce edge movements associated with shrink-swell movement and ensure that water can freely flow off the playing court surface onto adjacent grassed areas. Failure to ensure this free flowing nature will result in ponding and exacerbate shrink/swell behaviour.

8.4.2 Pavement Design Considerations

The CBR results are given in Table 2 in Section 7.1 and the test report sheets are provided in Appendix E. The laboratory test results indicate CBR values ranging of 1.0% to 10% were present with the range in results most likely to be attributed to the variation in plasticity of fines and variation in coarse (sand and gravel) content between the tested samples.

It should be noted that varying degrees of moisture contents relative to OMC were encountered with samples tested ranging from 0.8% to 3.6% dry of optimum moisture content. Field moisture contents are likely to be highly variable and effected by the pre-earthworks construction weather conditions. Careful moisture conditioning of the in-situ soils must be adhered to, in order to achieve design CBR results.
Whilst the laboratory CBR result is an accurate determination of a small, remoulded laboratory sample, it is considered that few of the samples tested overstate the in-situ strength of the material tested and as such the downgrading of CBR value of 3% is recommended for design purposes. This has also considered DP's experience in similar geotechnical settings and allowing for some variability in subgrade conditions. It should be noted that a CBR value of 1% was obtained on high plasticity clay sample of Pit 103. In areas with low CBR material (ie: high plasticity clays) at the surface or at shallow depth, a placement layer of select site material of CBR 30% or better would be required.

Due to the variability of the laboratory results, subgrade conditions will require review during construction by a suitably qualified engineer and would require additional CBR testing to confirm design assumptions regarding subgrade strength and re-use of materials and select layers.

Surface and subsoil drainage must be installed and maintained to protect the pavement, SMZ and subgrade. Subsoil drains should be located at a minimum of 0.5 m depth below the subgrade level.

Surface drainage is recommended to be present surrounding each individual tennis court to reduce the flow distance of surface water to be able to enter into the drainage system.

The standard of construction, the selection of materials and quality of workmanship for the roads should satisfy the requirements of the latest edition of the Standard Specification for Urban Infrastructure Works.

8.4.3 Light Pole Footings

Provided the SMZ layer doesn't comprise rock particles generally greater than 75 mm, pier drilling into suitable natural soils or weathered rock would be achievable. Large pad footings founding in the SMZ layer or suitable upper natural soil layer could also be feasible with design based on an allowable base bearing pressure of 100 kPa. Likely pier depths at this stage are unknown as it depends on the tower height and lighting arrangement. Pier design would likely be governed by lateral loading rather than vertical loading. Suitable design parameters could be provided once more details are known about the lighting poles.

8.5 Proposed Bridge

8.5.1 Bridge Approaches

Earthworks to create the filled embankments leading to the bridge abutments in the current weather and site conditions will most likely encounter significant issues with a stable foundation on which to compact filling. It is recommended that an allowance be made for a thick basal layer of geofabric then a rock bridging layer of minimum 500 mm thickness. Confirmation of the treatment measure(s) would be required onsite during construction.

8.5.2 Foundations

Based on the subsurface investigation results, it is considered that high level footings would not be considered suitable to support the proposed bridge loadings. It is recommended that a deep foundation system founded within the weathered rock would be a more suitable solution to support the bridge.

Consideration has been given to uncased bored piers; however the presence of groundwater would most likely inhibit construction by pile wall caving and base cleaning difficulties, rendering such piles inappropriate for these conditions. Test piling could be attempted; however it would more than likely be unsuccessful.

It is considered feasible to use bored piles, utilising either temporary or permanent steel casing and socketed into the underlying bedrock to carry the down-thrust on the foundations.

Preliminary design parameters for pile foundations are given below. The design of piles may be based on limit state design methods. The Young's modulus (E_v) values and the ultimate limiting (end bearing and shaft adhesion) pressures given in Table 4 may be used to assess the limiting states for pile design purposes in accordance with AS 2159:2009. The settlement of piles subjected to vertical loads will vary depending on the serviceability loads applied and the foundation conditions below the pile toe. It should

be noted that due to the likely disturbance during construction and use of liners, it is recommended that the soil profile should be neglected for footing design purposes.

Table 4: Preliminary Geotechnical Parameters for Pile Design

Soil Stratum	Vertical Elastic Modulus, E_v[5] (MPa)	Ultimate Strength	
		End Bearing, f_b[3],[4] (kPa)	Shaft Adhesion, f_s[1],[2] (kPa)
Clayey alluvial and residual soils	NA	NA	NA
Very low to low strength siltstone	50 – 300	2,000	150
Low strength to medium strength siltstone	300 – 1,000	3,500	400
Medium to high strength siltstone	1,000 – 2,000	30,000	1,500
High strength siltstone	2,000 – 3,000	60,000	3,000

Notes to Table 1:

All pile end bearing parameters are based on pile penetration of at least four pile diameters or 3 m whichever is greater, below the ground surface.

1 Shaft adhesion parameters are only applicable where adequate socket roughness is achieved.

2 For calculation of tension or uplift capacity the shaft adhesion should be taken as 50% of the above shaft adhesion parameters.

3 Bearing pressure values assume a minimum embedment of one pile diameter into the relevant bearing stratum.

4 Ultimate end bearing parameters mobilised at large settlements (i.e. > 5% of pile diameter).

5 A range of values has been given for vertical Young's Modulus (E_v) based on typical published correlations.

Basic geotechnical strength reduction factor (ϕ_g) of 0.4 is recommended for the pile design, as this does not require pile load testing after the pile installation.

Higher values of ϕ_g can be justified by more comprehensive static or dynamic load testing.

Pile designer should assess the average risk rating and adopt appropriate geotechnical reduction factor for the design of the piles.

No load information has yet been provided but it is expected that foundations may need to resist uplift load resulting from stormwater flow load during floods. These uplift loads could be resisted by pile sockets. For design purposes 50% of the shaft adhesion values provided above could be adopted.

It is strongly recommended that Douglas Partners review the geotechnical aspects of the pile design prior to issue for tender to determine if any potential issues are evident.

Where abutments act as retaining walls or separate retaining walls are required, it is suggested that for level surfaces behind the wall, earth pressures be calculated using the following parameters:

- unit weight of soil – 20 kN/m^3
- coefficient of active earth pressure (Ka) where some rotational movement of the wall is acceptable – 0.3
- coefficient of 'at rest' earth pressure where movement cannot occur or is unacceptable – 0.5

Design should make allowance for the ground slope behind any retaining structure and for hydrostatic pressures due to surcharge loadings, if appropriate.

8.6 Proposed Pavilion

8.6.1 Site Classification

Site classification in accordance with AS 2870:2011 provides guidance on the patterns and magnitude of moisture related seasonal ground movements that must be considered in design. Due to the adverse moisture conditions arising from the existing trees, the presence of undocumented fill (in Pit 106), the presence of groundwater seepages and the presence of sewer easement (likelihood of uncontrolled fill within service trenches), the site is classified as Class P. Notwithstanding the Class P classification, based on soil reactivity including the additional tree-induced suction change and allowing for variation in the subsoil profile, the current natural soil profile would be equivalent to worst case Class H1 (highly reactive) conditions. The site classification must be reassessed should the subsurface profile change by either cutting or filling and/or if the presence of service trenches, retaining walls or submerged structures are within the zone of influence of the proposed footings. Reference must also be made to the comments provided below.

8.6.2 Foundations

Design of pavilion footing systems must allow for the provision of a uniform bearing stratum below or outside any zone of influence created by existing service trenches or underground structures to prevent total and differential footing settlement issues.

Based on the strata likely to be presented in building platforms and the site conditions (groundwater seepages, potential inundation and presence of sewer main easement), it is recommended the pavilion to be founded on piled foundations which are embedded in weathered rock (refer Section 8.5.2 for bearing pressures for rock).

It should be noted that due to the presence of fill material (in Pit 106) and likely disturbance during construction, it is recommended that the filling and soil profile up to ~1.0 m depth should be neglected for footing design purposes.

If high level footings are preferred for the proposed pavilion and site earthworks can be undertaken to facilitate their use, the following allowable bearing pressures are recommended for a preliminary design purposes:

- Controlled fill (Level 1): 150 kPa
- Very stiff to hard natural soils: 200 kPa
- Very low to low strength rock: 600 kPa

Minor structures such as hitting walls and retaining walls could possibly founded on spread footings in suitable upper alluvium though this would require assessment of suitable bearing pressures by an experienced geotechnical engineer during construction. As a preliminary guide, spread footings (i.e. pads or strips) founded in the upper alluvium (stiff or harder) below any fill (if encountered) could be proportioned for an allowable bearing pressure of 100 kPa. Should controlled fill (either Level 1 or Level 2) be placed, high level footings may also be suitable however would need to be inspected by an experienced geotechnical engineer with a likely allowable bearing pressure of 100 kPa, should it be considered suitable.

The settlement of spread footings is dependent on the stiffness of the founding stratum, dimensions of the footing and the load applied. It is recommended that detailed analyses be undertaken to estimate settlement for footings once the proposed footing details and founding strata is known.

All footings should be inspected by a suitably qualified geotechnical engineer prior to placement of reinforcing steel and concrete to verify the design assumptions. In particular, footing depths may need to be adjusted to compensate for local variations in the strength of the founding material. Founding locations and depths must also take into consideration the influence of any adjacent service trenches, retaining walls or submerged structures.

9. Design Review

It is understood that the proposed development design was still at the preliminary stage at the time of reporting. Due to the complexity of the site as discussed in the constraints section above, it is highly recommended that the earthworks and pavement design and methodology, and other geotechnical design parameters to be reviewed by DP once designs are more established.

10. References

AS 1289.6.3.1. (2004). *Methods for testing soils for engineering purposes - Soil strength and consolidation tests - Determination of the penetration resistance of a soil - Standard penetration test (SPT).* Reconfirmed 2016: Standards Australia.

AS 1289.6.3.2. (1997). *Methods for testing soils for engineering purposes - Soil strength and consolidation tests - Determination of the penetration resistance of a soil - 9kg dynamic cone penetrometer test.* Reconfirmed 2013: Standards Australia.

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

Austroads. (2019). *Guide to Pavement Technology Part 2: Pavement Structural Design.* Publication No. AGPT02-17: Austroads Ltd.

BMR. (1992). *Geology of Canberra 1:100 000 Geological Series Sheet 8727.* Bureau of Mineral Resources.

Cardno (NSW/ACT) Pty Ltd. (2018). *Geotechnical Investigation Report for Proposed Amaroo Tennis Courts.* Canberra: Cardno (NSW/ACT) Pty Ltd.

TfNSW 3071. (2020). *QA Specification 3071, Selected Material for Formation Layers.* Edition 2 / Revision 2: Transport for NSW (formerly RMS).

TfNSW R44. (2020). *QA Specification R44, Earthworks.* Edition 5 / Revision 1: Transport for NSW (formerly RMS).

11. Limitations

Douglas Partners (DP) has prepared this report for this project at Part Block 4 Section 109, Amaroo in accordance with DP's proposal dated 30 January 2023 and acceptance received from Faraz Khan of Stantec Australia Pty Ltd dated 28 March 2023. The work was carried out under the Agreement for Subconsultant Engagement of Stantec Australia Pty Ltd (dated 27 March 2023). This report is provided for the exclusive use of Stantec Australia Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

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

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

The scope of work for this investigation/report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of fill of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such fill may contain contaminants and hazardous building materials.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

November 2020

Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

continued next page

Site Anomalies

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

Information for Contractual Purposes

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

Site Inspection

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

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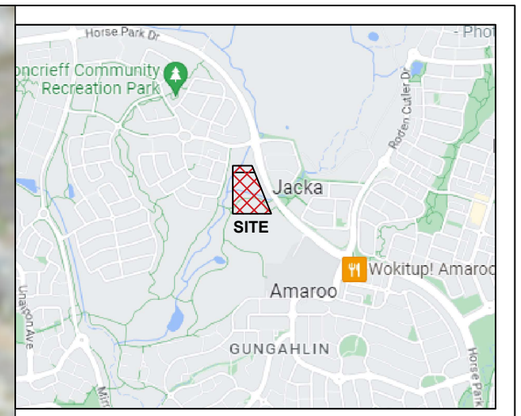
Appendix B

Drawings 1 - 3



Locality Plan

LEGEND

- Approximate Current Test Pit Location
- Approximate Current Borehole Location
- Approximate Previous Test Pit Location (2018)

0 15 30 45 60 75

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NOTE: Base drawing from Stantec Australia Pty Ltd (Drawing 50522032-GA-1010&1011, dated 08.02.2023

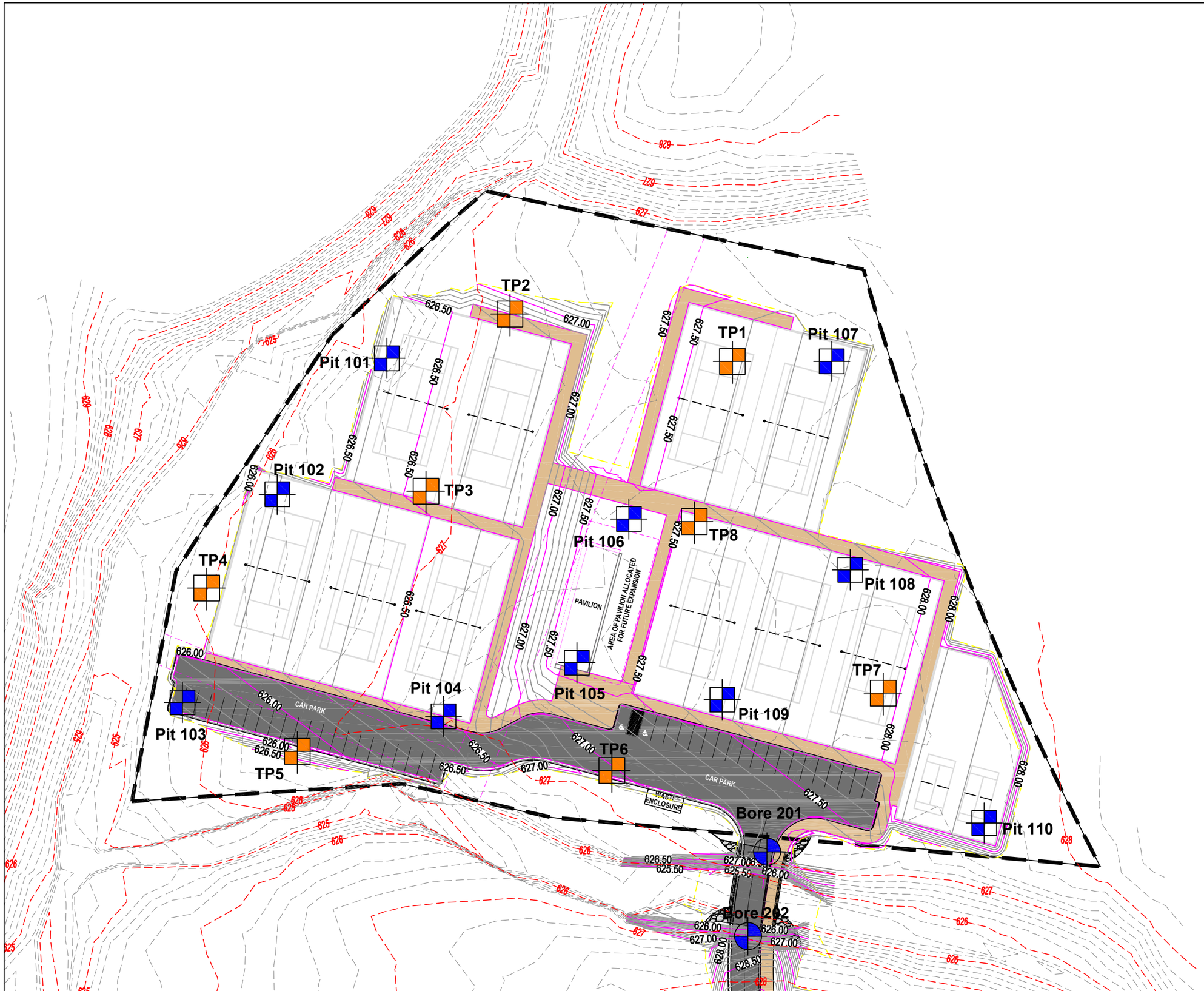
Douglas Partners
Geotechnics / Environment / Groundwater

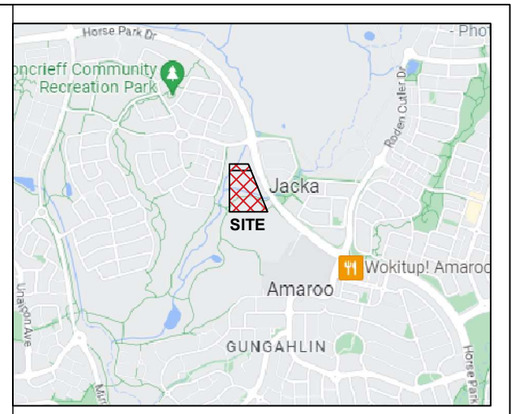
CLIENT: Stantec Australia Pty Ltd		
OFFICE: Canberra	DRAWN BY: GM	
SCALE: As Shown	DATE: 15.05.2023	

TITLE: **Test Location Plan**
Proposed Tennis Facility
Part Block 2 Section 109, Amaroo

N

PROJECT No:	220131.00
DRAWING No:	1
REVISION:	0





Locality Plan

LEGEND

- Approximate Current Test Pit Location
- Approximate Current Borehole Location
- Approximate Previous Test Pit Location (2018)
- Proposed Design Contour (0.5 m)
- Proposed Design Contour (0.1 m)
- Existing Contour (1 m)
- Existing Contour (0.2 m)

0 7.5 15 22.5 30 37.5

1:750 @ A3

NOTE: Base drawing from Stantec Australia Pty Ltd Drawing 50522032-GA-1010&1011, dated 08.02.2023

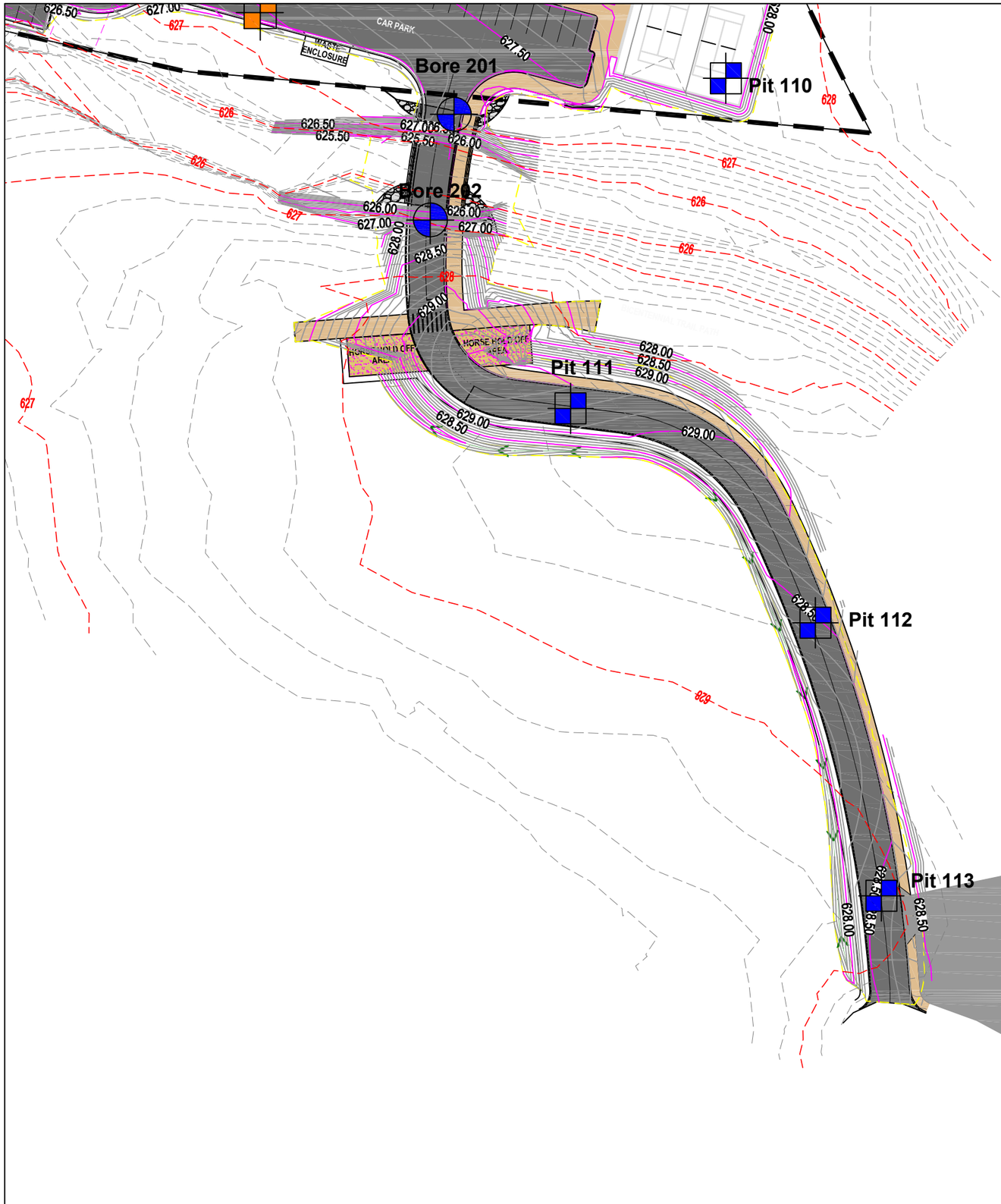
Douglas Partners
Geotechnics | Environment | Groundwater

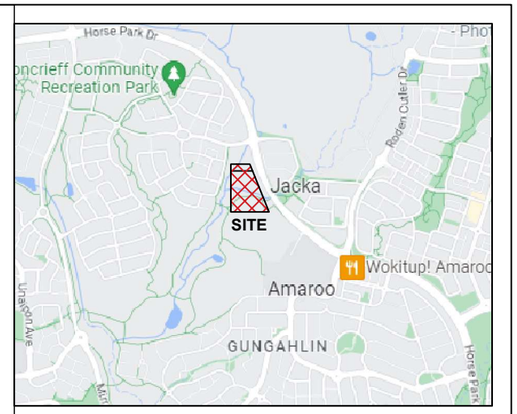
CLIENT: Stantec Australia Pty Ltd		
OFFICE: Canberra	DRAWN BY: GM	
SCALE: As Shown	DATE: 17.05.2023	

TITLE: **Contour Plan - North**
Proposed Tennis Facility
Part Block 2 Section 109, Amaroo

N

PROJECT No:	220131.00
DRAWING No:	2
REVISION:	0





Locality Plan

LEGEND

- Approximate Current Test Pit Location
- Approximate Current Borehole Location
- Approximate Previous Test Pit Location (2018)
- Proposed Design Contour (0.5 m)
- Proposed Design Contour (0.1 m)
- Existing Contour (1 m)
- Existing Contour (0.2 m)

0 7.5 15 22.5 30 37.5

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NOTE: Base drawing from Stantec Australia Pty Ltd Drawing 50522032-GA-1010&1011, dated 08.02.2023

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Stantec Australia Pty Ltd		
OFFICE: Canberra	DRAWN BY: GM	
SCALE: As Shown	DATE: 17.05.2023	

TITLE: **Contour Plan - South**
Proposed Tennis Facility
Part Block 2 Section 109, Amaroo

N

PROJECT No:	220131.00
DRAWING No:	3
REVISION:	0

Appendix C

Previous Investigation Report (Cardno, 2018)

Geotechnical Investigation

Amaroo Tennis Courts

50518098

Prepared for
ACT Sport and Recreation

07 October 2018

Cardno

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Document Information

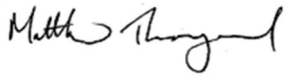
Prepared for	ACT Sport and Recreation
Project Name	Amaroo Tennis Courts
File Reference	50518098 Geotechnical Investigation_v01.docx
Job Reference	50518098
Date	07 October 2018
Version Number	01

Author(s):

Miles Thompson
Geotechnical Engineer

Effective Date 7/10/2018

Approved By:



Matt Thorogood
Senior Engineering Geologist

Date Approved 7/10/2018

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
01	07/10/2018	First Issue	MST	MET

Table of Contents

Appendices

Tables

1 Introduction

Cardno (NSW/ACT) Pty Ltd was commissioned by ACT Government, Sport and Recreation to undertake a geotechnical investigation Block 4 Section 109 Amaroo, ACT (northern section) (herein referred to as the Site). It is understood that the client wishes to redevelop the site through the construction of 10 tennis courts, 4 'hotshot' courts, a 'hit wall', car parking, lighting towers and a pavilion.

The objective of this investigation was to gain an improved understanding of the subsurface geological conditions across the site and provide geotechnical recommendations and design parameters for the project.

The geotechnical investigation undertaken by Cardno comprised:

- Review of project documentation provided and relevant geological literature;
- Site walkover survey;
- Excavation of eight (8) test pits, in situ testing and sampling of the encountered materials;
- Laboratory testing of selected samples; and
- Analysis of available data and compiling this geotechnical report.

The field investigations and laboratory testing were undertaken with reference to the following documentation:

- Australian Standard AS1726:2017 "Geotechnical Site Investigations"; and
- Australian Standard AS1289:2014 "Methods of Testing Soil for Engineering Purposes".

Geotechnical interpretation and discussion of the report findings has been undertaken with reference to the following documentation:

- Australian Standard AS2159:2009 "Piling-Design and Installation";
- Australian Standard AS2870:2011 "Residential Slabs and Footings";
- Australian Standard AS3798:2007 "Guidelines on earthworks for commercial and residential developments"

2 Scope of work

2.1 Field Investigation

Fieldwork was undertaken on 13 September 2018 and comprised the excavation of 8 test pits distributed across the area of the proposed development.

Materials encountered during the investigation were classified based on visual and tactile properties and logged on site by an experienced geotechnical engineer from Cardno with reference to AS1726:2017. Selected representative samples of the recovered material were recovered and transported to a NATA accredited laboratory for testing.

At the time of the field investigation, the location of the test pits were recorded using a hand-held GPS to an accuracy of ±5.0 metres. Borehole locations are outlined in Table 2-1 below.

Table 2-1 Borehole Locations

Borehole reference	Easting	Northing	Existing ground level (mAHD)[1]	Termination depth below existing ground level	
				mbgl	mAHD
TP1	693582	6107190	627.9	2.1	625.8
TP2	693539	6107200	627.6	1.9	625.7
TP3	693522	6107166	627.0	2.1	624.9
TP4	693479	6107148	626.0	1.5	624.5
TP5	693496	6107116	626.5	2.2	624.3
TP6	693557	6107111	627.0	2.2	624.8
TP7	693610	6107125	627.4	2.2	625.2
TP8	693574	6107159	627.6	2.0	625.6

[1]Ground level elevations have been based on interpolation of publically available survey data (ELVIS)

Site plans presenting the location of boreholes are presented on Figure 1 in Appendix A. Descriptive engineering logs are presented in Appendix B.

Test pits were excavated using a 6T excavator using a 450mm standard toothed bucket. Dynamic cone penetrometer (DCP) testing was conducted adjacent to each test pit, at a minimum distance of 2m as to ensure the results were not affected by the lateral stress relief induced by the test pit excavation. .

Test pits were then backfilled with spoil, with the spoil nominally compacted using the excavator bucket.

2.2 Laboratory testing

2.2.1 Classification

Laboratory testing of selected samples was undertaken to provide geomechanical data for engineering assessment. Subsurface characteristics such as strength and reactivity are evaluated through a range of laboratory testing.

Selected samples recovered from the boreholes at the time of the field investigation were submitted for the following laboratory tests:

- Particle Size Distribution (AS1289.3.6.1)
- Atterberg Limits and linear shrinkage (AS1289.3.1.1, AS1289.3.2.1, AS1289.3.3.1 and AS1289.3.4.1);
- Shrink Swell Index (AS1289.7.1.1);
- Moisture-Density Relationship (AS1289.5.1.1)
- 4-day soaked California Bearing Ratio at 95% SMDD (AS1289 6.1.1).

The geomechanical testing was carried out at Construction Sciences Pty Ltd, a NATA accredited geotechnical laboratory to the relevant Australian Standards. Laboratory reports are presented in Appendix C.

3 Site Description

3.1 Site Location

The site is located within Block 4 Section 109 Amaroo, ACT. The area of investigation is the northern portion of the Block, located on the corner of Bernard Heinze Ave and Horse Park Drive. The site is generally level, and covered with unkempt grasses.

The site is bounded to the north by a stormwater detention pond with Bernard Heinze Ave beyond. To the east is Horse Park Drive, located on an embankment approximately 3m above the level of the site. To the south is an unnamed creek/drainage channel with the Amaroo District Playing Fields beyond. Ginninderra Creek lies immediately west of the site, with Jorgensen Street beyond, located approximately 4m above the ground level of the site on a steep embankment.

3.2 Regional Geology

The Canberra 1:100,000 Geological Map (Sheet 8727, BMR Canberra) shows the site to be underlain by middle silurian aged sedimentary rocks of the Canberra Formation. The Canberra formation is characterised by sedimentary deposits including mudstone, siltstone, minor sandstone, limestone, hornfels, dacitic ignimbrite, and volcaniclastic sediments.

The Horse Park Wetlands are located to the north of the site. The wetlands are located in the leading face of an alluvial fan, which is likely to be present within this site due to its low lying down stream location. An unconfined aquifer is present in this fan, containing a region of gravels and sandy clays lying between surficial soils and bedrock, varying in thickness from 0.5m to around 3m flat gravels of siltstone within a silty clay matrix. Hydraulic testing of monitoring wells within the aquifer assessed a permeability of approximately $5x10^{-5}$m/s.

3.3 Subsurface Conditions

The subsurface profile encountered was generally consistent across the area of investigation. The encountered soils and rock were generally consistent with the regional geology described in Section 3.2.

Details of the encountered materials profiles are described in Tables 3-1 below. The depths of the various units are based on the depths identified at the borehole locations and may be different at other parts of the site.

Table 3-1 Inferred Geotechnical Model

Unit	Depth to base (mbgl)	Thickness (m)	Description
Unit 1 – Topsoil	0.3 - 0.5	0.3 - 0.5	Silty SAND and sandy CLAY; fine grained, low to medium plasticity, dark brown grey, rootlets throughout.
Unit 2A – Alluvium	1.4 - 2.0	1.0 - 1.7	Clayey SILT and Silty CLAY; medium plasticity, light brown mottled grey, trace fine sand.
Unit 2B – Alluvium (Unconsolidated Aquifer)	1.5 – 2.1	0.1 – 0.3	Gravelly CLAY; medium plasticity, grey, fine gravel of siltstone, flat, trace fine to coarse sand.
Unit 3 – Siltstone	Not encountered	Base not encountered	Siltstone, grey mottled dark grey, medium strength.

Descriptive engineering logs are presented in Appendix B.

3.4 Laboratory Testing

3.4.1 Atterberg Limits

Atterberg limit testing was conducted on selected samples to assess plasticity. Atterberg's limit testing confirm the field observations indicating the clay portion of the soils tested as medium plasticity clays (CL-CH). Table 3-2 below presents the results for field moisture content, liquid limit, plastic limit and plasticity index. Laboratory certificate are presented in Appendix C.

Table 3-2 Atterberg Limits Laboratory Results

Sample	Geotechnical Unit	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
TP03 0.5-0.6m	2A	37	22	15

3.4.2 Particle Size Distribution

Particle size distribution testing was conducted on selected samples to assess the proportion of gravel, sand and fines (silt/clay) in each sample to confirm the field observations of particle size. Table 3-3 below presents the results. Laboratory certificates presented in Appendix C.

Table 3-3 Particle Size Distribution Results

		% Soil type		
Sample	Geotechnical Unit	Gravel	Sand	Fines (Clay/Silt)
TP3 0.5-0.6	2A	4	5	91

3.4.3 Compaction and California Bearing Ratio

Standard compaction and CBR testing was conducted on a selected samples to allow assessment of subgrade conditions for pavement design. Table 3-2 below shows the results for the maximum dry density, optimum moisture content, CBR and CBR swell at 95% standard compaction. Laboratory certificates are presented in Appendix C.

Table 3-4 Compaction and CBR Laboratory Results

Sample	Geotechnical Unit	MDD (t/m^3)	OMC %	CBR %	CBR Swell (%)
TP2 0.5-0.8	2A	1.68	19.5	2.5	0
TP5 0.4-0.6	2A	1.72	18.5	4.5	0
TP7 0.4-0.7	2A	1.72	17.5	4.0	0

Legend:

MDD = Maximum Dry Density (t/m3)

CBR = California Bearing Ratio @ 95% MDD (modified maximum dry density)

OMC = Optimum moisture content (%)

3.4.4 Shrink Swell

Shrink swell index testing was conducted on selected samples to allow assessment of the expansive potential of the soils. The shrink swell test comprises of oven drying the sample from the initial moisture content and measurement of the shrinkage strain due to the reduction in soil moisture. The sample is then inundated with distilled water and allowed to swell, with the swelling measured to allow determination of the swell stain. The shrink swell index is defined as the moisture content variation (between oven dried and effective saturation) induced strain based on an assumed constant soil suction change. Table 3-3 below shows the results for the shrink swell index, shrinkage strain and swell strain. Laboratory certificates are presented in Appendix C.

Table 3-5 Shrink-Swell Laboratory Results

Sample	Geotechnical Unit	Shrink/Swell Index (%/ΔpF)	Shrinkage Strain (%)	Swell Strain (%)
TP4 0.5-0.7	2A	1.9	3.4	0.0
TP6 0.4-0.6	2A	0.9	1.6	0.0

3.5 Groundwater

At the time of the investigation (September - spring), standing water was encountered during the test pit excavation. Standing water levels and qualitative flow rates are shown on Table 3-6.

Table 3-6 Summary of Groundwater Levels

Test Pit	Standing Water Level (mbgl)	Standing Water Level (mAHD)[2]	Qualitative inflow rate
TP1	1.8	626.1	Fast
TP2	1.8	625.8	Slow
TP3	1.8	625.2	Fast
TP4	1.4	624.6	Slow
TP5	2.1	624.4	Slow
TP6	2.1	624.9	Slow
TP7	Dry	Dry	N/A
TP8	1.9	625.7	Slow

[1]Estimated based on existing ground level (Table 2-1)

Groundwater is expected to fluctuate throughout the year due to seasonal influence. It is likely that groundwater will be locally encountered as a perched water table within fracture zones within or overlying low permeability bedrock.

4 Engineering Assessment

The engineering assessment presented herein has been based on observations made during the site investigation, the material succession encountered within the test pits and in situ and laboratory test results.

4.1 Site reactivity and classification

The proposed structures associated with the redevelopment of the site may be outside the scope of AS2870:2011 “Residential Slabs and Footings”, but the site classification may still be used as a guide to the predicted ground surface movement as a result of soil moisture variations.

Based on the findings of the field investigation, laboratory test results, depth and relatively high proportion of fines locally ranging from low to medium plasticity material found at the site, we consider that the site classification for the site would be Class H1. A characteristic ground surface movement as a result of moisture variation (y_s) in the order of 40 to 60mm has been estimated for the subsurface profile encountered.

As the site is located in an area likely to flood, it is likely that the soils below the tennis courts and structures will be exposed to the full range of moisture conditions (that is to say, effective saturation during flooding or periods of high groundwater, and less than the plastic limit such as at the time of investigation) the characteristic ground surface movements should be allowed for as differential movement of the court slab.

4.2 Foundations

4.2.1 Shallow Foundations

DCPs were undertaken at the time of the investigation to assess the insitu strength of the underlying soil and rock profile. An allowable bearing capacity assessment using material descriptions and strengths obtained from the descriptive engineering logs and insitu test results has been carried out for shallow pad foundations, which are presented in Table 4-1 below.

Table 4-1 Summary of allowable bearing capacities

Unit	Allowable Bearing Capacity[1] *(kPa)*
Unit 2 – Alluvium	100
Unit 3 – Siltstone	300

[1] *bearing capacities given assumes a strip footing and does not account for embedment.*

These are the assessed design allowable bearing capacities for the site at the time of the investigation at the locations of the investigation holes. Drying of the site or increased soil moisture (subsurface water infiltration) may have an effect on the in situ soil strengths. Due to these factors and the potential for variability within the natural soils across the site, it is considered imperative that the site be inspected by an experienced Geotechnical Consultant at regular intervals during excavation and construction to confirm design allowable bearing pressures across the entire foundation have been achieved.

Any topsoil (or other deleterious materials, i.e. uncontrolled fill, roots, etc) located across the site is not considered a suitable founding layer as it is likely to exhibit variable settlement and bearing capacities. Beneath all foundations, all topsoil and fill should be removed and replaced engineered fill in accordance with AS3798:2007 “Guidelines on earthworks for commercial and residential developments”.

4.2.2 Deep Foundations

If heavy loaded structures, areas with particularly high point loads or structures susceptible to differential settlement are anticipated for this site, then shallow foundations may not be considered appropriate.

For the design of piles, geotechnical design parameters for ultimate strength limit state are provided in Table 4-2 and 4-3 for bored and driven piles, respectively. The design should also include assessment of both strength and serviceability limit states.

The values shown in Table 4-2 and 4-3 need to be factored to obtain design geotechnical strengths as outlined in the Australian Standards AS2159:2009 “Piling - Design and Installation”. Without assessing the design details for the proposed structures, we recommend using 0.45 and 0.33 for compression and uplift loads respectively for the geotechnical strength reduction values. The values in Table 4-2 and 4-3 are based on single pile design and do not take into account the effects of piles in groups.

We strongly recommend for piling that the works be supervised by a geotechnical professional who will assess whether the ground conditions encountered during piling are commensurate with the ground conditions described in this report.

The possibility of encountering groundwater is likely if piles are founded on Unit 3 – Siltstone, and will need to be considered when installing bored piles, particularly during and following the wetter months or following periods of flooding. The presence of groundwater can decrease wall stability in the bored pier. The accumulation of water at the base may reduce end bearing resistance if remedial-measures are not established. Casing of the pile and removal of accumulated water/softened material within the base of the bored pier during construction may be required.

Table 4-2 Geotechnical Parameters for Bored Piles

Unit	Ultimate Shaft Adhesion (f_s) *kPa*	Ultimate End Bearing Resistance (f_b) *kPa*	Elastic Modulus (MPa)
Unit 2 – Alluvium	*5*	*nil*	5
Unit 3 – Siltstone	*100*	*3,000*	*70*

Table 4-3 Geotechnical Parameters for Driven Piles

Unit	Ultimate Shaft Adhesion (f_s) *kPa*	Ultimate End Bearing Resistance (f_b) *kPa*	Elastic Modulus (MPa)
Unit 2 – Alluvium	*10*	*nil*	5
Unit 3 – Siltstone	*100*	*3,000*	*70*

Pile Notes:

1) *Design parameters for piles in the upper 1.0m of the soil profile across the site should be neglected due to the potential of soil reactivity as a result of seasonal moisture changes.*
2) *Pile parameters are based on a minimum pile embedment depth of 2.0m.*
3) *At Ultimate end bearing pressures, settlements in excess of 5% of foundation width may be realised*
4) *At allowable bearing pressures, pile settlements are expected to be less than 1% foundation width*
5) *Reference should be made to investigation logs for exact material description and depths.*

Should driven piles be considered, the capacity of piles driven to a refusal set may be evaluated by a pile driving formulae (such as Hiley) once the pile capacity and hammer size and type are known. Depth to the required set will be dependent on required capacity and size of piles and would be best evaluated by driving test piles.

Piling contractors should be provided with the borehole logs and be required to make their own assessment of suitability of piling plant and to verify the ultimate load-carrying pile capacities.

4.2.3 Settlement

The allowable bearing capacities for shallow foundations provided in Section 4.2.1 have assumed total settlements of no greater than 1% of the foundation width. Differential settlement would typically amount to around 1/3 of total settlement.

For piled foundations, some movement of the pile is necessary before full load capacity of the pile can be achieved. The full shaft capacity is usually achieved following approximately 10mm of vertical movement or 1% to 2% of the shaft diameter for piles less than 600mm in diameter. However, base resistance is usually achieved at greater displacements than that for shaft capacity. Full base resistance capacity is typically achieved following settlement of 5% to 10% of the pile diameter at the base of the pile.

A more detailed settlement analysis can be carried out as part of detailed design, as a detailed analysis must take into account foundation type, dimension and embedment depth.

4.3 Lateral Earth Pressures

Retaining walls or lighting towers subject to significant lateral loads may be required as part of the development. The design of retaining walls or laterally loaded piles/footings depends upon the type of

structure, the ground profile and the sequencing of construction. Detailed soil-structure interaction analyses will be required during the detailed design stage to assess magnitudes of movement.

For detailed design of the retention system, location specific geotechnical profiles should be developed. Recommended design parameters for the various soil units are presented in Table 4-4.

Where retaining walls are cantilevered, some wall movements can be tolerated. In this case and assuming no surcharge loading is present, retaining walls can de designed assuming a triangular earth pressure distribution using the design parameters provided. Passive resistance calculations should allow for unplanned excavation of up to 0.5m deep in front of a retaining wall.

Table 4-4 Lateral Earth Pressure Parameters

Geotechnical Unit	Bulk Density γ (kN m^{-3})	Effective Cohesion c' (kPa)	Effective Friction Angle ϕ' (degrees)	Active Earth Pressure (Ka)	Passive Earth Pressure (Kp)	Elastic Modulus (MPa)
Unit 2 – Alluvium	18	5	25	0.4	2.5	5
Unit 3 – Siltstone	22	50	30	0.33	3.0	70

Note:

(1) Earth pressure coefficients assume a smooth wall-soil interface. Detailed design should consider wall friction

(2) Retaining Walls in fill require site specific assessment of material properties

Where ground anchors or internal props restrain retaining wall movement, or where significant movements cannot be tolerated, an 'at-rest' earth pressure coefficient (K_0) of 0.5 should be adopted with a trapezoidal pressure distribution. However, it should be noted that wall designs for this 'at-rest' coefficient will still undergo some lateral movements, depending on the wall used and construction sequence.

The above advice assumes level ground and no seismic actions. The design of any retaining structures should make allowance for all applicable surcharge loading including construction activities and ground water conditions.

4.4 Pavements

Laboratory CBR testing conducted on samples of the Alluvium underlying topsoil attained CBR values of 2.5%.

It is recommended that a preliminary CBR value of 2.5% be adopted for pavement design on the site.

During pavement construction it is recommended that the prepared subgrade is assessed by a suitably experienced geotechnical engineer to confirm the ability of the actual subgrade materials to meet the design subgrade requirements. All topsoil, root affected soils, uncontrolled fill or deleterious material should be removed as part of subgrade preparation.

4.5 Earthworks

This section applies to all earthworks required for any construction preparation for the project. It is recommended that all earthworks on site are carried out in accordance with the project specifications and drawings, with reference to AS3798-*Guidelines on Earthworks for Commercial and Residential Developments*.

It is recommended that any uncontrolled fill, topsoil and deleterious material (e.g. tree roots) should be removed from the vicinity of footings. It is also recommended that any earthworks are carried out with consideration to Section 8.2 of AS3798:2007, and in strict accordance with compaction, supervision and testing requirements specified in the project specifications and drawings.

4.5.1 Stripping Requirements

It is recommended that all topsoil and other deleterious material (ie uncontrolled fill, soft/compressible soils) be stripped from within pavement areas and either removed from site or stockpiled for landscaping purposes. Unsuitable material should be defined in the design specification. Any tree roots present following the initial stripping should also be grubbed out and removed. The exposed surface should be compacted with a least 6 passes of a minimum 12-tonne roller. The compacted surface should be proof rolled using the roller or a fully laden water cart (or similar) undertaken under the guidance of a geotechnical professional. Any soft or

loose areas that are identified should be continually compacted until movement ceases or removed and replaced with more competent material.

4.5.2 Site Filling

It recommended that any earthworks are carried out with consideration to Section 8.2 of AS 3798 and in strict accordance with compaction, supervision and testing requirements specified in the project specifications and drawings.

Any proposed fill should be placed in layers not exceeding 200mm (loose thickness) and compacted to a dry density ratio of not less than 95% of Maximum Dry Density (MDD) and no more than ± 2.0% of Optimum Moisture Content (OMC).

Within pervious (unsealed) areas, the fill should be constructed with soil with a component of low plasticity fines which on compaction will allow the fill to easily shed surface water and limit infiltration. Uncontrolled infiltration would result in the development of a perched water table at the transition zone between the fill and the natural soils, especially where the top of the natural ground is not profiled to efficiently drain penetrated water.

4.5.3 Site Preparation and Trafficability

It is likely that imported road base or recycled road base type material such as crushed brick and concrete will be required to provide a stable surface for temporary access and roadways during or following wet weather.

Following excavation level to the proposed subgrade, or stripping for pavement construction, the subgrade should be proof rolled in accordance with AS3798. Any areas where excessive heave or deflection is found to occur should be excavated and replaced with appropriate fill.

Consideration should be given to the design of crane pads or working platforms for sensitive plant and equipment should these be a requirement of the project.

4.5.4 Erosion and Sediment Control

It is imperative that during earthworks, erosion and sediment control practices are investigated and put in place to ensure any activities carried out on site will not have a detrimental impact to the neighbouring environment. It is also recommended that during the development of the bulk earthworks specification, consideration is made to the *Urban Stormwater: Soils and Construction,* Landcom 2004 (“the Blue Book”)

Erosion and sediment controls should be incorporated early in any large or small scale development process and be included in budget estimates. In selecting and constructing erosion and sediment control systems, an appreciation of the differences between the two is important.

- Erosion control measures assist in protecting or strengthening the soil’s surface or subsurface from being eroded and diverts runoff in a non-erosive way.
- Sediment control measures capture and remove eroded soil particles from runoff prior to the water leaving the site.

The key to successful erosion and sediment control is planning. Generally control measures are not enough if just considered on their own. There must be a combination of structural controls, good site management and construction practices to achieve effective controls. An Erosion and Sediment Control Plan (ESCP) can assist in bringing together all of these aspects. These plans should communicate how erosion and sedimentation can be controlled on and off site. The erosion and sediment control measures as outlined in the plan must be installed before any disturbance of the site occurs.

It is best practice to develop an erosion and sediment control plan for any earthworks to be undertaken whether they are subject to statutory requirements or not. Developing a plan helps to identify the overall requirements for drainage and revegetation, assists in determining what level of protection methods may be required and reduces costs for repairs and/or rehabilitation.

4.5.5 Site management

In order to minimise foundation movement, it is important that proper site management for the existing soil conditions are observed by both the contractor at the time of the construction and the plant manager/operator throughout the life of the proposed plant.

We recommend that appropriate drainage be provided around the buildings and structures to ensure adequate foundation performance and prevent scouring. It is also recommended that the ground around structures or building platform should slope away at 1 in 20 for 2m and then fall to the stormwater runoff system.

The importance of avoiding leakage from underground services and drains near the buildings and structures is stressed. Any leaking services or blocked drains should be remedied promptly. It is advisable to use flexible joints, allowing horizontal and vertical movement where service pipes pass through the foundation structure (floor and slab). The bases of service trenches should fall away from the buildings and structures.

It is recommended that future shrubs and trees be planted away from the buildings and structures, at a distance at least equivalent to their mature height, to avoid shrinkage movement in expansive founding soils. New buildings and structures should also be located away from any existing trees on the site, at a distance equivalent to the tree's mature height.

5 Closure

We appreciate the opportunity to work collaboratively with you on this project. Our team looks forward to bringing our high level of expertise to deliver successful outcomes in your future projects.

Your attention is drawn to the appended document titled "*Important Information about this Geotechnical Report".* This document is intended to clarify to the reader what the realistic expectations of this report should be, and what is the correct use of the document. Misinterpretation of geotechnical information presents significant risk to projects: The document includes a discussion on general limitations of geotechnical services, which by nature, are based extensively on opinion and judgement.

The statements included in this document are not intended to be exculpatory clauses or to reduce the general responsibility accepted by Cardno, but rather to identify where Cardno and our Client's responsibilities lie. The statements ensure that all parties that may rely on the report are aware of their respective responsibilities.

For further enquiries, please do not hesitate to contact Cardno on the information supplied.

6 References

Abell, R. S. (1992). *Canberra 1:100,000 Scale Geolgical Map Sheet 8727.* Canberra: BMR.

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Landcom NSW. (2004). *Managing Urban Stormwater: Soils and Construction.*

Look, B. (2007). *Handbook of Geotechnial Investigation and Design Tables.* (1. Edition, Ed.)

APPENDIX A

SITE PLANS

DATE PLOTTED:19/09/2018 3:04:17 PM BY: CANBERRA GEOTECH
FILE: K:\Projects\50518098_AMAROO & FARRER TENNIS COURTS SIR_Data-InGeotech Investigation\Report\50518098_Tespits.mxd

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Date
19/09/2018

Size
A3

Scale
1:10,000

0 80 160 240 320 Metres

TEST PIT LOCATION PLAN

AMAROO TENNIS COURTS

GEOTECHNICAL INVESTIGATION

FIGURE 1

50518098_TESPITS

APPENDIX

B

DESCRIPTIVE ENGINEERING LOGS

TEST PIT LOG SHEET

Client: ACT Sport and Recreation
Project: Amaroo Tennis
Location: Amaroo

Hole No: TP1

Job No: 50518098 **Sheet:** 1 of 1

Position: 693582 6107190 **Angle from Horizontal:** 90° **Surface Elevation:** 627.900 m AHD

Machine Type: 6 tonne Excavator **Excavation Method:** 450mm GP

Excavation Dimensions: 2.50m LONG AND 0.50m WIDE **Contractor:** CMC Excavating

Date Excavated: 13/09/18 **Logged By:** MST **Checked By:** MET

Excavation				Sampling & Testing				Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP (blows per 150 mm) 1 3 6 12	RL (m AHD)	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Rapid			627.5	0.5		SM	Silty SAND: fine grained, low plasticity, dark brown grey, with rootlets throughout.	M	VL to L	TOPSOIL
						627.0	1.0		ML	0.40m Clayey SILT: medium plasticity, light brown mottled grey, trace fine sand	D to M	St VSt St	ALLUVIUM
						626.5	1.5						
						626.0	2.0		CH	1.80m Gravelly CLAY: medium plasticity, grey, fine of siltstone, flat gravel, with fine to coarse sand	W	VSt	
						625.5	2.5			2.10m TERMINATED AT 2.10 m End of hole at 2.1m. Target Depth			
						625.0	3.0						
						624.5	3.5						
						624.0	4.0						
						623.5	4.5						
						623.0							

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CARDNO (NSW/ACT) PTY LTD

TEST PIT LOG SHEET

Client: ACT Sport and Recreation
Project: Amaroo Tennis
Location: Amaroo

Hole No: TP2

Job No: 50518098 **Sheet:** 1 of 1

Position: 693539 6107200 **Angle from Horizontal:** 90° **Surface Elevation:** 627.600 m AHD

Machine Type: 6 tonne Excavator **Excavation Method:** 450mm GP

Excavation Dimensions: 2.50m LONG AND 0.50m WIDE **Contractor:** CMC Excavating

Date Excavated: 13/09/18 **Logged By:** MST **Checked By:** MET

Excavation			Water	Sampling & Testing		RL (m AHD)	Depth (m)	Material Description					
Method	Resistance	Stability		Sample or Field Test	DCP (blows per 150 mm) 1 3 6 12			Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Sow	B 0.50 - 0.80 m	Refusal	627.5	0		SM	Silty SAND: fine grained, low plasticity, dark brown grey, with rootlets throughout.	D to M	F	TOPSOIL
										0.20m			
									CH	Sandy CLAY: medium plasticity, dark brown grey, fine sand, with rootlets throughout.			
						627.0	0.5			0.50m			
									ML	Clayey SILT: medium plasticity, grey mottled brown, trace fine sand		VSt	ALLUVIUM
						626.5	1.0					St	
						626.0	1.5			1.70m		H	
									CH	Gravelly CLAY: medium plasticity, grey, fine of siltstone, flat gravel, with fine to coarse sand	W		
										1.90m			
						625.5	2.0			SILTSTONE, grey mottled dark grey, medium strength. TERMINATED AT 1.90 m End of hole at 1.9m. Target depth.			ROCK
						625.0	2.5						
						624.5	3.0						
						624.0	3.5						
						623.5	4.0						
						623.0	4.5						

METHOD
- EX Excavator bucket
- R Ripper
- HA Hand auger
- PT Push tube
- SON Sonic drilling
- AH Air hammer
- PS Percussion sampler
- AS Short spiral auger
- AD/V Solid flight auger: V-Bit
- AD/T Solid flight auger: TC-Bit
- HFA Hollow flight auger
- WB Washbore drilling
- RR Rock roller

PENETRATION
- VE Very Easy (No Resistance)
- E Easy
- F Firm
- H Hard
- VH Very Hard (Refusal)

WATER
- Water Level on Date shown
- water inflow
- water outflow

FIELD TESTS
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer
- DCP - Dynamic Cone Penetrometer
- PSP - Perth Sand Penetrometer
- MC - Moisture Content
- PBT - Plate Bearing Test
- IMP - Borehole Impression Test
- PID - Photoionisation Detector
- VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
- B - Bulk disturbed sample
- D - Disturbed sample
- ES - Environmental sample
- U - Thin wall tube 'undisturbed'

MOISTURE
- D - Dry
- M - Moist
- W - Wet
- PL - Plastic limit
- LL - Liquid limit
- *w* - Moisture content

SOIL CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CARDNO (NSW/ACT) PTY LTD

TEST PIT LOG SHEET

Client: ACT Sport and Recreation
Project: Amaroo Tennis
Location: Amaroo

Hole No: TP3

Job No: 50518098 **Sheet:** 1 of 1

Position: 693522 6107166 **Angle from Horizontal:** 90° **Surface Elevation:** 627.000 m AHD

Machine Type: 6 tonne Excavator **Excavation Method:** 450mm GP

Excavation Dimensions: 2.50m LONG AND 0.50m WIDE **Contractor:** CMC Excavating

Date Excavated: 13/09/18 **Logged By:** MST **Checked By:** MET

Excavation				Sampling & Testing				Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP (blows per 150 mm) 1 3 6 12	RL (m AHD)	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Fast	D 0.50 - 0.60 m		626.5 626.0 625.5 625.0	0.5 1.0 1.5 2.0		CH ML CH	Sandy CLAY: medium plasticity, dark brown grey, fine sand, with rootlets throughout. 0.30m Clayey SILT: medium plasticity, light grey mottled dark grey and brown, trace fine sand 1.80m Gravelly CLAY: medium plasticity, brown, fine to coarse of siltstone, flat gravel, with fine to coarse sand 2.10m	M D W	F St VSt to H	TOPSOIL ALLUVIUM
						624.5 624.0 623.5 623.0 622.5	2.5 3.0 3.5 4.0 4.5			SILTSTONE, grey mottled dark grey, medium strength. TERMINATED AT 2.10 m End of hole at 2.1m. Target Depth			ROCK

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CARDNO (NSW/ACT) PTY LTD

TEST PIT LOG SHEET

Client: ACT Sport and Recreation
Project: Amaroo Tennis
Location: Amaroo

Hole No: TP4

Job No: 50518098 **Sheet:** 1 of 1

Position: 693479 6107148 **Angle from Horizontal:** 90° **Surface Elevation:** 626.000 m AHD

Machine Type: 6 tonne Excavator **Excavation Method:** 450mm GP

Excavation Dimensions: 2.50m LONG AND 0.50m WIDE **Contractor:** CMC Excavating

Date Excavated: 13/09/18 **Logged By:** MST **Checked By:** MET

Excavation				Sampling & Testing				Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP (blows per 150 mm) 1 3 6 12	RL (m AHD)	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable		D 0.50 - 0.70 m		625.5	0.5		CH	Sandy CLAY: medium plasticity, dark brown grey, fine sand, with rootlets throughout.			TOPSOIL
										0.40m			
									ML	Clayey SILT: medium plasticity, light grey mottled dark grey and brown, trace fine sand	M	F	ALLUVIUM
						625.0	1.0					St	
										1.40m		VSt	
	H		Slow		Refusal	624.5	1.5			1.50m SILTSTONE, grey mottled dark grey, medium strength.	D		ROCK
										TERMINATED AT 1.50 m End of hole at 1.5m. Refusal.			
						624.0	2.0						
						623.5	2.5						
						623.0	3.0						
						622.5	3.5						
						622.0	4.0						
						621.5	4.5						

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

Water Level on Date shown
water inflow
water outflow

FIELD TESTS

SPT	-	Standard Penetration Test
HP	-	Hand/Pocket Penetrometer
DCP	-	Dynamic Cone Penetrometer
PSP	-	Perth Sand Penetrometer
MC	-	Moisture Content
PBT	-	Plate Bearing Test
IMP	-	Borehole Impression Test
PID	-	Photoionisation Detector
VS	-	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	-	Bulk disturbed sample
D	-	Disturbed sample
ES	-	Environmental sample
U	-	Thin wall tube 'undisturbed'

MOISTURE

D	-	Dry
M	-	Moist
W	-	Wet
PL	-	Plastic limit
LL	-	Liquid limit
w	-	Moisture content

SOIL CONSISTENCY

VS	-	Very Soft
S	-	Soft
F	-	Firm
St	-	Stiff
VSt	-	Very Stiff
H	-	Hard

RELATIVE DENSITY

VL	-	Very Loose
L	-	Loose
MD	-	Medium Dense
D	-	Dense
VD	-	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CARDNO (NSW/ACT) PTY LTD

TEST PIT LOG SHEET

Client: ACT Sport and Recreation
Project: Amaroo Tennis
Location: Amaroo

Hole No: TP5

Job No: 50518098 **Sheet:** 1 of 1

Position: 693496 6107116 **Angle from Horizontal:** 90° **Surface Elevation:** 626.500 m AHD

Machine Type: 6 tonne Excavator **Excavation Method:** 450mm GP

Excavation Dimensions: 2.50m LONG AND 0.50m WIDE **Contractor:** CMC Excavating

Date Excavated: 13/09/18 **Logged By:** MST **Checked By:** MET

Excavation				Sampling & Testing				Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP (blows per 150 mm) 1 3 6 12	RL (m AHD)	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Past			626.0	0.5		SM	Silty SAND: fine grained, low plasticity, dark brown grey, with rootlets throughout.	D	F	TOPSOIL
										0.30m			
				B 0.40 - 0.60 m		625.5	1.0		CL	Silty CLAY: medium plasticity, light brown mottled grey, trace fine sand	D to M	St to VSt	ALLUVIUM
						625.0	1.5						
						624.5	2.0			2.00m			
									CH	Gravelly CLAY: medium plasticity, grey, fine to medium of siltstone, flat gravel, with fine to coarse sand	W		
										2.20m			
										TERMINATED AT 2.20 m End of hole at 2.2m. Target depth.			
						624.0	2.5						
						623.5	3.0						
						623.0	3.5						
						622.5	4.0						
						622.0	4.5						

METHOD
- EX Excavator bucket
- R Ripper
- HA Hand auger
- PT Push tube
- SON Sonic drilling
- AH Air hammer
- PS Percussion sampler
- AS Short spiral auger
- AD/V Solid flight auger: V-Bit
- AD/T Solid flight auger: TC-Bit
- HFA Hollow flight auger
- WB Washbore drilling
- RR Rock roller

PENETRATION
- VE Very Easy (No Resistance)
- E Easy
- F Firm
- H Hard
- VH Very Hard (Refusal)

WATER
- Water Level on Date shown
- water inflow
- water outflow

FIELD TESTS
- SPT - Standard Penetration Test
- HP - Hand/Pocket Penetrometer
- DCP - Dynamic Cone Penetrometer
- PSP - Perth Sand Penetrometer
- MC - Moisture Content
- PBT - Plate Bearing Test
- IMP - Borehole Impression Test
- PID - Photoionisation Detector
- VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
- B - Bulk disturbed sample
- D - Disturbed sample
- ES - Environmental sample
- U - Thin wall tube 'undisturbed'

MOISTURE
- D - Dry
- M - Moist
- W - Wet
- PL - Plastic limit
- LL - Liquid limit
- *w* - Moisture content

SOIL CONSISTENCY
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VSt - Very Stiff
- H - Hard

RELATIVE DENSITY
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CARDNO (NSW/ACT) PTY LTD

Cardno

TEST PIT LOG SHEET

Client: ACT Sport and Recreation
Project: Amaroo Tennis
Location: Amaroo

Hole No: TP6

Job No: 50518098 | **Sheet:** 1 of 1

Position: 693557 6107111 | **Angle from Horizontal:** 90° | **Surface Elevation:** 627.000 m AHD

Machine Type: 6 tonne Excavator | **Excavation Method:** 450mm GP

Excavation Dimensions: 2.50m LONG AND 0.50m WIDE | **Contractor:** CMC Excavating

Date Excavated: 13/09/18 | **Logged By:** MST | **Checked By:** MET

Excavation Method	Excavation Resistance	Excavation Stability	Water	Sample or Field Test	DCP (blows per 150 mm) 1 3 6 12	RL (m AHD)	Depth (m)	Graphic Log	Classification	Material Description: SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable							SM	Silty SAND: fine grained, low plasticity, dark brown grey, with rootlets throughout.	D	F	TOPSOIL
										0.30m			
				B 0.40 - 0.60 m		626.5	0.5		CL	Silty CLAY: medium plasticity, light brown mottled grey, trace fine sand	D to M	VSt	ALLUVIUM
												H	
						626.0	1.0					VSt	
					Refusal	625.5	1.5					H	
						625.0	2.0			2.00m			
			Slow						CH	Gravelly CLAY: medium plasticity, grey, fine to medium of siltstone, flat gravel, with fine to coarse sand	W		
										2.20m			
										TERMINATED AT 2.20 m End of hole at 2.2m. Target depth.			
						624.5	2.5						
						624.0	3.0						
						623.5	3.5						
						623.0	4.0						
						622.5	4.5						

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CARDNO (NSW/ACT) PTY LTD

Cardno

TEST PIT LOG SHEET

Client: ACT Sport and Recreation
Project: Amaroo Tennis
Location: Amaroo

Hole No: TP7

Job No: 50518098 | **Sheet:** 1 of 1

Position: 693610 6107125 | **Angle from Horizontal:** 90° | **Surface Elevation:** 627.400 m AHD

Machine Type: 6 tonne Excavator | **Excavation Method:** 450mm GP

Excavation Dimensions: 2.50m LONG AND 0.50m WIDE | **Contractor:** CMC Excavating

Date Excavated: 13/09/18 | **Logged By:** MST | **Checked By:** MET

Excavation: Method	Resistance	Stability	Water	Sampling & Testing: Sample or Field Test	DCP (blows per 150 mm) 1 3 6 12	RL (m AHD)	Depth (m)	Graphic Log	Classification	Material Description: SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable		B 0.40 - 0.70 m	Refusal	627.0	0.5		SM	Silty SAND: fine grained, low plasticity, dark brown grey, with rootlets throughout.	D	F	TOPSOIL
										0.40m		St	
												VSt	ALLUVIUM
						626.5	1.0		CL	Silty CLAY: medium plasticity, brown mottled grey, trace fine sand, trace fine, of siltstone gravel		H	
						626.0	1.5				D to M		
										1.80m			
						625.5	2.0		CH	Gravelly CLAY: medium plasticity, dark brown, fine to medium of siltstone, flat gravel, with fine to coarse sand			
	H									2.10m			
										2.20m SILTSTONE, grey mottled dark grey, medium strength.	D		ROCK
										TERMINATED AT 2.20 m End of hole at 2.2m. Target depth.			
						625.0	2.5						
						624.5	3.0						
						624.0	3.5						
						623.5	4.0						
						623.0	4.5						
						622.5							

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CARDNO (NSW/ACT) PTY LTD

TEST PIT LOG SHEET

Client: ACT Sport and Recreation
Project: Amaroo Tennis
Location: Amaroo

Hole No: TP8

Job No: 50518098 **Sheet:** 1 of 1

Position: 693574 6107159 **Angle from Horizontal:** 90° **Surface Elevation:** 627.600 m AHD

Machine Type: 6 tonne Excavator **Excavation Method:** 450mm GP

Excavation Dimensions: 2.50m LONG AND 0.50m WIDE **Contractor:** CMC Excavating

Date Excavated: 13/09/18 **Logged By:** MST **Checked By:** MET

Excavation				Sampling & Testing				Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP (blows per 150 mm) 1 3 6 12	RL (m AHD)	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Stow			627.5	0		SM	Clayey Silty SAND: fine grained, low plasticity, dark brown grey, with rootlets throughout.	M	F	TOPSOIL
										0.40m		St	
				D 0.40 - 0.60 m		627.0	0.5		ML	Clayey SILT: medium plasticity, light brown mottled grey, trace fine sand	D to M	VSt	ALLUVIUM
						626.5	1.0					H	
												VSt	
						626.0	1.5					H	
										1.80m		VSt	
									CH	Gravelly CLAY: medium plasticity, brown, fine of siltstone, flat gravel, with fine to coarse sand	M		
							2.0			2.00m	W		
						625.5				TERMINATED AT 2.00 m End of hole at 2.0m. Target depth.			
							2.5						
						625.0							
							3.0						
						624.5							
							3.5						
						624.0							
							4.0						
						623.5							
							4.5						
						623.0							

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CARDNO (NSW/ACT) PTY LTD

DYNAMIC CONE PENETROMETER

Project	Amaroo Tennis	Project Number:	50518098
Location	Amaroo	Date Tested	13/09/2018
Tested By	MST	Date Checked	4/10/2018
Checked By	MET	Material Type	Silty Clay

	Blows/100mm							
Depth (mbgl)	**TP1**	**TP2**	**TP3**	**TP4**	**TP5**	**TP6**	**TP7**	**TP8**
0	1	3	2	2	2	2	1	1
0.1	1	2	2	3	2	2	3	3
0.2	2	2	3	2	3	2	5	4
0.3	2	3	3	2	6	8	9	5
0.4	4	6	2	2	7	14	11	7
0.5	6	9	3	2	3	21	13	12
0.6	11	7	3	2	7	10	14	20
0.7	11	8	5	2	8	7	16	15
0.8	13	8	4	3	8	8	17	16
0.9	9	7	3	4	6	7	19	13
1.0	11	6	3	5	6	7	24	10
1.1	10	4	3	7	7	7	R	9
1.2	9	5	3	11	7	22		9
1.3	8	4	5	15	9	R		7
1.4	8	5	9	R	7			15
1.5	5	R	10		5			10
1.6	12		13		5			9
1.7	12				6			9
1.8	11							10
1.9								
2.0								

Tested in general accorance with AS1289.6.3.2

APPENDIX C

LABORATORY REPORTS

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Unit 3/180 Gladstone Street,
Fyshwick ACT 2609

Laboratory: Fyshwick Laboratory
Phone: 02 6285 5314
Fax:
Email: Canberra@constructionsciences.net

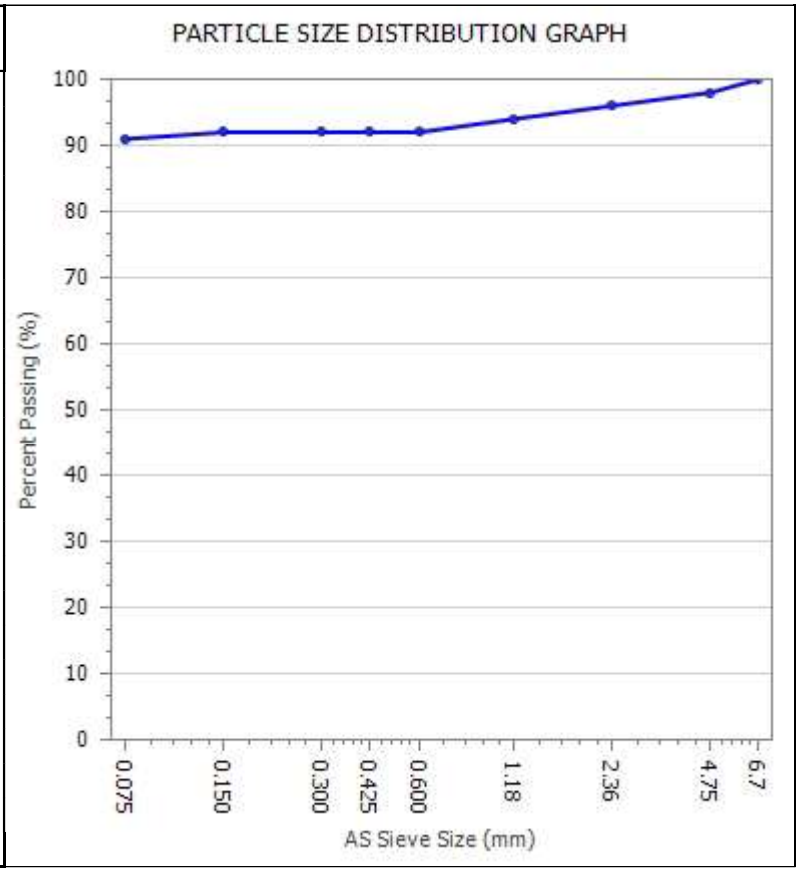
PARTICLE SIZE DISTRIBUTION REPORT

Client:	Cardno ACT	Report Number:	455/R/14934-1
Client Address:	2/14-16 Wormald Street, Symonston	Project Number:	455/P/31
Project:	Amaroo Tennis	Lot Number:	
Location:	NSW/ACT	Internal Test Request:	455/T/10193
Supplied To:	Cardno ACT	Client Reference/s:	50518098
Area Description:		Report Date / Page:	4/10/2018 Page 1 of 1

Test Procedures: AS1289.3.6.1

Sample Number	455/S/64092	Sample Location	
Sampling Method		Client Supplied	TP3
Date Sampled	13/09/2018 12:00		
Sampled By	Client Sampled		
Date Tested	4/10/2018		0.5-0.6m
Material Source	Unknown	Material Type	-

AS Sieve (mm)	Specification Minimum	**Percent Passing (%)**	Specification Maximum
6.7		**100**	
4.75		**98**	
2.36		**96**	
1.18		**94**	
0.600		**92**	
0.425		**92**	
0.300		**92**	
0.150		**92**	
0.075		**91**	



Remarks

NATA

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation Number: 1986
Corporate Site Number: 455

Approved Signatory: Kevin Spicer
Form ID: W9Rep Rev 2

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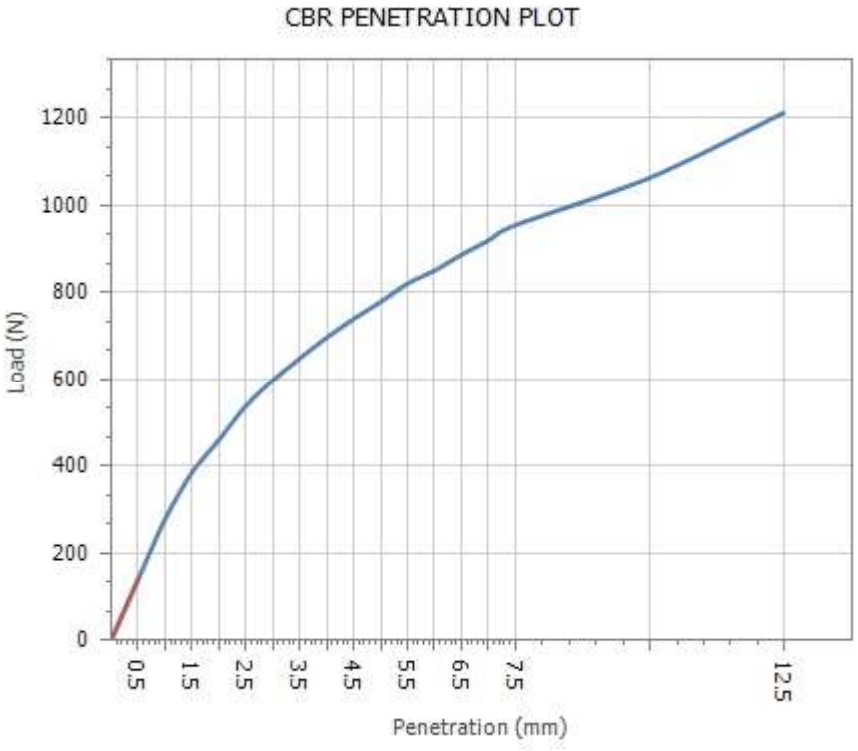
CALIFORNIA BEARING RATIO REPORT

Client:	Cardno ACT	Report Number:	455/R/14919-1
Client Address:	2/14-16 Wormald Street, Symonston	Project Number:	455/P/31
Project:	Amaroo Tennis	Lot Number:	
Location:	NSW/ACT	Internal Test Request:	455/T/10193
Supplied To:	Cardno ACT	Client Reference/s:	50518098
Area Description:		Report Date / Page:	4/10/2018 Page 3 of 3

Test Procedures	AS1289.6.1.1, AS1289.5.1.1, AS1289.2.1.1

Sample Number	455/S/64091	Sample Location	
Sampling Method		Client Supplied	TP7
Date Sampled	13/09/2018		
Sampled By	Client Sampled		
Date Tested	2/10/2018		0.4-0.7m
Material Source	Unknown	Material Limit Start	-
Material Type	-	Material Limit End	-
Client Reference	-	Compactive Effort	Standard
Material Description	(CI) Silty CLAY		

Maximum Dry Density (t/m³):	1.72
Optimum Moisture Content (%):	17.5
Field Moisture Content (%):	12.0
Sample Percent Oversize (%)	0.0
Oversize Included / Excluded	-
Target Density Ratio (%):	95
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	1.64
Placement Dry Density Ratio (%):	95.0
Placement Moisture Content (%):	17.9
Placement Moisture Ratio (%):	101.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	-
Dry Density After Soak (t/m³):	-
Total Curing Time (hrs)	n/a
Liquid Limit Method	Estimation
Moisture (top 30mm) After Soak (%)	24.1
Moisture (remainder) After Soak (%)	21.3
CBR Swell (%):	-
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**4.0**



Remarks

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Corporate Site Number: 455

Approved Signatory: Kevin Spicer
Form ID: W2ASRep Rev2

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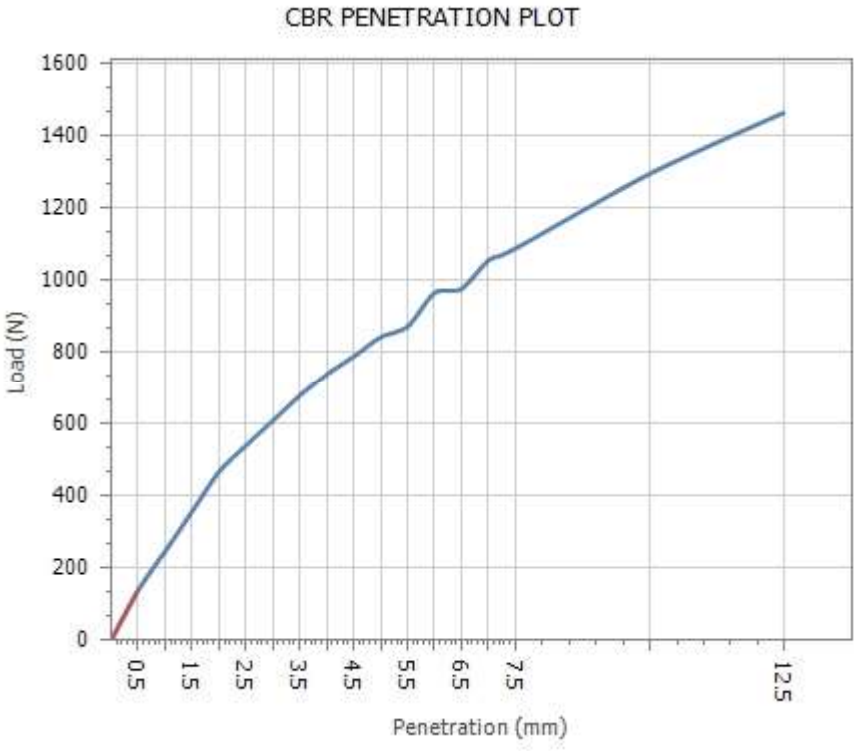
CALIFORNIA BEARING RATIO REPORT

Client:	Cardno ACT	Report Number:	455/R/14919-1
Client Address:	2/14-16 Wormald Street, Symonston	Project Number:	455/P/31
Project:	Amaroo Tennis	Lot Number:	
Location:	NSW/ACT	Internal Test Request:	455/T/10193
Supplied To:	Cardno ACT	Client Reference/s:	50518098
Area Description:		Report Date / Page:	4/10/2018 Page 2 of 3

Test Procedures	AS1289.6.1.1, AS1289.5.1.1, AS1289.2.1.1		
Sample Number	455/S/64090	Sample Location	
Sampling Method		Client Supplied	TP5
Date Sampled	13/09/2018		
Sampled By	Client Sampled		
Date Tested	4/10/2018		0.4-0.6m
Material Source	Unknown	Material Limit Start	-
Material Type	-	Material Limit End	-
Client Reference	-	Compactive Effort	Standard
Material Description	(CI) Silty CLAY		

Maximum Dry Density (t/m³):	1.72
Optimum Moisture Content (%):	18.5
Field Moisture Content (%):	17.8
Sample Percent Oversize (%)	0.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	95
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	1.64
Placement Dry Density Ratio (%):	95.5
Placement Moisture Content (%):	18.6
Placement Moisture Ratio (%):	101.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	-
Total Curing Time (hrs)	n/a
Liquid Limit Method	Estimation
Moisture (top 30mm) After Soak (%)	22.9
Moisture (remainder) After Soak (%)	18.0
CBR Swell (%):	-
Minimum CBR Specification (%):	-
CBR Value @ 5.0mm (%):	**4.5**



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NATA

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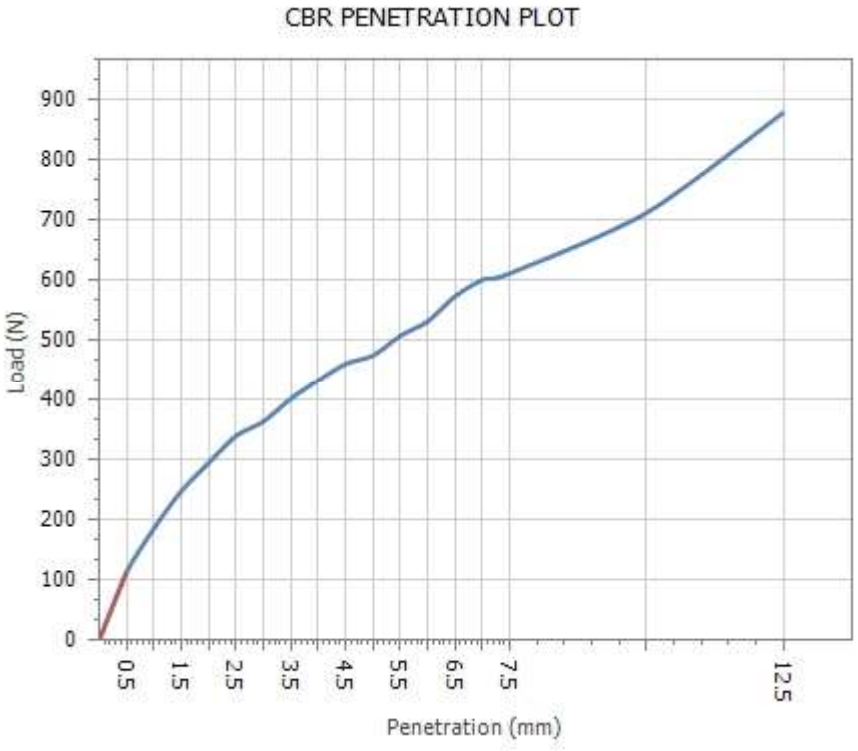
Client:	Cardno ACT	Report Number:	455/R/14919-1
Client Address:	2/14-16 Wormald Street, Symonston	Project Number:	455/P/31
Project:	Amaroo Tennis	Lot Number:	
Location:	NSW/ACT	Internal Test Request:	455/T/10193
Supplied To:	Cardno ACT	Client Reference/s:	50518098
Area Description:		Report Date / Page:	4/10/2018 Page 1 of 3

Test Procedures	AS1289.6.1.1, AS1289.5.1.1, AS1289.2.1.1		
Sample Number	455/S/64089	Sample Location	
Sampling Method		Client Supplied	TP2
Date Sampled	13/09/2018		
Sampled By	Client Sampled		
Date Tested	2/10/2018		0.5-0.8m
Material Source	Unknown	Material Limit Start	-
Material Type	-	Material Limit End	-
Client Reference	-	Compactive Effort	Standard
Material Description	(CI) Silty CLAY		

Maximum Dry Density (t/m³):	1.68
Optimum Moisture Content (%):	19.5
Field Moisture Content (%):	17.4
Sample Percent Oversize (%)	0.0
Oversize Included / Excluded	Excluded
Target Density Ratio (%):	95
Target Moisture Ratio (%):	100
Placement Dry Density (t/m³):	1.59
Placement Dry Density Ratio (%):	95.0
Placement Moisture Content (%):	20.3
Placement Moisture Ratio (%):	103.5
Test Condition / Soaking Period:	Soaked / 4 Days
CBR Surcharge (kg)	4.5
Dry Density After Soak (t/m³):	-
Total Curing Time (hrs)	n/a
Liquid Limit Method	Estimation
Moisture (top 30mm) After Soak (%)	27.5
Moisture (remainder) After Soak (%)	23.5
CBR Swell (%):	-
Minimum CBR Specification (%):	-
CBR Value @ 2.5mm (%):	**2.5**



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SHRINK SWELL INDEX

Client:	Cardno (NSW/ACT)	Report Number:	10848/R/4675-1
Client Address:	Level 9 - The Forum, 203 Pacific Highway, St. Leonards	Project Number:	10848/P/3
Project:	Laboratory Testing	Lot Number:	
Location:	Sydney, NSW	Internal Test Request:	10848/T/2849
Supplied To:	n/a	Client Reference/s:	50518098
Area Description:		Report Date / Page:	26/09/2018 Page 2 of 2

Test Procedures:	AS1289.7.1.1, AS1289.2.1.1	Client Sample ID	TP 4
Sample Number	10848/S/12310		0.5-0.7m
Sampling Method	Tested As Received		
Date Sampled	13/09/2018		
Sampled By	Client Sampled	Material Source	Not Supplied
Date Tested	24/09/2018	Material Type	CLAY

Soil Description:	(CH) Silty CLAY		
Cracking / Crumbling:	Nil		
Estimated Inert Inclusions (%):	0.00	Swell Pre-Soak Moisture Content (%)	20.5
Shrinkage Moisture Content (%):	20.3	Swell Post-Soak Moisture Content (%)	22.6

Shrinkage Strain (%)	3.4	Shrink / Swell Index	1.9
Swell Strain (%)	0.0		

Remarks

NATA

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Accreditation Number: 1318
Corporate Site Number: 10848

Approved Signatory: Luke Romano
Form ID: W21Rep Rev 1

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SHRINK SWELL INDEX

Client:	Cardno (NSW/ACT)	Report Number:	10848/R/4675-1
Client Address:	Level 9 - The Forum, 203 Pacific Highway, St. Leonards	Project Number:	10848/P/3
Project:	Laboratory Testing	Lot Number:	
Location:	Sydney, NSW	Internal Test Request:	10848/T/2849
Supplied To:	n/a	Client Reference/s:	50518098
Area Description:		Report Date / Page:	26/09/2018 Page 1 of 2

Test Procedures:	AS1289.7.1.1, AS1289.2.1.1	Client Sample ID	TP 6
Sample Number	10848/S/12309		0.4-0.6m
Sampling Method	Tested As Received		
Date Sampled	13/09/2018		
Sampled By	Client Sampled	Material Source	Not Supplied
Date Tested	24/09/2018	Material Type	CLAY

Soil Description:	(CL) Silty CLAY		
Cracking / Crumbling:	Nil		
Estimated Inert Inclusions (%):	0.00	Swell Pre-Soak Moisture Content (%)	14.1
Shrinkage Moisture Content (%):	15.2	Swell Post-Soak Moisture Content (%)	18.3

Shrinkage Strain (%)	1.6	Shrink / Swell Index	0.9
Swell Strain (%)	0.0		

Remarks

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Accreditation Number: 1318
Corporate Site Number: 10848

Approved Signatory: Luke Romano
Form ID: W21Rep Rev 1

APPENDIX

D

IMPORTANT INFORMATION

Important Information about this Geotechnical Report

Scope of Work

The purpose of this report and any associated documentation is expressly stated in the document. This document does not form a complete assessment of the site, and no implicit determinations about Cardno's scope can be taken if not specifically referenced. Whilst this report is intended to reduce geotechnical risk, no level of detail or scope of work can entirely eliminate risk.

The nature of geotechnical data typically precludes auxiliary environmental assessment without undertaking specific methods in the investigation. Therefore, unless it is explicitly stated in the scope of work, this report does not provide any contamination or environmental assessment of the site or adjacent sites, nor can it be inferred or implied from any component of the document.

The scope of work, geotechnical information, and assessments made by Cardno may be summarised in the report; however, all aspects of the document, including associated data and limitations should be reviewed in its entirety.

Standard of care

Cardno have undertaken investigations, performed consulting services, and prepared this report based on the Client's specific requirements, data that was available or was collected, and previous experience.

Cardno's findings and assessment represent its reasonable judgment, diligence, skill, with sound professional standards, within the time and budget constraints of its commission. No warranty, expressed or implied, is made as to the professional advice included in this report.

Data sources

In preparing this document, or providing any consulting services during the commission, Cardno may have relied on information from third parties including, but not limited to; sub-consultants, published data, and the Client including its employees or representatives. This data may not be verified and Cardno assumes no responsibility for the adequacy, incompleteness, inaccuracies, or reliability of this information.

Cardno does not assume any responsibility for assessments made partly, or entirely based on information provided by third parties.

Variability in conditions and limitations of data

Subsurface conditions are complex and can be highly variable; they cannot be accurately defined by discrete investigations. Geotechnical data is based on investigation locations which are explicitly representative of the specific sample or test points. Interpretation of conditions between such points cannot be assumed to represent actual subsurface information and there are unknowns or variations in ground conditions between test locations that cannot be inferred or predicted.

The precision and reliability of interpretive assessment between discrete points is dependent on the uniformity of the subsurface strata, as well as the frequency, detail, and method of sampling or testing.

Subsurface conditions are formed by various natural and anthropogenic processes and therefore are subject to change over time. This is particularly relevant with changes to the site ownership or usage, site boundary or layout, and design or planning modifications. Aspects of the site may also not be able to be determined due to physical or project related constraints and any information provided by Cardno cannot apply following modification to the site, regulations, standards, or the development itself.

It is important to appreciate that no level of detail in investigation, or diligence in assessment, can eliminate uncertainty related to subsurface conditions and thus, geotechnical risk. Cardno cannot and does not provide unqualified warranties nor does it assume any liability for site conditions not observed or accessible during the investigations.

Verification of opinions and recommendations

Geotechnical information, by nature, represents an opinion and is based extensively on judgment of both data and interpretive assessments or observation. This report and its associated documentation are provided explicitly based on Cardno's opinion of the site at the time of inspection, and cannot be extended beyond this.

Any recommendations or design are provided as preliminary until verified on site during project implementation or construction. Inspection and verification on site shall be conducted by a suitably qualified geotechnical consultant or engineer, and where subsurface conditions or interpretations differ from those provided in this document or otherwise anticipated, Cardno must be notified and be provided with an opportunity to review the recommendations.

Client and copyright

Appendix D

Explanatory Notes
Test Pit Logs for Current Investigation (Pits 101 – 115)
Borehole Logs for Current Investigation (Bores 201 and 202)

Terminology, Symbols and Abbreviations

November 2020

Introduction to Terminology, Symbols and Abbreviations

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

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

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

Abbreviation Codes

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

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

Data Integrity Codes

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

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

Graphic Symbols

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

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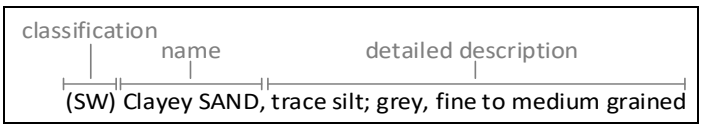
Introduction

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



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

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

Particle size designation and Behaviour Model

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

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

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

[1] – refer grain size subdivision descriptions below

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

Component proportions

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

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

[1] As defined in AS1726-2017 6.1.4.4

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

Composite Materials

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

Classification

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

Soil Name

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

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

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

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

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

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

Identification of minor components

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

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

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

Soil Composition

Plasticity

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

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

Grain Size

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

Grading

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

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

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Soil Condition

Moisture

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

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

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

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

Consistency/Density/Compaction/Cementation/Extremely Weathered Rock

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

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

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

Consistency (fine grained soils)

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

Relative Density (coarse grained soils)

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

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

Compaction (anthropogenically modified soil)

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

Cementation (natural and anthropogenic)

Cementation Term	Abbreviation Code
Moderately cemented	MCE
Weakly cemented	WKCE
Cemented	CE
Strongly bound	SB
Weakly bound	WB
Unbound	UB

Extremely Weathered Rock

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

Soil Origin

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

Cobbles and Boulders

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

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

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Rock Strength

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

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

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

[1] Assumes a ratio of 20:1 for UCS to $I_{s(50)}$. It should be noted that the UCS to $I_{s(50)}$ ratio varies significantly for different rock types and specific ratios may be required for each site.

On investigation logs only, the following data contiguity codes may be in rock strength tables for layers or seams of material "within rock", but for which the equivalent UCS strength is less than 0.6 MPa.

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

Degree of Weathering

The degree of weathering of rock is classified as follows:

Weathering Term	Description	Abbreviation Code
Residual Soil[1,2]	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.	RS
Extremely weathered[1,2]	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible	XW
Highly weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.	HW
Moderately weathered	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.	MW
Slightly weathered	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.	SW
Fresh	No signs of decomposition or staining.	FR
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathered products in pores.	DW

[1] AS1726-2017 6.1.9 provides similar definitions for "residual soil" and "extremely weathered material" as soil origins. Generally, the soil origin terms would be used above the depth at which very low strength or stronger rock material is first encountered, while both soil origin and weathering should may be stated for soil encountered below the first contact with rock material, where appropriate.

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

Degree of Alteration

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

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

Degree of Fracturing

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

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

Rock Quality Designation

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

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

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

Stratification Spacing

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

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

Defect Descriptions

Defect Type

Term	Abbreviation Code
Bedding plane	B
Clay seam	CS
Cleavage	CV
Crushed zone	CZ
Decomposed seam	DS
Fault	F
Joint	J
Lamination	LAM
Parting	PT
Sheared zone	SZ
Vein	VN
Drilling/handling break	DB , HB
Fracture	FCT

Rock Defect Orientation

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

Rock Defect Coating

Term	Abbreviation Code
Clean	CLN
Coating	CO
Healed	HE
Infilled	INF
Stained	STN
Tight	TI
Veneer	VEN

Rock Defect Infill

Term	Abbreviation Code
Calcite	CA
Carbonaceous	CBS
Clay	CLY
Iron oxide	FE
Manganese	MN
Silty	SLT

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Rock Defect Shape/Planarity

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

Rock Defect Roughness

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

Other Rock Defect Attributes

Term	Abbreviation Code
Fragmented	FG
Band	BND
Quartz	QTZ

Defect Orientation

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

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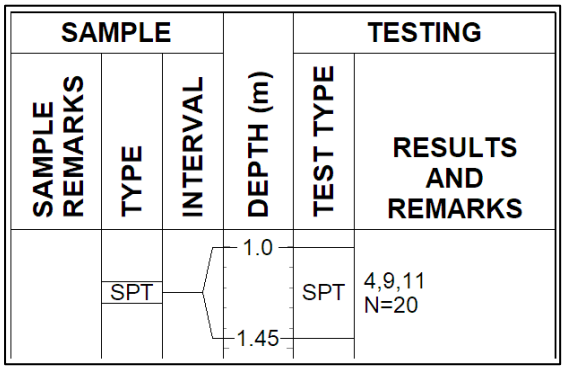
Sampling, Testing and Excavation Methodology

Terminology
Symbols
Abbreviations

November 2020

Sampling and Testing

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



Sampling

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

Sample Type	Code
Auger sample	A
Acid sulfate sample	ASS
Bulk sample	B
Core sample	C
Disturbed sample	D
Sample from SPT test	SPT
Environmental sample	E
Gas sample	G
Jar sample	J
Undisturbed tube sample	U[1]
Water sample	W
Piston sample	P
Core sample for unconfined compressive strength testing	UCS

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

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

Field and Laboratory Testing

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

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

Field and laboratory testing (continued)

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

Groundwater Observations

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

Drilling or Excavation Methods/Tools

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

Method	Abbreviation Code
Excavator/backhoe bucket	B[1]
Toothed bucket	TB[1]
Mud/blade bucket	MB[1]
Ripping tyne/ripper	RT
Rock breaker/hydraulic hammer	RB
Hand auger	HA[1]
NMLC series coring	NMLC
HMLC series coring	HMLC
NQ coring	NQ
HQ coring	HQ
PQ coring	PQ
Push tube	PT [1]
Rock roller	RR[1]
Solid flight auger. Suffixes: (TC) = tungsten carbide tip, (V) = v-shaped tip	SFA[1]
Sonic drilling	SON[1]
Vibrocore	VC[1]
Wash bore (unspecified bit type)	WB[1]
Existing exposure	X
Hand tools (unspecified)	HT
Predrilled	PD
Specialised bit (refer report)	SPEC[1]
Diatube	DT[1]
Hollow flight auger	HFA[1]
Vacuum excavation	VE

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

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 626.1 AHD
COORDINATE E:693514.9 **N:** 6107191.9
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 101
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	626 / 0.0	TOPSOIL/ (CL) Silty CLAY; dark brown; low plasticity; with rootlets		TOP	NA	=PL						
	0.15	(CI) CLAY, trace silt, trace sand; yellow brown mottled grey; clay fraction medium plasticity; sand fraction fine to medium; trace weathered siltstone		RES	F	>PL		B, D		0.4, 0.5, 0.6	DCP/150	5, 10, 15
					ST	>PL						
	1				VST	=PL		D		1.0		
	625 / 1.1	(CI) Sandy CLAY, trace silt; grey mottled brown; clay fraction medium plasticity; sand fraction fine to coarse		XWM	(ST TO VST)	<PL to =PL						
1.2 m depth, 26/04/23, Slow seepage	1.2											
	1.4	SILTSTONE: fine grained, grey, moist to wet, low strength, highly weathered, fractured, trace iron staining 1.3m: medium strength, moderately weathered						D		1.3		
		Test pit discontinued at 1.40m depth Bucket refusal										
	2 / 624									2		
	3 / 623									3		

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK
METHOD: 450mm wide toothed bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

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TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 626.3 AHD
COORDINATE E:693493.2 **N:** 6107165.9
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 102
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed	626 / 0.0	TOPSOIL/ (CL) Silty CLAY; dark brown; low plasticity; with rootlets		TOP	NA	<PL						
	0.15	(CI-CH) CLAY, with silt; dark brown; medium to high plasticity; with rootlets		ALV	F	>PL						
					ST	>PL		D		0.4	PP	330-390
	0.5	(CI-CH) CLAY, trace silt; yellow brown mottled grey; medium to high plasticity		RES	ST TO VST	>PL		D		0.8	PP	150-210
	1 / 1.1	Test pit discontinued at 1.10m depth Limit of investigation									DCP/150	

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK
METHOD: 450mm wide toothed bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 625.8 AHD
COORDINATE E:693473.9 **N:** 6107125.9
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 103
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed	625 / 0.0	TOPSOIL/ (CL) Silty CLAY; dark brown; low plasticity		TOP	NA	<PL						
	0.2	(CH) CLAY, with silt; black brown; high plasticity; with rootlets		ALV	F TO ST	>PL		D		0.5	PP / DCP	110-130
	0.6	(CI-CH) CLAY, trace sand, trace silt; yellow brown mottled grey; clay fraction medium to high plasticity; sand fraction fine to medium		RES	ST TO VST	>PL						
	1	1.4m: trace weathered siltstone fragments			VST	<PL to =PL		D		1.2	PP	210-230
	1.5 / 624	Test pit discontinued at 1.50m depth Limit of investigation										
	2 / 623											
	3 / 622											

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK
METHOD: 450mm wide toothed bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:50. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.2 AHD
COORDINATE E:693524.5 **N:** 6107122.2
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 104
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING AND REMARKS: TEST TYPE	RESULTS AND REMARKS
	627	0.0	TOPSOIL/ (CL) Silty CLAY, with sand; brown; clay fraction low plasticity; sand fraction fine to coarse; with rootlets		TOP	NA	<PL to =PL						
		0.15	(CL-CI) Silty CLAY, with sand, with gravel; red brown; clay fraction low to medium plasticity; sand fraction fine to coarse; gravel fraction fine to medium, rounded		ALV	H	<PL		D		0.3	DCP/150	22
		0.45	(CL-CI) Silty CLAY, with sand, trace gravel; yellow brown; clay fraction low to medium plasticity; sand fraction fine to coarse; gravel fraction fine; with rootlets		ALV	H	<PL		D		0.5		
		0.6	(GW) Sandy GRAVEL, trace silt, trace clay; brown; gravel fraction fine to coarse; sand fraction fine to coarse		ALV	MD	M		D		1.5		
⊻1	626	1.9	(Cl) Sandy Gravelly CLAY, with silt; brown; clay fraction medium plasticity; sand fraction fine to coarse, sub-rounded; gravel fraction fine to coarse		RES	S	>PL		D		2.0	PP	<50
1.9 m depth, 26/04/23, Moderate seepage	625	2.2	Test pit discontinued at 2.20m depth Limit of investigation										
	624	3									3		

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK

METHOD: 450mm wide toothed bucket

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

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Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.5 AHD
COORDINATE E:693550.6 **N:** 6107132.1
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 105
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING AND REMARKS: TEST TYPE	RESULTS AND REMARKS
	627	0.0	TOPSOIL/ (CL) Silty CLAY, trace sand; dark brown; clay fraction low plasticity; sand fraction fine to medium; with rootlets		TOP	NA	<PL					PP	>400
		0.3	(CL) Silty CLAY, trace sand; brown; clay fraction low plasticity; sand fraction fine to medium; trace rootlets		ALV	VST	<PL		D		0.35		
		0.4	(ML) Clayey SILT, with sand; pale brown; silt fraction low plasticity; sand fraction fine to coarse; trace rootlets, desiccated		ALV	H	<PL					DCP/150	
		0.7	(CI) Silty CLAY; yellow brown mottled grey; medium plasticity; trace rootlet, trace ironstone nodules, desiccated						D		0.8	PP	>400
		1									1		
	626		1.3m: grey mottled yellow		RES becoming XWM	H	<PL						
		2	1.9m: trace weathered siltstone fragments becoming extremely weathered, yellow brown mottled grey			VST	<PL to =PL		D		2.0 2.2	PP	220-300
2.3 m depth, 26/04/23, moderate seepage	625	2.3	SILTSTONE: fine grained, grey mottled black, wet, low to medium strength, highly weathered, highly fragmented, trace iron staining						D		2.9		
		3.0	Test pit discontinued at 3.00m depth Limit of investigation								3		
	624												

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK

METHOD: 450mm wide toothed bucket

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:50. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.4 AHD
COORDINATE E:693561.3 **N:** 6107159.7
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 106
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING AND REMARKS: TEST TYPE	RESULTS AND REMARKS
		0.0	TOPSOIL/FILL/ (CL) Silty CLAY, trace sand; dark brown; clay fraction low plasticity; sand fraction fine to medium; with rootlets		TOP and FILL	NA	<PL						
		0.25							D		0.25		
		0.3	FILL/ (CI-CH) CLAY, with silt, trace sand; yellow brown; clay fraction medium to high plasticity; sand fraction fine to medium; with rootlets		FILL	ST	>PL				0.3		
	627		TOPSOIL/ (ML) Clayey SILT, trace sand; pale grey brown; silt fraction low plasticity; sand fraction fine to medium; with rootlets		TOP	H	<PL		D		0.5	DCP/150 PP	>400
		0.6	(CI) Silty CLAY, trace sand, trace gravel; yellow brown; clay fraction medium plasticity; sand fraction fine to coarse; gravel fraction fine; trace weathered siltstone										
		1							D		1.0	PP	>400
	626		1.4m: extremely weathered material		RES becoming XWM	H	<PL						
1.9 m depth, 26/04/23, Moderate seepage		2.0	SILTSTONE: fine grained, grey brown, wet, very low to low strength, highly weathered, fractured						D		2.0		
	625		2.5m: medium strength, moderately weathered, with high strength fragments						D		2.5		
		2.6	Test pit discontinued at 2.60m depth Bucket refusal										
		3									3		
	624												

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK

METHOD: 450mm wide toothed bucket

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:50. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.4 AHD
COORDINATE E:693601.3 **N:** 6107189.5
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 107
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING AND REMARKS: TEST TYPE	TESTING AND REMARKS: RESULTS AND REMARKS
	627	0.0	TOPSOIL/ (CL) Silty CLAY; black brown; low plasticity; with rootlets		TOP	NA	<PL				0.0	DCP/150	5 10 15
		0.25	(CL-CI) Silty CLAY, trace sand; yellow brown; clay fraction low to medium plasticity; sand fraction fine to medium		ALV	ST TO VST	<PL				0.25		
		0.4	(CI) Silty CLAY, trace sand, trace gravel; orange grey brown; clay fraction medium plasticity; sand fraction fine to coarse; gravel fraction fine to medium; trace rootlets		ALV	VST TO H	<PL		B		0.4		
	626	1									0.6		
		1.5	(GW) Sandy GRAVEL, trace silt, trace clay; grey brown; gravel fraction fine to coarse; sand fraction fine to coarse; with weathered siltstone fragments		XWM	(D TO VD)	M to W		D		1.0		
1.7 m depth, 26/04/23, Moderate seepage		2.0	Test pit discontinued at 2.00m depth Limit of investigation						D		1.8		
	625	3									2		
	624										3		

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK
METHOD: 450mm wide toothed bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:50. TEMPLATE ID: DP_101.02.00_SOILLOG

Refer to explanatory notes for symbol and abbreviation definitions

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.7 AHD
COORDINATE E:693604.5 **N:** 6107147.8
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 108
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING AND REMARKS: TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed		0.0	TOPSOIL/ (CL) Silty CLAY, trace sand; brown; clay fraction low plasticity; sand fraction fine to medium; with rootlets		TOP	NA	<PL						
		0.2	(CI) Sandy Gravelly CLAY, trace silt; red brown; clay fraction medium plasticity; sand fraction fine to coarse; gravel fraction fine to medium; trace rootlets		ALV	ST	>PL						
						VST	<PL		D		0.5	DCP/150	5 10 15
		0.6	(GW) Sandy GRAVEL, trace silt, trace clay; grey brown; gravel fraction fine to coarse; sand fraction fine to coarse; with weathered siltstone fragments										12/100mm
	627				XWM	(D)	D to M		D		1.0		
	626	1											
		2.0	Test pit discontinued at 2.00m depth Limit of investigation								2		
	625	3									3		
	624												

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK

METHOD: 450mm wide toothed bucket

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:50. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.4 AHD
COORDINATE E:693578.8 **N:** 6107124.2
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 109
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING AND REMARKS: TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed	627	0.0	TOPSOIL/ (CL) Silty CLAY; brown; low plasticity; with rootlets		TOP	NA	<PL						
		0.25	(CL-CI) Sandy Gravelly CLAY; grey brown; clay fraction low to medium plasticity; sand fraction fine to coarse; gravel fraction fine to medium		ALV	VST TO H	<PL		D		0.3	DCP/150	5 10 15
		0.5	(CI) Silty CLAY, trace sand; yellow brown; clay fraction medium plasticity; sand fraction fine		RES	VST	<PL						
		1				H	<PL		D		1.0	PP	320-330
	626	1.3	(CI) Sandy Gravelly CLAY, trace silt; grey; clay fraction medium plasticity; sand fraction fine to coarse; gravel fraction fine to coarse; with weathered siltstone fragments, dessicated		XWM	H	<PL		D		1.7	PP	>400
		2.0	Test pit discontinued at 2.00m depth Limit of investigation								2		
	625	3									3		
	624												

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK

METHOD: 450mm wide toothed bucket

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:50. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.7 AHD
COORDINATE E:693629.1 **N:** 6107099.4
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 110
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed	627	0.0	TOPSOIL/ (CL) Silty CLAY, with sand; dark brown; clay fraction low plasticity; sand fraction fine to medium; with rootlets		TOP	NA	<PL					DCP/150	5 10 15
		0.2	(CI) Silty CLAY, with sand, trace gravel; red brown; clay fraction medium plasticity; sand fraction fine to coarse; gravel fraction fine and coarse		ALV	ST	>PL				0.4		
						VST	=PL		B D		0.5 0.6		
		0.6	(CI) Silty CLAY, with sand, with gravel; yellow brown; clay fraction medium plasticity; sand fraction fine to coarse; gravel fraction fine to coarse; trace ironstone nodules			VST	<PL						
		1			RES	H	<PL		D		1.0		
	626	1.7	SILTSTONE: fine grained, grey brown, moist, low strength, highly weathered, fractured						D		1.75		
		1.8	1.75m: medium strength, moderately weathered										
		2	Test pit discontinued at 1.80m depth Bucket refusal								2		
	625												
		3									3		
	624												

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK
METHOD: 450mm wide toothed bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:50. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 628.4 AHD
COORDINATE E:693604 **N:** 6107048.5
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 111
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING AND REMARKS: TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed		0.0	TOPSOIL/ (CL) Silty CLAY, with sand, trace gravel; dark brown; clay fraction low plasticity; sand fraction fine to coarse; gravel fraction fine, rounded		TOP	NA	<PL					DCP/150	5 10 15
	628	0.2	(GM) Silty GRAVEL, with sand; red brown; gravel fraction fine to coarse, rounded; sand fraction fine to coarse; with weathered siltstone fragments		ALV	D TO VD	D to M		D	0.5	0.5		22
		0.7	(SM) Silty SAND, with gravel; red brown; sand fraction fine to coarse; gravel fraction fine to coarse, rounded; with weathered siltstone fragments		ALV	VD	D to M		D	1.0	1.0		22
	627	1											
		1.2	Test pit discontinued at 1.20m depth Limit of investigation										
	626	2									2		
	625	3									3		

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK

METHOD: 450mm wide toothed bucket

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:51. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 628.2 AHD
COORDINATE E:693641.3 **N:** 6107014.7
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 112
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed	628 0.0	TOPSOIL/ (CL) Sandy CLAY, with silt; grey brown; low plasticity; with rootlets		TOP	NA	<PL					DCP/150	15/100mm (5, 10, 15)
	0.2	(CI) Silty CLAY, with sand; red brown; clay fraction medium plasticity; sand fraction fine to medium		ALV	(VST TO H)	<PL		D B		0.4 0.6		
	0.6	(CI) Sandy Silty CLAY, with gravel; yellow brown; clay fraction medium plasticity; sand fraction fine to coarse; gravel fraction fine to coarse, rounded; dessicated, trace weathered siltstone fragments		possibly XWM	H	<PL		D		1.0	PP	>400
	1.1 627	Test pit discontinued at 1.10m depth Limit of investigation										
	626											
	625											

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK
METHOD: 450mm wide toothed bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:51. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.8 AHD
COORDINATE E:693650.3 **N:** 6106971.9
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 113
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed	627 / 0.0	TOPSOIL/ (CL) Silty CLAY, with sand; dark brown; clay fraction low plasticity; sand fraction fine to medium; with rootlets		TOP	NA	<PL					DCP/150	5 10 15
	0.2	(CL) Silty CLAY, trace sand; pale grey brown; clay fraction low plasticity; sand fraction fine to medium		ALV	VST / ST	<PL / >PL		D		0.3		
	0.4	(CH) Silty CLAY, trace sand; yellow brown; clay fraction high plasticity; sand fraction fine to coarse		RES	VST	<PL		D		0.9		
	1 / 1.1	Test pit discontinued at 1.10m depth Limit of investigation								1		
	626 / 2									2		
	625 / 3									3		
	624											

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK
METHOD: 450mm wide toothed bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:51. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 628.9 AHD
COORDINATE E:693687.6 **N:** 6106964.8
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 114
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed		0.0	TOPSOIL/FILL/ (CL) Silty CLAY, with sand, trace gravel; dark brown; clay fraction low plasticity; sand fraction fine to coarse; gravel fraction fine, sub-rounded to rounded		TOP and FILL	NA	<PL to =PL					DCP/150	5 10 15 17/100mm
		0.15	FILL/ (CL-CI) Sandy Gravelly CLAY, with silt; pale brown; clay fraction low to medium plasticity; sand fraction fine to coarse; gravel fraction fine to coarse; with cobbles		FILL	(VST TO H)	<PL to =PL		D B		0.4		
	628	0.6	(GW) Sandy GRAVEL, with clay, trace silt; red brown; gravel fraction fine to coarse, sub-rounded to rounded; sand fraction fine to coarse; with weathered siltstone fragments		possibly XWM	(D TO VD)	D to M		D		0.6 0.8		
		1.0	Test pit discontinued at 1.00m depth Limit of investigation								1		
	627	2									2		
	626	3									3		
	625												

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK

METHOD: 450mm wide toothed bucket

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:51. TEMPLATE ID: DP_101.02.00_SOILLOG

TEST PIT LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 629.2 AHD
COORDINATE E:693713.7 **N:** 6106931.7
DATUM/GRID: MGA94 Zone 55

LOCATION ID: 115
PROJECT No: 220131.00
DATE: 26/04/23
SHEET: 1 of 1

CONDITIONS ENCOUNTERED								SAMPLE				TESTING AND REMARKS	
GROUNDWATER	RL (m) / DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) / DENSITY.(*)	MOISTURE	REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
26/04/23, No free groundwater observed	0.0 / 629	TOPSOIL/FILL/ (CL) Silty CLAY, with sand; dark brown; clay fraction low plasticity; sand fraction fine to medium		TOP and FILL	NA	<PL						
	0.15	FILL/ (CL) Silty CLAY, trace gravel, trace sand; grey brown; clay fraction low plasticity; gravel fraction fine; sand fraction fine to medium; trace rootlets		FILL	(ST)	>PL		D		0.3		
	0.35	(CI-CH) Silty CLAY, trace sand; red brown; clay fraction medium to high plasticity; sand fraction fine to coarse; trace rootlets, trace weathered siltstone fragments		RES	VST	<PL		D		0.5	DCP/150	5 10 15
	0.7	SILTSTONE: fine grained, grey brown, dry to moist, very low strength, highly weathered, fractured						D		1.0		
	1.1 / 628	Test pit discontinued at 1.10m depth Limit of investigation										
	2 / 627									2		
	3 / 626									3		

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

PLANT: CAT 306 CR mini-excavator
OPERATOR: Bingley Electrical Pty Ltd
LOGGED: JH/SK
METHOD: 450mm wide toothed bucket
REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.

EXPORTED 07/06/23 11:51. TEMPLATE ID: DP_101.02.00_SOILLOG

BOREHOLE LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 626.9 AHD
COORDINATE E:693582.7 **N:** 6107078.3
DATUM/GRID: MGA94 Zone 55
DIP/AZIMUTH: 90°/---

LOCATION ID: 201
PROJECT No: 220131.00
DATE: 19/04/23
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL ORIGIN(#)	SOIL CONSIS.(*) DENSITY.(*)	SOIL MOISTURE	ROCK WEATH.	ROCK DEPTH (m)	ROCK STRENGTH	ROCK RECOVERY (%)	ROCK RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	DEPTH (m)	TESTING TEST TYPE	TESTING RESULTS AND REMARKS
		0.0	TOPSOIL/ (CL) Silty CLAY, trace sand; dark brown; clay fraction low plasticity; sand fraction fine to medium; with rootlets		TOP	H	<PL													
		0.2	(CL-CI) Silty CLAY, with sand, trace gravel; brown; clay fraction low to medium plasticity; sand fraction fine to coarse; gravel fraction fine to medium		ALV	(ST)	>PL										A	0.4		
																		0.6		
		0.8	(CL-CI) Silty CLAY, with sand, with gravel; pale brown; clay fraction low to medium plasticity; sand fraction fine to coarse; gravel fraction fine to coarse		ALV	ST	>PL										A			
	626	1																1.0		
		1.3	(CL-CI) Gravelly Sandy CLAY, with silt; brown; clay fraction low to medium plasticity; gravel fraction fine to coarse; sand fraction fine to coarse		ALV	(ST TO VST)	=PL to >PL													SPT	9,7,8 N=15
	625	2															A	2.0		
		2.4	(CI) Silty CLAY, trace sand; grey mottled orange brown; clay fraction medium plasticity; sand fraction fine to medium; trace weathered siltstone fragments		RES	(VST)	<PL to =PL													SPT	10/100 (HB)
		2.6	SILTSTONE; grey, mottled brown; fine					HW-MW	2.6	L-M				2.6-2.76m: FCT FG						
									2.75											
	624	3						MW-SW		M-H	100	28		2.79-3.0m: J x4 20°-30° PL, SM, 60-80mm spacing 3.06-3.08m: CS 3.12-3.3m: J x5 50°-60° PL, SM, CLY INF, 30-50mm spacing 3.45m: J 0°-10° UN, RO, TI				3	PLT	PL(D)=1.8
																			PLT	PL(A)=1.9
														3.61-3.65m: J x2 60°-70° PL, SM 3.69-3.72m: DS 3.75m: J 0°-10° PL, SM, CLY INF 3.82-3.83m: J x2 60°-70° PL, SM, CLY INF 3.89-3.99m: FCT						
	623																			

2.0 m depth, 19/04/23, groundwater seepage observed

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

PLANT: Hanjin D&B 8D
OPERATOR: GE Drilling
LOGGED: JH/SK

METHOD: SFA to 2.6m, then NMLC to 6.3m
CASING: HQ to 2.6m

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.
* Rock failed along plane of pre-existing weakness during point load test.

BOREHOLE LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 626.9 AHD
COORDINATE E:693582.7 **N:** 6107078.3
DATUM/GRID: MGA94 Zone 55
DIP/AZIMUTH: 90°/---

LOCATION ID: 201
PROJECT No: 220131.00
DATE: 19/04/23
SHEET: 2 of 2

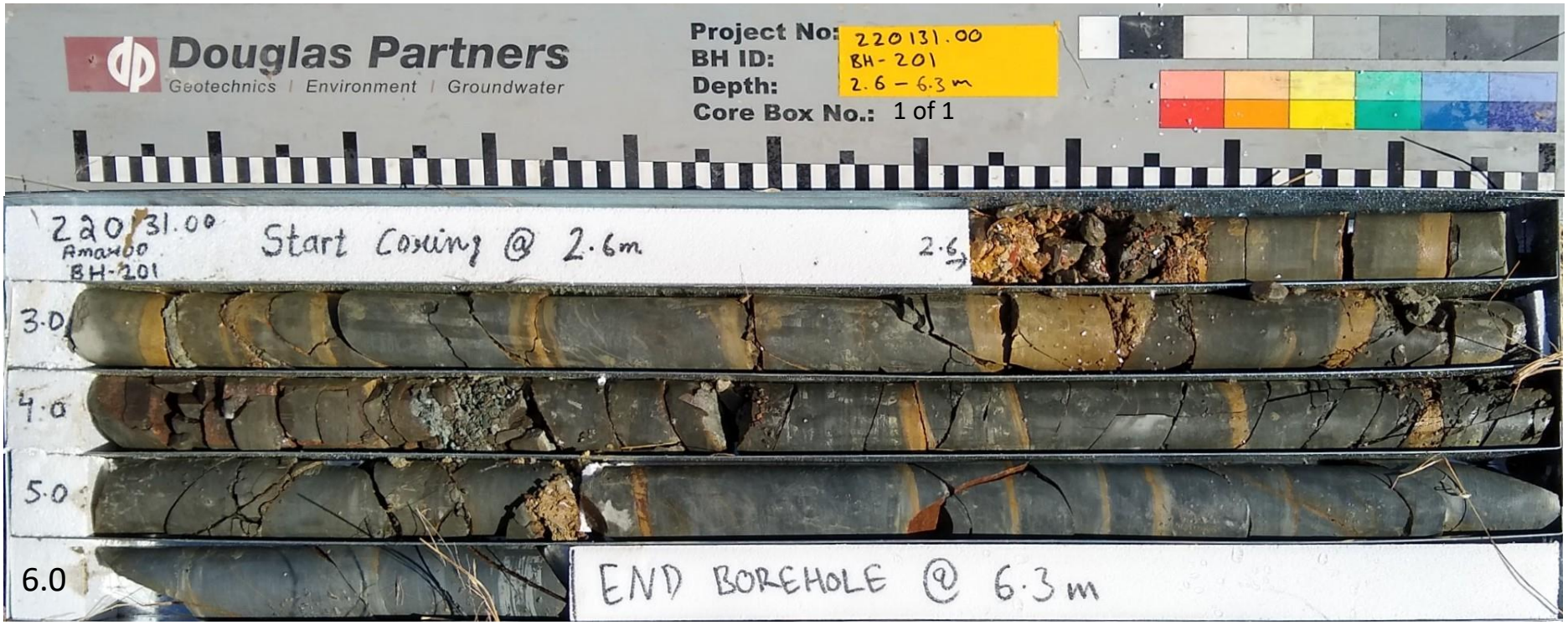
CONDITIONS ENCOUNTERED																		SAMPLE				TESTING	
				SOIL				ROCK															
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH VL L M H VH EH	RECOVERY (%)	RQD	FRACTURE SPACING (m) 0.01 0.05 0.10 0.50 1.00 5.00	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	622	5	SILTSTONE; grey, mottled brown; fine *(continued)*					MW-SW		M-H	100	0		4.0m: DB 4.0-4.24m: FCT 4.24-4.3m: CS/DS 4.3-5.3m: FCT 5.3m: DB				5	PLT	PL(A)=0.56*
	621	6						SW-FS	5.4	H	100	53		5.58m: J 30°-40° PL, SM, INF 5.62m: J 60°-70° PL, RO, TI 5.66m: J 30°-40° PL, SM, TI 5.77m: J 40°-50° PL, SM, TI 5.87-5.9m: J x2 40°-50° PL, SM, TI				6	PLT PLT	PL(D)=0.72* PL(A)=2.5
	620	7	Borehole discontinued at 6.30m depth Limit of investigation						6.3					6.17-6.3m: J x4 40°-50° PL, SM, TI, 40-60mm spacing				7		
	619																			

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

PLANT: Hanjin D&B 8D
OPERATOR: GE Drilling
LOGGED: JH/SK

METHOD: SFA to 2.6m, then NMLC to 6.3m
CASING: HQ to 2.6m

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.
* Rock failed along plane of pre-existing weakness during point load test.


Douglas Partners
Geotechnics | Environment | Groundwater
Project No: 220131.00
BH ID: BH-201
Depth: 2.6 – 6.3 m
Core Box No.: 1 of 1
220131.00
Amaroo
BH-201
Start Coring @ 2.6m
2.6
3.0
4.0
5.0
6.0
END BOREHOLE @ 6.3 m

BOREHOLE LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.3 AHD
COORDINATE E:693586.8 **N:** 6107094.7
DATUM/GRID: MGA94 Zone 55
DIP/AZIMUTH: 90°/---

LOCATION ID: 202
PROJECT No: 220131.00
DATE: 19/04/23
SHEET: 1 of 2

GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	SOIL ORIGIN(#)	SOIL CONSIS.(*) DENSITY.(*)	SOIL MOISTURE	ROCK WEATH.	ROCK DEPTH (m)	ROCK STRENGTH	ROCK RECOVERY (%)	ROCK RQD	FRACTURE SPACING (m)	DEFECTS & REMARKS	SAMPLE REMARKS	SAMPLE TYPE	SAMPLE INTERVAL	TESTING DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
19/04/23, No free groundwater observed		0.0	TOPSOIL/ (CL) Silty CLAY, trace sand; dark brown; clay fraction low plasticity; sand fraction fine to medium; with rootlets		TOP	NA	=PL													
	627	0.3	(CI-CH) Silty CLAY, trace sand; yellow brown; clay fraction medium to high plasticity; sand fraction fine to medium; trace ironstone nodules		RES	(VST TO H)	<PL									A	0.5			
		0.6	(CI) Silty CLAY, trace sand, trace gravel; orange brown; clay fraction medium plasticity; sand fraction fine to medium; trace weathered siltstone fragments		XWM	(VST TO H)	<PL									A	0.6			
		1																1.0	SPT	14/60 (HB)
	626	1.4	SILTSTONE; grey brown; fine					MW-SW	1.4	M-H	100	59		1.42m: J 20°-30° UN, RO 1.58m: J 50°-60° PL, SM 1.63m: J 50°-60° PL 1.72m: J 20°-30° UN, RO 1.72-1.77m: CS 1.83m: J 20°-30° UN, RO, TI					PLT	PL(A)=1.0*
																			PLT	PL(D)=1.2
		2												2.0m: J 20°-30° UN, RO				2		
	625													2.36-2.39m: CS 2.45m: J 60°-70° CU, RO 2.55m: J x2 60°-70° CU/UN, RO						
		3												2.77m: J 50°-60° UN, RO, CLY INF 2.77-2.9m: FCT 2.9m: DB 3.0m: HB 3.02-3.09m: CS				3	PLT	PL(D)=1.2
	624										100	70		3.21-3.24m: FCT FG						
														3.53-3.68m: FCT 3.69m: DB 3.74m: J 10°-20° PL, RO, TI						
											100	59		3.93m: J 0°-10° UN, RO					PLT	PL(A)=0.52*

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

PLANT: Hanjin D&B 8D
METHOD: SFA to 1.4m, then NMLC to 5.1m
OPERATOR: GE Drilling
CASING: HQ to 1.4m
LOGGED: JH/SK

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.
Auger refusal at 1.4m.
*Rock failed along plane of pre-existing weakness during point load test.

BOREHOLE LOG

CLIENT: Stantec Australia Pty Ltd
PROJECT: Proposed Gungahlin Tennis Facility
LOCATION: Part Block 4 Section 109, Amaroo

SURFACE LEVEL: 627.3 AHD
COORDINATE E:693586.8 **N:** 6107094.7
DATUM/GRID: MGA94 Zone 55
DIP/AZIMUTH: 90°/---

LOCATION ID: 202
PROJECT No: 220131.00
DATE: 19/04/23
SHEET: 2 of 2

CONDITIONS ENCOUNTERED																				SAMPLE				TESTING	
				SOIL				ROCK																	
GROUNDWATER	RL (m)	DEPTH (m)	DESCRIPTION OF STRATA	GRAPHIC	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE	WEATH.	DEPTH (m)	STRENGTH VL L M H VH EH	RECOVERY (%)	RQD	FRACTURE SPACING (m) 0.01 0.05 0.10 0.50 1.00 5.00	DEFECTS & REMARKS	SAMPLE REMARKS	TYPE	INTERVAL	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
	623		SILTSTONE; grey brown; fine *(continued)*					MW-SW		M-H				4.0m: J 20°-30° PL, SM 4.06-4.12m: FCT/CS x2 4.22m: J 20°-30° PL, SM, TI 4.32-4.35m: CS					PLT	PL(D)=1.1
											100	59		4.5m: J 10°-20° CU, SM, TI 4.54-4.56m: CS 4.6m: J 50°-60° UN, SM, TI 4.66-4.69m: FCT						
									4.8					4.76m: J 30°-40° ST, RO, TI					PLT	PL(D)=2.1
		5						SW-FS		H				4.91-5.0m: FCT 5.0m: HB 5.0-5.1m: FCT/HB				5		
		5.1	Borehole discontinued at 5.10m depth Limit of investigation						5.1											
	622																			
		6																6		
	621																			
		7																7		
	620																			

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

PLANT: Hanjin D&B 8D
OPERATOR: GE Drilling
LOGGED: JH/SK

METHOD: SFA to 1.4m, then NMLC to 5.1m
CASING: HQ to 1.4m

REMARKS: Surface levels and coordinates are approximate only and must not be relied upon.
Auger refusal at 1.4m.
*Rock failed along plane of pre-existing weakness during point load test.


Douglas Partners
Geotechnics | Environment | Groundwater
Project No: 220131.00
BH ID: BH 202
Depth: 1.4-5.1m
Core Box No.: 1 of 1
220131.00
Amaroo
BH-202
Start Coring @ 1.4m
1.4
2.0
3.0
4.0
5.0
END BOREHOLE @ 5.1m

Appendix E

Results of Laboratory Testing

Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Goulburn Laboratory
54 Sinclair Street Goulburn NSW 2580
Phone: 02 4822 8395
Email: Nicole.Purton@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Nicole Purton
Laboratory Manager
Laboratory Accreditation Number: 828

Report Number: **220131.00-1**
Issue Number: 1
Date Issued: 17/05/2023
Client: Stantec Australia Pty Ltd
Stantec Australia Pty Ltd, Canberra ACT 2601
Contact: John Sutcliffe
Project Number: 220131.00
Project Name: Proposed Gungahlin Tennis Facility
Project Location: Part Block 4 Section 109, Amaroo ACT
Work Request: 8658
Sample Number: GU-8658A
Date Sampled: 02/05/2023
Dates Tested: 02/05/2023 - 12/05/2023
Sample Location: **Pit 103 , Depth: 0.4 - 0.6m**
Material: Clay

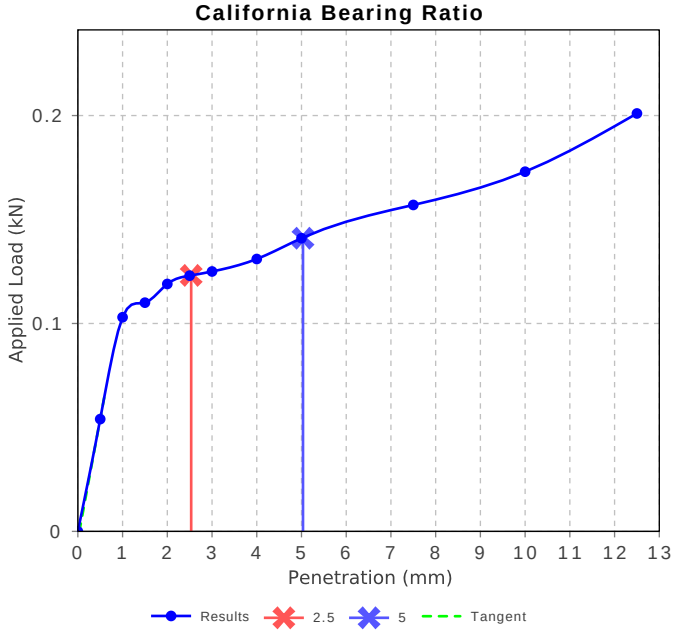
California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**1.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.48		
Optimum Moisture Content (%)	29.5		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.47		
Field Moisture Content (%)	27.6		
Moisture Content at Placement (%)	29.6		
Moisture Content Top 30mm (%)	31.2		
Moisture Content Rest of Sample (%)	30.3		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	96.0		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
2.36 mm	**100**		
1.18 mm	**100**		
0.6 mm	**99**		
0.425 mm	**99**		
0.3 mm	**99**		
0.15 mm	**99**		
0.075 mm	**98**		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	62		
Plastic Limit (%)	22		
Plasticity Index (%)	**40**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**9.5**		
Cracking Crumbling Curling	Cracking		

California Bearing Ratio



Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		
* Mineral Present	Carbonate and Gypsum		

Material Test Report

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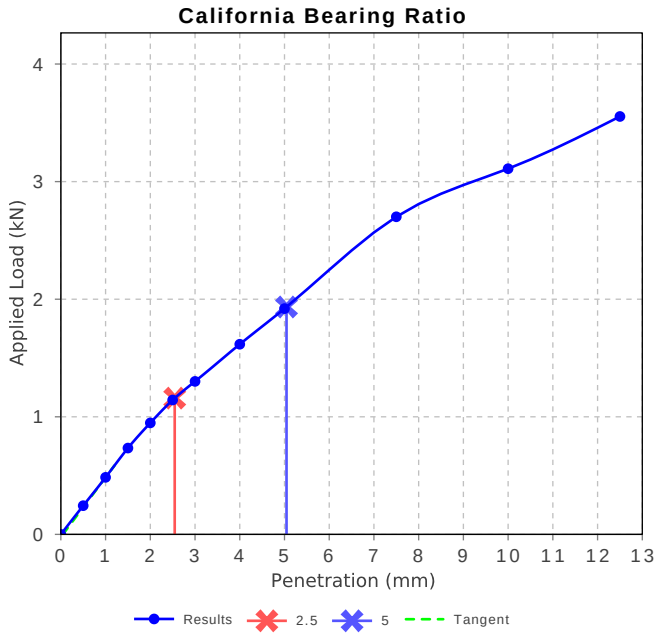
Stantec Australia Pty Ltd, Canberra ACT 2601
Contact: John Sutcliffe
Project Number: 220131.00
Project Name: Proposed Gungahlin Tennis Facility
Project Location: Part Block 4 Section 109, Amaroo ACT
Work Request: 8658
Sample Number: GU-8658B
Date Sampled: 02/05/2023
Dates Tested: 02/05/2023 - 12/05/2023
Sample Location: **Pit 110 , Depth: 0.4 - 0.6m**
Material: Silty Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**10**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.89		
Optimum Moisture Content (%)	14.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.88		
Field Moisture Content (%)	10.4		
Moisture Content at Placement (%)	14.2		
Moisture Content Top 30mm (%)	16.6		
Moisture Content Rest of Sample (%)	16.4		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	48.0		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Silty Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		
* Mineral Present	Carbonate and Gypsum		



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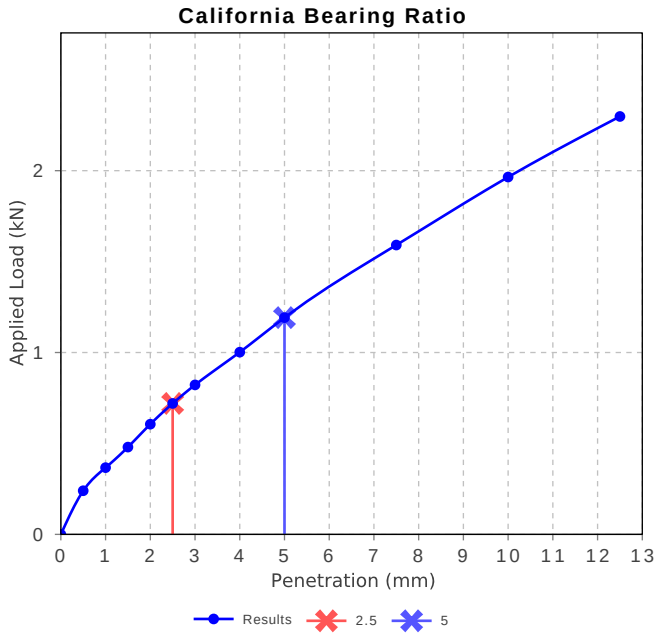
Client: Stantec Australia Pty Ltd
Stantec Australia Pty Ltd, Canberra ACT 2601
Contact: John Sutcliffe
Project Number: 220131.00
Project Name: Proposed Gungahlin Tennis Facility
Project Location: Part Block 4 Section 109, Amaroo ACT
Work Request: 8658
Sample Number: GU-8658C
Date Sampled: 02/05/2023
Dates Tested: 02/05/2023 - 12/05/2023
Sample Location: **Pit 112 , Depth: 0.4 - 0.6m**
Material: Silty Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**6**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.79		
Optimum Moisture Content (%)	16.5		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.78		
Field Moisture Content (%)	13.2		
Moisture Content at Placement (%)	16.6		
Moisture Content Top 30mm (%)	18.8		
Moisture Content Rest of Sample (%)	17.8		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	120.0		
Swell (%)	1.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Silty Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		
* Mineral Present	Carbonate and Gypsum		



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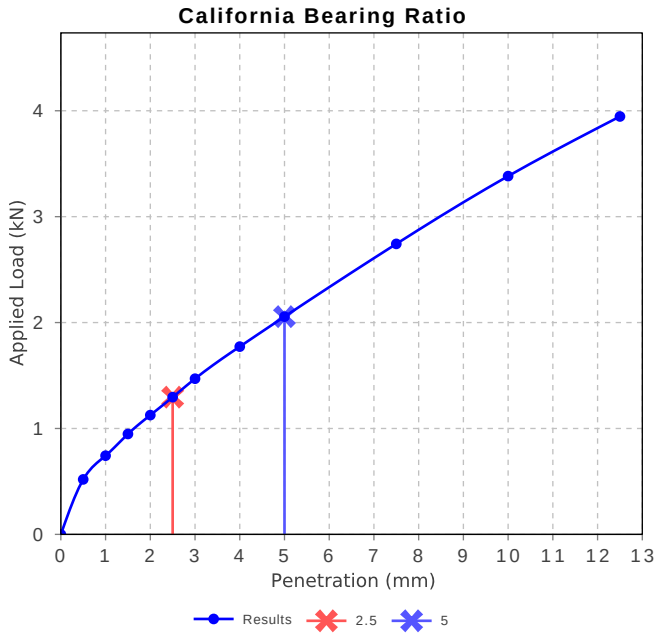
Date Issued: 17/05/2023
Client: Stantec Australia Pty Ltd
Stantec Australia Pty Ltd, Canberra ACT 2601
Contact: John Sutcliffe
Project Number: 220131.00
Project Name: Proposed Gungahlin Tennis Facility
Project Location: Part Block 4 Section 109, Amaroo ACT
Work Request: 8658
Sample Number: GU-8658D
Date Sampled: 02/05/2023
Dates Tested: 02/05/2023 - 12/05/2023
Sample Location: **Pit 114 , Depth: 0.4 - 0.6m**
Material: Fill/Sandy Gravelly Clay

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**10**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual Assessment		
Maximum Dry Density (t/m^3)	1.87		
Optimum Moisture Content (%)	15.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.87		
Field Moisture Content (%)	14.2		
Moisture Content at Placement (%)	14.9		
Moisture Content Top 30mm (%)	16.7		
Moisture Content Rest of Sample (%)	15.6		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	48.4		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	28.4		

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Fill/Sandy Gravelly Clay		
Nature of Water	Distilled		
Temperature of Water (^{o}C)	19		
* Mineral Present	Carbonate and Gypsum		



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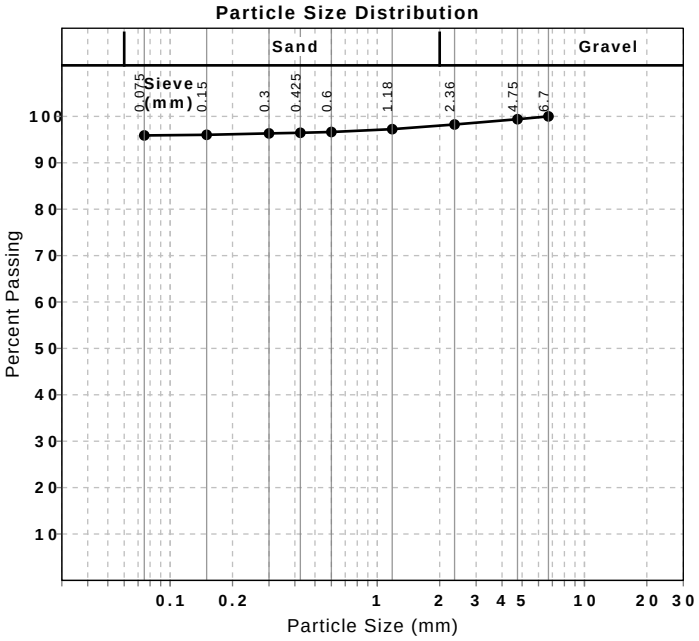
Date Issued:	17/05/2023
Client:	Stantec Australia Pty Ltd
	Stantec Australia Pty Ltd, Canberra ACT 2601
Contact:	John Sutcliffe
Project Number:	220131.00
Project Name:	Proposed Gungahlin Tennis Facility
Project Location:	Part Block 4 Section 109, Amaroo ACT
Work Request:	8658
Sample Number:	GU-8658E
Date Sampled:	02/05/2023
Dates Tested:	02/05/2023 - 08/05/2023
Sample Location:	**Pit 106 , Depth: 1.0m**
Material:	Silty Clay

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
6.7 mm	**100**		
4.75 mm	**99**		
2.36 mm	**98**		
1.18 mm	**97**		
0.6 mm	**97**		
0.425 mm	**96**		
0.3 mm	**96**		
0.15 mm	**96**		
0.075 mm	**96**		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	48		
Plastic Limit (%)	22		
Plasticity Index (%)	**26**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**10.5**		
Cracking Crumbling Curling	Cracking		



Material Test Report

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Laboratory Manager
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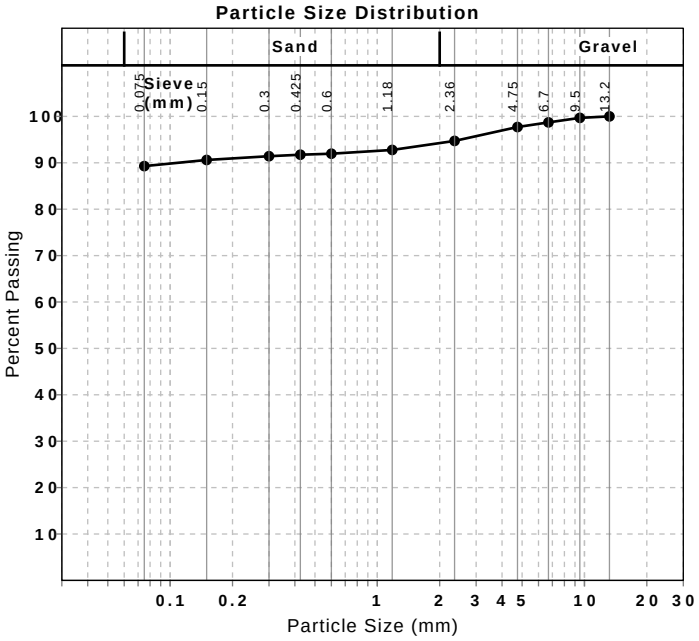
Report Number: **220131.00-1**
Issue Number: 1
Date Issued: 17/05/2023
Client: Stantec Australia Pty Ltd
Stantec Australia Pty Ltd, Canberra ACT 2601
Contact: John Sutcliffe
Project Number: 220131.00
Project Name: Proposed Gungahlin Tennis Facility
Project Location: Part Block 4 Section 109, Amaroo ACT
Work Request: 8658
Sample Number: GU-8658F
Date Sampled: 02/05/2023
Dates Tested: 02/05/2023 - 08/05/2023
Sample Location: **Pit 107 , Depth: 1.0m**
Material: Sandy Clay

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
13.2 mm	**100**		
9.5 mm	**100**		
6.7 mm	**99**		
4.75 mm	**98**		
2.36 mm	**95**		
1.18 mm	**93**		
0.6 mm	**92**		
0.425 mm	**92**		
0.3 mm	**91**		
0.15 mm	**91**		
0.075 mm	**89**		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	38		
Plastic Limit (%)	20		
Plasticity Index (%)	**18**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**9.0**		
Cracking Crumbling Curling	Cracking		



Material Test Report

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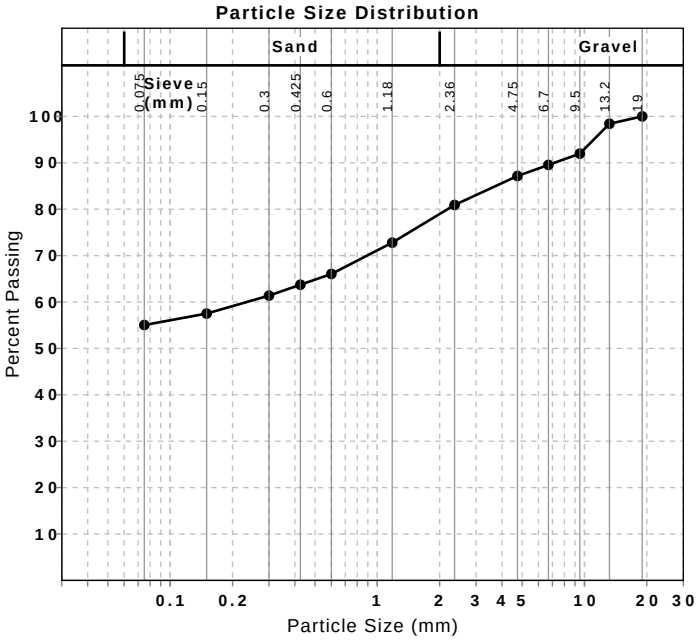
Stantec Australia Pty Ltd, Canberra ACT 2601
Contact: John Sutcliffe
Project Number: 220131.00
Project Name: Proposed Gungahlin Tennis Facility
Project Location: Part Block 4 Section 109, Amaroo ACT
Work Request: 8658
Sample Number: GU-8658G
Date Sampled: 02/05/2023
Dates Tested: 02/05/2023 - 08/05/2023
Sample Location: **Pit 110 , Depth: 1.0m**
Material: Silty Clay

Particle Size Distribution (AS1289 3.6.1)			
Sieve	Passed %	Passing Limits	
19 mm	**100**		
13.2 mm	**98**		
9.5 mm	**92**		
6.7 mm	**90**		
4.75 mm	**87**		
2.36 mm	**81**		
1.18 mm	**73**		
0.6 mm	**66**		
0.425 mm	**64**		
0.3 mm	**61**		
0.15 mm	**58**		
0.075 mm	**55**		

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried / Air Dried / Natural / Unknown		
Preparation Method			
Liquid Limit (%)	32		
Plastic Limit (%)	19		
Plasticity Index (%)	**13**		

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**7.5**		
Cracking Crumbling Curling	None		



Material Test Report

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Contact: John Sutcliffe
Project Number: 220131.00
Project Name: Proposed Gungahlin Tennis Facility
Project Location: Part Block 4 Section 109, Amaroo ACT
Work Request: 8658
Dates Tested: 02/05/2023 - 03/05/2023
Location: Part Block 4 Section 109, Amaroo

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Moisture Content AS 1289 2.1.1

Sample Number	Sample Location	Moisture Content (%)	Min	Max	Material
GU-8658A	Pit 103 , Depth: 0.4 - 0.6m	27.6 %	**	**	Clay
GU-8658B	Pit 110 , Depth: 0.4 - 0.6m	10.4 %	**	**	Silty Clay
GU-8658C	Pit 112 , Depth: 0.4 - 0.6m	13.3 %	**	**	Silty Clay
GU-8658D	Pit 114 , Depth: 0.4 - 0.6m	14.2 %	**	**	Fill/Sandy Gravelly Clay
GU-8658E	Pit 106 , Depth: 1.0m	15.4 %	**	**	Silty Clay
GU-8658F	Pit 107 , Depth: 1.0m	10.3 %	**	**	Sandy Clay
GU-8658G	Pit 110 , Depth: 1.0m	11.3 %	**	**	Silty Clay

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12 Ashley St Chatswood NSW 2067
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CERTIFICATE OF ANALYSIS 322295

Client Details

Client	Douglas Partners Canberra
Attention	Guanghui Meng
Address	Unit 2, 73 Sheppard St,, HUME, ACT, 2620

Sample Details

Your Reference	**220131.00 Amaroo**
Number of Samples	3 Soil
Date samples received	04/05/2023
Date completed instructions received	04/05/2023

Analysis Details

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

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

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

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	11/05/2023
Date of Issue	17/05/2023
Reissue Details	This report replaces R00 created on 11/05/2023 due to: sample ID error

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil				
Our Reference		322295-1	322295-2	322295-3
Your Reference	UNITS	Bore 201	Bore 201	Bore 202
Depth		2	3.1-3.2	1.7-1.85
Date Sampled		19/04/2023	19/04/2023	19/04/2023
Type of sample		Soil	Soil	Soil
Date prepared	-	10/05/2023	10/05/2023	10/05/2023
Date analysed	-	10/05/2023	10/05/2023	10/05/2023
pH 1:5 soil:water	pH Units	8.2	9.0	8.7
Electrical Conductivity 1:5 soil:water	µS/cm	30	85	13
Chloride, Cl 1:5 soil:water	mg/kg	<10	<10	<10
Sulphate, SO4 1:5 soil:water	mg/kg	10	10	<10

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25°C in accordance with APHA latest edition 2510 and Rayment & Lyons.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			10/05/2023	2	10/05/2023	10/05/2023		10/05/2023	[NT]
Date analysed	-			10/05/2023	2	10/05/2023	10/05/2023		10/05/2023	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	2	9.0	9.1	1	101	[NT]
Electrical Conductivity 1:5 soil:water	µS/cm	1	Inorg-002	<1	2	85	71	18	104	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	<10	<10	0	97	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	2	10	10	0	97	[NT]

Result Definitions

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

Quality Control Definitions

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

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

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

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

Laboratory Acceptance Criteria

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

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

Spikes for Physical and Aggregate Tests are not applicable.

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

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

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

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

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

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

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

Measurement Uncertainty estimates are available for most tests upon request.

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

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

Report Comments

pH analysed outside holding time