REPORT TO

NSW DEPARTMENT OF EDUCATION

ON

GEOTECHNICAL INVESTIGATION

FOR

NEW HIGH SCHOOL IN BUNGENDORE

AT

BIRCHFIELD DRIVE, BUNGENDORE, NSW

Date: 4 February 2025
Ref: 37083LTrptRev1

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1 CLIENT SUPPLIED INTRODUCTION

This geotechnical report been prepared to support a Review of Environmental Factors (REF) for the NSW Department of Education (DoE) for the construction and operation of the new Bungendore High School (the activity).

We understand that the purpose of the REF is to assess the potential environmental impacts of the activity prescribed by *State Environmental Planning Policy (Transport and Infrastructure) 2021* (T&I SEPP) as "development permitted without consent" on land carried out by or on behalf of a public authority under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The activity is to be undertaken pursuant to Chapter 3, Part 3.4, Section 3.37A of the T&I SEPP.

The purpose of this report is to provide comments and recommendations on excavation, groundwater, retention, earthworks, footings, floor slabs and pavements.

1.1 Proposed Activity Description

The proposed activity is for the construction and operation of a new high school in Bungendore at part 18 Harp Avenue, Bungendore (the site). The new high school will accommodate 600 students and 68 staff. The school will provide 26 general learning spaces, and three support learning spaces across two buildings. The buildings will be predominantly three-storeys in height and will include permanent and support teaching spaces, specialist learning hubs, a library, administrative areas and a staff hub.

Additional core facilities are also proposed including a standalone school hall with covered outdoor learning area (COLA), a car park, a kiss and drop zone along Birchfield Drive, sports courts and a sports field. The new school also features a single storey building with associated paddocks in the far western portion of the site designed for livestock management and hands-on agricultural learning.

Specifically, the proposal involves the following:

- Building A, a three-storey learning hub accommodating general learning spaces, a special education learning unit (SELU), a physical education centre, a performing arts space, and other core facilities including administrative areas, staff hub, library and end of trip facilities.
- Building B, a part three/part four storey learning hub accommodating general learning spaces, specialist workshops for food, textile, wood and metal workshops, as well as visual arts studios, science labs and staff areas.
- Building C, a standalone school hall with COLA.
- Building D, a single-storey agricultural block comprising an animal storage space, a COLA and internal workshop.
- On-site staff car park with 50 spaces with access via Bridget Avenue.

- Kiss and drop zones and bus bays along Birchfield Drive.
- Open play space including a sports courts and sports field.
- Associated utilities and services including a 1000kV padmount substation.
- Main pedestrian entrance to be located off Birchfield Drive.
- Secondary pedestrian access from Bridget Avenue.
- Public domain/off-site works including the removal of street trees.

The design has been master-planned to allow for an additional future stage. The second stage does not form part of this proposal.

Figure A provides an extract of the proposed site plan.

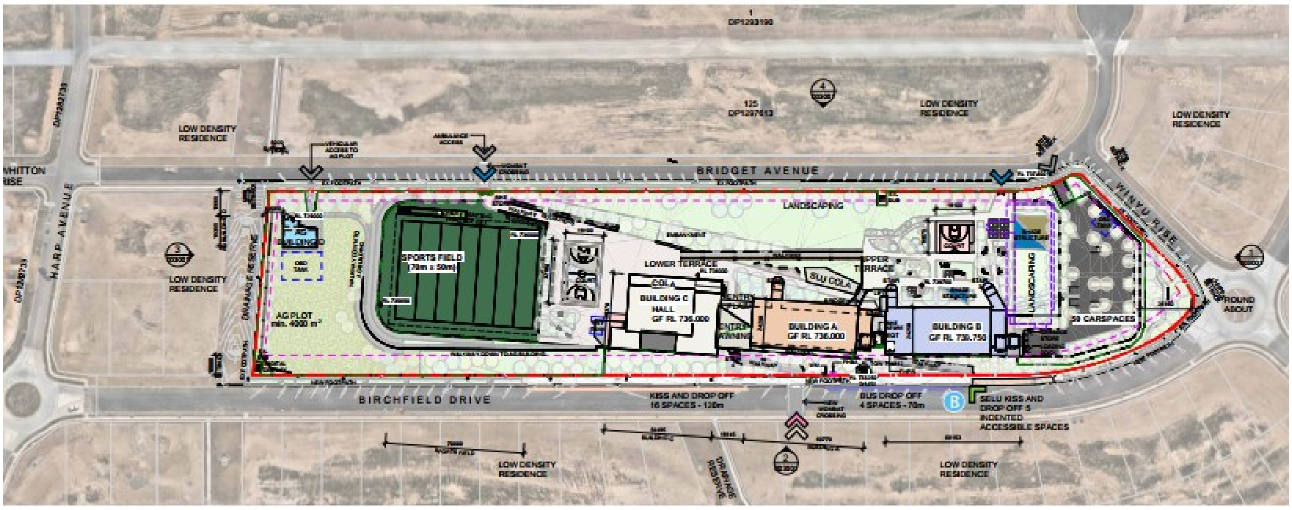

Figure A: Site Plan, Source: NBRS, 2025

2 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed new high school in Bungendore at Birchfield Avenue, Bungendore, NSW. The current street address is part of 18 Harp Avenue, Bungendore, NSW, 2621 (the site) and is legally described as part Lot 125 in Deposited Plan 1297613. The location of the site is shown in Figure 1. The geotechnical investigation was commissioned by School Infrastructure NSW (SINSW) on behalf of the NSW Department of Education.

We have been supplied with the architectural drawings prepared by NBRS (Drawing Refs. BHS-NBRS-ZZ-GF-DR-A-001000, BHS-NBRS-ZZ-L1-DR-A-001001, BHS-NBRS-ZZ-L2-DR-A-001002, BHS-NBRS-ZZ-L3-DR-A-001003 and BHS-NBRS-ZZ-ZZ-DR-A-4001, Revision C dated 22 January 2025). From the architectural drawings, we understand that the proposed activity will comprise:

- Formation of two relatively level terraces within the central portion of the site for the main building area. The upper terrace has a proposed surface level of RL739.75m and the lower terrace has a proposed level of RL736m. Cut and fill earthworks will be required to form these levels with excavation up to approximately 5.5m and filling up to 4m, although generally excavation will be less than 4m and filling less than 3m. Between the terraces surface levels are proposed to step down through retaining walls.
- Within the northern portion of the site excavation will be required to grade levels from Bridget Avenue to the upper and lower terraces. Depending on preference, this proposed excavation may be achieved using either batter slopes or an in-situ retention system.
- Construction of two (2) three-storey buildings (Buildings A and B) within the eastern portion of the site. Building A will be constructed on the lower terrace and Building B on the upper terrace with proposed floor levels of RL736m and RL740m respectively.
- Construction of a hall (Building C) adjacent to the western end of Building A on the lower terrace with a proposed ground floor level at RL736m.
- Construction of two multi-sports courts one west of Building C on the lower terrace and one north of Building B on the upper terrace.
- Within the western portion of the site, a large sports field is proposed with surface levels in the order of RL736m. To form the sports field will require cut and fill earthworks with up to approximately 2m of excavation required in the north-eastern corner and up to 8m of fill at the south-western corner.
- Construction of an agricultural building (Building D) in the western end of the site. The proposed floor level of this building is RL729m which will require filling to heights of approximately 3m to 4.5m above existing surface levels.
- A link bridge is proposed from the upper terrace to the north-eastern corner of Building A and Level 1.
- Installation of OSD tanks adjacent to Building D and within the carpark at the eastern end of the site.
- Construction of an on-grade carpark with access from Bridget Avenue at the eastern end of the site. To achieve the design levels cut and fill earthworks will be required which generally appear to be within 1m to 2m of existing levels, although fill up to about 3m in height will be required towards the eastern edge of the carpark.

The purpose of the investigation was to obtain geotechnical information on the subsurface conditions as a basis for providing comments and recommendations on excavation, groundwater, retention, earthworks, footings, floor slabs and pavements.

This geotechnical investigation was carried out in conjunction with an environmental site assessment by our environmental division, JK Environments (JKE). Reference should be made to the separate reports by JKE, Ref: E37084PT, for the results of the environmental site assessments.

3 INVESTIGATION PROCEDURE

The fieldwork for the investigation comprised the drilling of thirty-five boreholes (BH1 to BH35 inclusive) to depths ranging from 1.85m to 21.5m below existing surface levels. The boreholes were drilled using our track-mounted JK308 and truck-mounted JK500 drilling rigs. All boreholes were initially advanced through the soils and upper weathered bedrock using spiral auger drilling techniques and a Tungsten Carbide (TC) bit. Six boreholes (BH8, BH11, BH17, BH19, BH26 and BH28) were then extended to the final depths by rotary diamond coring techniques, using an NMLC triple tube core barrel and water flush.

The borehole locations, as shown on the attached Figure 2, and reduced levels, as shown on the borehole logs, were obtained by a differential GPS unit. The height datum is Australian Height Datum.

Obtaining undisturbed tube samples in the generally hard residual silty clay was limited as the thin-wall steel tubes used for obtaining the samples frequently buckled or became misshapen. In this regard, the number of samples available for shrink-swell index testing was limited and so Atterberg Limit/linear shrinkage tests have been used to supplement the shrink-swell index test results.

The apparent compaction of the fill and strength of the cohesive soils was assessed from Standard Penetration Test (SPT) ‘N’ values, augmented by hand penetrometer tests carried out on cohesive samples recovered in the SPT split tube sampler or disturbed lump samples recovered from the auger. The strength of the bedrock in the augered portion was assessed from observation of the drilling resistance using the TC drill bit attached to the augers, tactile examination of rock cuttings, and correlation with the results of subsequent laboratory moisture content tests. It should be noted that strengths assessed in this way are approximate and variances of at least one strength order should not be unexpected.

For the cored portion of the bedrock, the recovered core was returned to our laboratory for photographing and Point Load Strength Index (Is(50)) testing. Using established correlations, the Unconfined Compressive Strength (UCS) of the bedrock was then calculated from the Is(50) results. These Point Load Strength test results are summarised in the attached Table D and on the borehole logs.

Groundwater observations were recorded in all boreholes during and on completion of auger drilling. Standpipe piezometers were installed in BH1, BH6, BH17 and BH28 to allow for longer-term groundwater monitoring. No longer-term groundwater monitoring has been completed as part of this engagement.

Our geotechnical engineers, Mr Keagen Rousseau and Mr Chris Rooke, were present on a full-time basis during the fieldwork, to nominate testing and sampling and prepare the borehole logs. The borehole logs, which include field test results and groundwater observations, are attached, together with a set of explanatory notes which describe the investigation techniques, and their limitations and define the logging terms and symbols used.

Selected soil samples were also returned to Soil Test Services Pty Ltd (STS) and Envirolab Services Pty Ltd, both NATA accredited laboratories. STS completed moisture content, Atterberg limits, linear shrinkage, shrink-swell index and CBR testing, and the results of these tests are provided in the attached STS Tables A, B and C. Soil aggression testing was completed by Envirolab Services Pty Ltd and the results are provided in the attached Certificate of Analysis No. 364911.

4 RESULTS OF INVESTIGATION

4.2 Site History

A review of the historical aerial imagery obtained by JKE and publicly available imagery, indicates that the site remained largely unchanged from the earliest image in 1944 to 2022. During this period the site appears to have comprised grazing farmland with no trees visible on the property from the earliest imagery. An overland flow path leading to a small farm dam south of the site is visible along the western site boundary in each of the images during this period.

In 2022 large-scale earthworks are visible west of the site which appear to be for the current residential subdivision development. In 2023 some earthworks appear to have been carried out on the site, although the nature and extent are difficult to confirm. In the 2023 image the existing roads around the site are visible.

4.3 Site Description

The site is located within regional topography generally comprising rolling, low relief hills generally sloping at less than 10°. The site is located on the southern flank of a hill which rises on the northern side of Bungendore township. Surface levels within the site generally slope down to the south-east, south and south-west at approximately 6° to 8° from a local rise located within the central portion of the northern boundary.

The site is bounded by Bridget Avenue, Winyu Rise and Birchfield Drive to the north, east and south respectively. Each of these roads comprises asphalt surfaced two-lane single carriageways with concrete kerb and gutter except at the intersection of Winyu Rise and Birchfield Drive where a concrete roundabout is present. The pavements appear to be in good condition. Buried services including sewer and electricity appear to be located within the grassed verges along the streets.

The site comprises a large vacant lot which was grass covered. Towards the southern and eastern site boundaries surface levels slope down at approximately 15° to 20° through a generally 2m to 2.5m high cut batter, which increases in height up to 3.5m towards the south-eastern corner of the site. The toe of the southern batter is supported by four separated mortared sandstone retaining walls which have a height of about 1.1m and were set back approximately 4m from Birchfield Drive. Between the retaining walls outcrops of bedrock, assessed as comprising mudstone of at least low strength, were observed towards the base of the batter. The mudstone outcrops appear to have cleavage dipping at approximately 50°. At a few locations along the batter erosion rills have formed through the clay soils. In the north-western corner of the site surface levels appear to have been altered to form a batter, up to 2.5m high, sloping down into the site at approximately 15° from the northern site boundary.

West of the site is a drainage reserve which contains a grassed swale which drains to a rock-lined apron and culvert extending below Birchfield Drive. A concrete footpath extends along the crest of the eastern edge of the swale adjacent to the western site boundary.

4.4 Subsurface Conditions

The NSW Seamless Geology Version 2.4 indicates that the site is underlain by sandstone units of the Abercrombie Formation comprising *"brown and buff to grey, thin- to thick-bedded, fine- to coarse-grained mica-quartz sandstone, interbedded with laminated siltstone and mudstone. Sporadic chert-rich units"*. The boreholes encountered a generalised profile comprising residual silty clay grading to weathered sandstone bedrock at relatively shallow depths. A summary of the subsurface conditions encountered within the boreholes is provided below, however for a detailed description at each location reference should be made to the attached borehole logs.

Fill

Fill was encountered in BH4, BH10, BH16 and BH34 and extended to depths of up to 1.4m below existing surface levels, although was generally less than 1m deep. The fill was assessed as comprising silty clay ranging from low to high plasticity. The deeper fill in BH10 and BH16 was assessed as being well and moderately compacted, respectively, based on the SPT 'N' values.

Residual Silty Clay

Residual silty clay was encountered below the fill or from the surface in all boreholes. The residual clay was generally assessed as being of medium or high plasticity and hard strength. Some very stiff and stiff clay was encountered in three boreholes towards the surface of the underlying weathered bedrock. The residual clays generally contained inclusions of ironstone and quartz gravel.

Weathered Bedrock

Weathered sandstone and mudstone was encountered in all boreholes, except BH2, at depths ranging from 0.7m to 3.5m below existing surface levels. These depths correlate with levels ranging from RL744.2m to RL721.9m with the surface of the rock appearing to dip down to the south-west and south-east from the crest of the hill on the northern site boundary. Interpolated contour intervals of the surface level of sandstone bedrock of at least low strength are shown on the attached Figure 3. The bedrock was assessed as predominantly comprising sandstone, however within the eastern portion of the site mudstone was also encountered with the surface of this stratum ranging from approximately RL740.4m to RL733.3m with a dip in the surface levels down to the south and east.

The weathered sandstone and mudstone generally comprised an upper layer of extremely weathered material although this layer was less frequently encountered within the eastern portion of the site. The extremely weathered material is effectively a hard clay with structure from the parent rock. The extremely weathered layer was generally less than 1m thick although some thicker layers, up to 1.7m, were encountered within the central portion of the site.

Weathered bedrock, generally assessed as being distinctly weathered and of low, low to medium or medium strength from initial contact was encountered below the extremely weathered material (where present) or directly below the residual clay. The bedrock generally increased in strength to medium or high strength at relatively shallow depths below the rock surface with 'TC' bit refusal generally occurring within 1.5m of initial contact in the deeper boreholes. The upper weathered profile generally contained ironstone and extremely weathered bands which appear to reduce in frequency with depth. The following table summarises the depths to the low or low to medium and medium or higher strength strata of bedrock within the site:

Depths to Bedrock Strata within Site

Borehole	Depth to (m) / Surface Level (mAHD) of Bedrock Strata	
	Low or Low to Medium Strength	Medium or Higher Strength
1	3.0 / 721.9	3.0 / 721.9*
4	2.2 / 732.8	2.5 / 732.5*
6	2.5 / 732.8	3.2 / 732.1
7	2.3 / 736.5	3.0 / 735.8*
8	2.0 / 741.8	7.5 / 736.3
9	2.2 / 738.7	2.8 / 738.1*
10	3.5 / 732.4	3.5 / 732.4*
11	1.8 / 743.8	>10.0 / <735.6
12	1.7 / 740.3	Not encountered
13	1.0 / 736.4	1.6 / 735.8
14	1.2 / 733.8	2.4 / 732.6
15	1.4 / 737.4	2.1 / 736.7
16	3.7 / 733.4	3.7 / 733.4*
17	1.3 / 742.9	3.0 / 741.2
18	1.1 / 742.6	2.7 / 741.0
19	2.0 / 738.6	6.9 / 733.7*
20	1.4 / 741.8	2.3 / 740.2
21	1.8 / 739.7	2.2 / 739.3*
22	1.2 / 738.5	1.2 / 738.5*
23	1.9 / 740.1	Not encountered
24	1.2 / 740.6	1.2 / 740.6*
25	1.4 / 738.7	1.4 / 738.7
26	2.1 / 736.9	5.5 / 733.5
27	2.0 / 737.7	2.0 / 737.7*
28	2.1 / 738.6	3.2 / 737.5
29	2.4 / 735.4	3.2 / 734.6*
30	1.3 / 737.5	1.3 / 737.5*
31	2.5 / 734.2	Not encountered
32	2.0 / 735.4	2.0 / 735.4*
33	1.5 / 736.9	1.5 / 736.9*
34	2.4 / 732.8	Not encountered
35	2.1 / 733.2	2.1 / 733.2*

* The presence of medium or higher strength bedrock has not been proven at these depths/surface levels and further investigation will be required to confirm the continuity of the stratum.

From field observations of rock outcrops, completed as part of mapping for preparation of the Captains Flat 1:50,000 Geological Series Sheet, cleavage within the Abercrombie Formation in proximity to the site was generally measured as dipping at 55° to 70°. The azimuth (dip direction) of the cleavage in these outcrops was generally in the range of 070° to 090° i.e. dipping down east-north-east to east. These observations correlate reasonably well with the foliation noted in the recovered core which generally dipped in the order of 35° to 65°.

Within the cored portions of the sandstone and mudstone bedrock, defects primarily comprise, bedding partings, joints and extremely weathered/clay seams. Defects logged as bedding partings are those inclined roughly parallel to the angle of foliation within the bedrock. Defects logged as joints are those orientated at angles varying from the angle of foliation and are inclined at angles ranging from 0° to 90° from the horizontal. Joints and bedding partings were iron stained or clay coated with some containing extremely weathered or quartz infill. Extremely weathered and clay seams were encountered in the core and ranged from 1mm to 200mm thick, although were generally in the order of 2mm to 70mm thick. Thicker bands of extremely weathered material or 'no core' (which is inferred to correlate with extremely weathered material washed away during the coring process) were encountered within each of the cored boreholes, except BH26. These bands were generally 0.4m or thicker.

Groundwater

No groundwater was encountered during or on completion of drilling in any of the boreholes.

4.5 Laboratory Test Results

The moisture content and Atterberg Limits tests on the residual clay and weathered bedrock correlated reasonably well with our field assessments. Based on the Atterberg limits and linear shrinkage test results, the residual silty clay is generally of medium or high plasticity. The shrink-swell index results generally indicate low to moderate reactivity however from comparison with the linear shrinkage values it appears that some of the residual clay will have a moderate to high potential for shrink-swell movements with changes in moisture content.

The four-day soaked CBR tests on the samples of residual clay from BH31, BH32 and BH33 compacted to 98% of their Standard Maximum Dry Density (SMDD) returned values of 6%, 5% and 2%. The in-situ moisture contents of these residual clays were 1.4% 'wet' and 1.6% and 3.6% 'dry' of their Standard Optimum Moisture Contents. During soaking swell values of 0.5% and 4.5% were measured for the samples from BH32 and BH33 indicating reactivity to variations in moisture content. No swelling was measured on the sample from BH31.

The soil aggression test results are summarised in the table below:

Borehole No.	Sample Depth (m)	Soil Type	pH	Chloride Content (mg/kg)	Sulphate Content (mg/kg)	Resistivity (ohm.cm)
1	0.3-0.4	RESIDUAL Silty Clay	7.5	10	<10	29,000
7	0.5-0.95	RESIDUAL Silty Clay	6.4	<10	10	56,000
11	0.1-0.3	RESIDUAL Silty Clay	6.0	<10	20	19,000

13	1.6-2.0	RESIDUAL Silty Clay	7.0	<10	<10	46,000
17	0.2-0.3	RESIDUAL Silty Clay	5.1	<10	10	25,000
18	1.2-1.4	Sandstone BEDROCK	6.8	24	<10	23,000
24	0.5-0.95	RESIDUAL Silty Clay	7.1	<10	10	38,000
27	1.8-1.95	XW Sandstone	7.4	10	10	30,000
28	0.5-0.8	RESIDUAL Silty Clay	6.9	<10	21	27,000

5 COMMENTS AND RECOMMENDATIONS

5.1 Geotechnical Considerations

From a geotechnical perspective, we consider the site will be suitable for the scale of activity proposed. We consider that the main geotechnical considerations relating to the design and construction of the proposed activity will be as follows:

- The boreholes indicate that weathered sandstone and mudstone bedrock will likely be encountered at relatively shallow depths and therefore a large volume of ‘hard rock’ excavation will be required. Excavation through such material will require specialised rock excavation equipment.
- Due to the frequency and of defects within the recovered core we do not recommend unsupported sub-vertical cuts through the bedrock. Along the northern site boundary excavation to depths of up to 6.5m are proposed to form the upper terrace at RL739.75m and, if sufficient space is available, excavation could be achieved by forming temporary or permanent batters through the soil and weathered bedrock. If sub-vertical cuts are preferred then the proposed excavation will need to be supported by an in-situ retention system requiring lateral restraint to reduce displacements.
- Earthworks appear to have been carried out in some areas of the site since commencement of the surrounding residential subdivision. Based on the investigation boreholes the extent of existing fill appears limited however, unless records are provided to confirm that this material comprises engineered fill, then it will need to be considered as uncontrolled fill. Where uncontrolled fill is present at bulk excavation level below any of the proposed buildings, or other movement sensitive structures, then additional excavation will be required to remove the existing fill to the underlying competent natural material.
- The residual silty clays are generally of medium or high plasticity and care will be required during any earthworks where clay fill is used. Clay fill will need to be compacted at close to its optimum moisture content and must not be over compacted as this will increase the risk of swelling of the clays. Adequate drainage will be required during earthworks so the exposed clays are not moisture affected. Ideally any clay fill will be placed in the lower layers with a capping of inert rockfill.
- Excavated sandstone and mudstone bedrock may also be used for filling. The sandstone and mudstone units are anticipated to have varying potential for reactive movements when compacted as engineered fill. Laboratory testing could be completed to assess whether the variability between the units is significant to assess whether the sandstone may be used as a non-reactive fill to reduce shrink-swell movements.

- Weathered bedrock will be encountered at bulk excavation level below portions of each of the Stage 1 buildings, except Building D. In this regard, all footings for the proposed main buildings should be uniformly founded within the weathered bedrock.
- Low CBR values were measured for the residual silty clay and this will require the use of relatively thick pavements, placement of capping layers of select rockfill, some form of subgrade treatment to improve the subgrade quality or bound subbases for concrete pavements.

Further comments on these items are provided within the following sections of this report.

5.2 Site Classification

We note that in the strictest sense, AS2870-2011 does not apply to developments such as this, however it provides a useful guide for footing design on reactive clay sites. Reference may also be made to AS2870 for design, construction, performance criteria and maintenance precautions on reactive clay sites.

Assessment of the site classification for this site has been completed with reference to the results of the shrink-swell index, Atterberg Limits and linear shrinkage testing completed on the residual clays. The soils encountered were found to be of such reactivity that, assuming no earthworks, and that the residual clays are not subject to any adverse moisture conditions (such as from trees etc.), the site would classify as either Class 'S' or 'M' in accordance with AS2870-2011. The difference in the classification is primarily due to the variability in the reactivity of the soils and the depth to bedrock. Where the depth to bedrock is less than 1m deep or less reactive soils are present then the Class 'S' would apply, otherwise Class 'M' would apply.

As part of the proposed activity however, the site will be subjected to cut and fill earthworks. Therefore, where either the residual clays are re-used as engineered fill, or where the upper residual clays are removed from the surface during bulk earthworks, higher soil shrink-swell movements can occur. In this regard, considering that there is likely to be cut and fill earthworks on the site, our recommendation is that structures be designed to accommodate shrink-swell movements normally associated with a Class 'H1' site. These movements can be reduced to Class 'S' or 'M' if a capping layer of inert rockfill 1m to 1.5m thick is included in the earthworks specification.

Apart from the characteristics of the soil and the presence of fill, there are many factors that affect the actual surface movements that occur. Such factors include:
- The depth of the soil profile;
- The presence of proposed trees;
- The previous presence of proposed structures and concrete slabs;
- The control and maintenance of drainage; and
- The installation of underground services.

In those areas where, following bulk excavation, the weathered sandstone or mudstone bedrock is encountered at the surface over portions of the building footprint, negligible shrink-swell movements would be expected to occur in these areas. However, the design of on-grade floor slabs, if preferred, will need to consider the largest possible movements for each structure. Similarly, lower or negligible shrink-swell soil movements, similar to could be achieved by use of inert (non-reactive) fill following stripping of residual clays or placing inert material in the upper 1.8m of the fill profile where deeper fill is required.

The weathered bedrock will likely be less reactive than the residual clay and the sandstone is anticipated to be less reactive than the mudstone. In this regard, consideration could be given to use of the weathered sandstone as a less reactive fill material below buildings to reduce shrink-swell movements. Further testing is recommended to assess the reactivity of the sandstone and mudstone units to provide more refined advice regarding use of these materials below buildings to reduce shrink-swell movements. Similarly, site-won clay fill should preferably be placed in the lower portion of areas requiring deeper fill to reduce the impact on shrink-swell potential.

From the current proposed bulk earthworks levels, Buildings A, B and C could achieve a Class 'M' or lower classification based on a combination of exposed rock at bulk excavation level and use of inert fill where surface levels need to be raised. For Buildings D and E, where a greater height of fill is required, to reduce surface movements will require the use of inert fill within the upper profile. Once detailed earthworks and building levels are known, as well as testing on materials proposed for reuse as engineered fill then further advice should be sought from the geotechnical engineers on an appropriate assessment of likely reactive soil movements for each individual structure.

The designers of structures on Class 'M' or higher reactivity sites must consider the additional requirements of such sites as defined in Sections 5.6 and 6.6 of AS2870-2011. 'Owners' of such lots must be made aware of the foundation maintenance requirements as stated in Appendix B of AS2870-2011. The landscape designers, structural and civil engineers should also be made aware of potential reactive soil issues.

Reference should also be made to Appendix B of AS2870-2011, for guidance on appropriate site maintenance, including site drainage and planting of trees and shrubs.

It must be noted that any fill that is not placed under Level 1 supervision during bulk earthworks will not conform as engineered fill and will result in a site classification of Class 'P'.

5.3 Excavation Conditions

The following recommendations should be read in conjunction with the latest version of *'Excavation Work – Code of Practice'* prepared by SafeWork NSW.

Based on the current bulk earthworks plan, excavation up to 7m below existing surface levels is proposed within the central portion of the site to form the upper and lower terraces at RL739.75m and RL736m respectively. The depth of excavation will generally reduce towards the south-east and south-west from the crest of the hill located on the northern site boundary. Based on the investigation results, excavation to the proposed depths will encounter predominantly residual soils and extremely and distinctly weathered sandstone and mudstone bedrock.

Excavation of the soils and any extremely weathered to low strength sandstone and mudstone should be achievable using conventional earthmoving equipment, such as the buckets of large hydraulic excavators. Very low to low strength bedrock or iron indurated bands within the extremely weathered profile may require using a ripping tyne and/or by ripping with a dozer.

Excavation of sandstone or mudstone bedrock of medium or higher strength will require rock excavation techniques such as rock saws, rock grinders and/or hydraulic impact hammers attached to large excavators. Due to the distance from the site boundaries to adjacent structures we do not consider that quantitative vibration monitoring will be required where hydraulic impact hammers are used. Ripping of medium to high strength bedrock should also be feasible using a Caterpillar D9 bulldozer or equivalent, though contractors should make their own assessment of rippability based on the information available.

As noted in Section 4.2, the sandstone and mudstone bedrock when used as fill are anticipated to have varying degrees of reactivity to variations in moisture content. Should laboratory testing of the rock indicate that the difference in reactivity is significant then we would recommend that, as much as possible, the excavated mudstone and sandstone units be stockpiled separately during bulk earthworks.

Based on the results of the monitoring we do not consider that the proposed excavations will encounter the groundwater table, however groundwater seepage will likely occur at the soil/rock interface or through joints and defects within the rock, particularly during or immediately following periods of wet weather. We expect that any seepage encountered will be controllable using gravity drainage and/or conventional sump and pump techniques.

Excavated spoil for off-site disposal will need to be suitably classified for waste disposal purposes. Reference should be made to the preliminary environmental report prepared by JKE.

5.4 Excavation Batters and Retention

Within the site it generally appears that levels will be transitioned through either permanent batters or landscaped retaining walls with maximum heights of approximately 4m. However, along the northern site boundary, excavation to depths of up to 6.5m are proposed to achieve design levels on the upper terrace. This deeper excavation may be completed using either temporary or permanent batters if sufficient space is available. If vertical cuts are preferred then we consider that this will require installation of an in-situ retention system.

5.4.1 Excavation Batters

Temporary Batters

Temporary batters should be feasible for most of the proposed excavations. Where there is insufficient space for temporary batters, or temporary batters are not preferred, then in-situ retention systems will need to be constructed prior to excavation commencing. There are also cost implications with excavating and disposing of additional soil to form temporary batters and importing durable granular backfill. Therefore, it may be preferable to install in-situ retention systems rather than form temporary batters.

Temporary batters formed through residual clays and the extremely weathered sandstone/mudstone may be formed no steeper than 1 Vertical (V) in 1 Horizontal (H), subject to inspection by a geotechnical engineer. Steeper temporary batters, provisionally formed at no steeper than 1V:0.5H may be formed through bedrock of low or higher strength. Temporary batters should be benched with a mid-height bench, at least 1.5m wide, where they exceed 3m in height. All temporary excavations should be inspected by the geotechnical engineers at not greater than 1.5m depth intervals and if there is any concern about the stability of excavations. The geotechnical engineers can provide specific advice during excavation. Geotechnical inspection of excavations is essential to identify any adverse defects present and to provide advice on stabilisation measures where required.

Surcharge loads such as construction traffic, site sheds etc. should be no closer than 2H from the crest of any temporary batter, where H is the vertical height of the batter. Surface drainage should not be allowed to flow over the crest of temporary batters, and should be directed and discharged in a manner which avoids concentrated flows and erosion.

Where retaining walls are to be constructed in front of temporary batters, care will need to be exercised in backfilling between the temporary batter slope and the new retaining wall. Uncontrolled backfilling will lead to large settlements which may adversely affect pavements, structures or landscaping areas. It is often difficult to achieve adequate compaction of backfill due to limited access and the need to use small hand compaction equipment. We recommend therefore the use of a single-sized durable gravel, such as "blue metal" gravel or crushed concrete (free of fines and with less than 10% brick), which do not require significant compactive effort. Such material should be nominally compacted using a hand operated vibrating plate (sled) compactor in 200mm thick loose layers. A non-woven geotextile filter fabric such as Bidim A34 should be placed as a separation layer immediately above the cut batter slope to control subsoil erosion. Provided the gravel backfill is placed as recommended above, density testing of the gravel backfill would not be required. The geotextile should then be wrapped over the surface of the gravel backfill and capped with at least a 0.5m thick compacted layer of clayey engineered fill.

There are also cost implications with excavating and disposing of additional soil to form temporary batters and importing large quantities of durable granular backfill. Therefore, it may be preferable to install in-situ retention systems rather than form temporary batters.

Permanent Batters

Permanent batter slopes will likely be suitable for transitioning between existing and proposed surface levels around landscaped and pavement areas. The formation of permanent batters will be dependent on the height of the cut and the materials exposed. As a guide we suggest the following general recommendations;

- Permanent batters through the residual soils and all bedrock up to and including very low strength should be battered at not steeper than 1V:3H.

- Permanent batters through low or higher strength bedrock should be battered at not steeper than 1V:1H. Steeper permanent batters through low or higher strength bedrock may be feasible subject to specific inspection and mapping by the geotechnical engineers. Steeper batters of up to about 70° formed through bedrock may require additional stabilisation measures such as rock bolting, shotcreting etc the extent of which will only be possible to determine during construction. In this regard, if the possibility of forming steeper batters through bedrock is to be considered, we recommend a reasonable budget be allowed for rock stabilisation measures.

Any permanent batters will need to be fully protected from erosion, in the long term, by a suitable and approved erosion protection measure. Suitable measures would include revegetation or shotcrete. Where revegetation is being proposed, consideration should be given to flattening the permanent batters even further than recommended above to assist with initial vegetation and topsoil establishment, to reduce the risk of topsoil washing from the face during heavy rainfall, and to provide for ease of maintenance. Erosion protection may not be required if batters will be located within undercroft areas, subject to approval from the geotechnical engineers.

5.4.2 Landscape Retaining Walls

Where temporary batter slopes are adopted and permanent retaining walls constructed within the excavation, we recommend that the following characteristic parameters may be adopted for preliminary wall design. These recommendations also apply to any landscape retaining walls that may be required around the site. The following parameters are on the basis of either a properly placed and compacted engineered backfill or backfill comprising a uniform sized durable granular material which is surrounded in a geotextile fabric as discussed in Section 6.4.1 above.

- For cantilever walls where some movement can be tolerated, we recommend a triangular lateral earth pressure distribution using an ‘active’ earth pressure coefficient (K_a) of 0.35.
- For cantilever walls which will be propped by floor slabs or where movements are to be reduced, we recommend a triangular lateral earth pressure distribution using an ‘at rest’ earth pressure coefficient (K_0) of 0.6.
- A bulk unit weight of 20kN/m^3 may be used for the backfill.
- All surcharge loads affecting the walls (e.g. nearby footings, construction loads and traffic etc) are additional to the earth pressure recommendations above and should be included in the design.

Compaction of engineered fill behind retaining walls is very difficult. The use of a single sized durable aggregate, such as ‘Blue Metal’ gravel, crushed concrete aggregate (free of fines) or ‘no fines’ concrete, which do not require significant compactive effort is often preferred if good performance is a priority; at least in the lower layers. Gravel material should be nominally compacted using a hand operated vibrating plate (sled) compactor in maximum 200mm thick loose layers. A non-woven geotextile filter fabric such as Bidim A34 should be placed as a separation layer immediately above the cut batter slope (prior to backfilling) to control subsoil erosion. Provided the aggregate backfill is placed as recommended above, density testing would not be required. The geotextile should then be wrapped over the surface of the aggregate backfill and capped with at least a 0.3m thick compacted layer of clay engineered fill unless impermeable pavements are proposed at the surface.

The wall designers must make an assessment of likely wall movements during the design process to ensure that any predicted wall movements will not be problematic to nearby structures, landscaping, services, pavements etc.

5.4.3 In-Situ Retention Systems

Along the northern site boundary, excavation up to 6.5m below existing surface levels is proposed to achieve the design surface levels on the upper terrace. The recovered core generally contained closely spaced defects throughout the bedrock profile and therefore sub-vertical, unsupported cuts through bedrock are not considered appropriate. If insufficient space is available to form permanent batters through the soil and weathered bedrock along the northern boundary then the excavation face along the northern boundary will need to be supported by an in-situ retention system. In-situ retention systems may also be adopted elsewhere where temporary batters are not preferred.

Based on the subsurface profile encountered we consider that solider piles walls with shotcrete infill panels would be appropriate, provided some movement of the wall is tolerable.

Piled retaining walls no more than 3m in height may, subject to deflections being acceptable, be designed as cantilevered walls with sockets formed within the weathered bedrock below adjacent bulk excavation levels. However, where the wall height exceeds 3m, in order to limit deflections and to satisfy stability criteria, additional lateral restraint or stiffness will likely be required. This restraint or stiffness may be achieved by installing temporary anchors/props or constructing more rigid wall types such as contiguous pile walls or using large diameter soldier piles. Long-term lateral support may be provided either by buttresses, earthen berms or structures in front of the walls or by installation of permanent anchors.

Cantilevered retaining walls may be designed in accordance with the design parameters in Section 4.4.2.

Propped or anchored retaining walls may be provisionally designed based on a trapezoidal lateral pressure distribution of 6H kPa (where H is the retained height in metres) where some resulting movements are tolerable. Where movements are to be kept low, a higher trapezoidal lateral pressure distribution of 8H kPa should be used. These maximum pressures should be applied for the central 50% of the trapezoidal pressure distribution reducing to zero at the crest of the wall and at the proposed bulk excavation level.

The above pressures assume horizontal backfill surfaces and where inclined backfill is proposed the inclined backfill must be taken as a surcharge load. All surcharge loads should be allowed for in the design, plus full hydrostatic pressures, unless measures are undertaken to provide complete and permanent drainage behind the wall.

The weathered bedrock may contain large continuous inclined joints or foliation, with joints and foliation observed within the recovered rock core. As noted above it appears that the orientation of foliation within the surrounding area is generally adverse and initially at least the assumption must be that defects are adversely orientated. Therefore, we recommend that the design of any shoring system also be checked at each stage of excavation and support for the possible presence of a 45° inclined joint within the bedrock which daylights at or just above the current stage excavation level; and in the final stage at or just above the bulk excavation level. The joint should be assumed to be clay coated and smooth with a friction angle of not greater than 20° and with a partial water pressure behind the wedge

Where retaining wall piles are embedded in the weathered bedrock of at least low strength an allowable lateral pressure of 200kPa can be assumed, though the upper 0.5m of socket below the adjacent excavation level (including bulk and detailed excavations such as for services and footings) must be ignored to allow for possible over-excavation or fracturing of the rock near the bulk excavation level.

Where temporary or permanent anchors are installed to provide lateral restraint to retaining walls then these will generally be bonded in low or higher strength sandstone or mudstone bedrock. An allowable bond stress of 150kPa should be achievable for such materials. The anchor bond zone should be formed entirely behind a line drawn up at 45° from bulk excavation level. Permanent anchors should be constructed to allow for re-tensioning should greater than anticipated movements occur during the design life of the wall and would require a monitoring program for wall movements. In this regard, anchors would also need to be accessible for testing as part of the maintenance program for the anchors. Permission must be obtained from the owners of the adjoining land before installation of rock anchors if they extend beyond site boundaries.

The retaining walls should be designed as drained and measures taken to induce complete and permanent drainage of the ground behind the wall. This however is difficult to achieve in weathered rock. Strip drains incorporating a geofabric to act as a filter against subsoil erosion would be appropriate for soldier pile walls, and regularly spaced (both horizontally and vertically) weep holes would be required for contiguous piled walls. These drainage systems only provide drainage to the immediate rear of the retaining wall and full hydrostatic pressures can still occur behind rock wedges, which must be allowed for in any retaining design.

Specific retaining wall analysis should be completed using appropriate FEM software, such as Plaxis or similar. These programs also predict the movements behind the walls. The more frequently used retaining wall analysis program, WALLAP, is considered inappropriate for the design of the retaining walls where walls will support cuts through rock as it can only accurately model the soil profile, not a jointed rock profile, and cannot predict movements behind the walls. Due to the numerous geotechnical engineering inputs required to drive and rationalise FEM programs, the analyses should only be carried out by engineers with a good understanding of retaining wall design, and soil and rock mechanics.

5.5 Earthworks

Earthworks recommendations in this report should be read in conjunction with AS3798-2007 '*Guidelines on Earthworks for Commercial and Residential Developments*'.

Based on the supplied cut and fill plans, site earthworks will result in filling across the site with the maximum height of fill approximately 8m adjacent to the south-western corner of the proposed sports field. However, generally the height of fill will be less than 3m.

5.5.1 Subgrade Preparation

Material assessed as comprising existing fill was encountered in a few of the boreholes towards the southern and eastern edges of the site. We are unaware of any records of placement or compaction control for the existing fill and as such it must be considered 'uncontrolled' and is not suitable for the support of footings or floor slabs. Where the footprints of proposed buildings are underlain by existing fill then, unless suspended slab construction is adopted, all existing uncontrolled fill must be fully stripped and replaced with controlled, engineered fill. Where uncontrolled fill is present within pavement or landscaped areas it may remain in place, subject to environmental approval, provided it performs adequately during proof rolling as recommended below. However, the upper fill containing roots must be removed, similar to the topsoil within other parts of the site. Root affected soils will not be suitable for reuse as engineered fill, but may be reused within landscaped areas.

The following procedures should be followed for subgrade preparation and placement of engineered fill for the proposed activity.

- Initially strip root-affected material. Where the existing uncontrolled fill is located within proposed building areas, and slab on-grade construction is proposed, this should also be stripped to expose the residual silty clay.
- Proof roll the exposed subgrade with at least 8 passes of a minimum 12 tonne smooth drum roller. The final pass of the proof rolling should be carried out in the presence of a geotechnical engineer or experienced earthworks technician to detect any soft or heaving areas.
- Any areas of heaving subgrade should be locally excavated to a competent base and replaced with engineered fill. Alternative subgrade improvement measures may be required and this is best determined in consultation with the geotechnical engineer at the time of proof rolling.
- Place engineered fill as required in horizontal layers as recommended in Section 4.5.2 below.

During construction the subgrade should be well graded to promote runoff and reduce the risk of water ponding on the surface. If the subgrade becomes wet it may become untrafficable and a working platform of granular material may be required during construction for trafficability.

5.5.2 Engineered Fill and Compaction Control

Engineered fill should preferably comprise a good quality granular material, such as crushed sandstone, free of deleterious materials and having a maximum particle size not exceeding 75mm. Such fill should be compacted in horizontal layers of maximum 300mm loose thickness to a density of at least 98% of Standard

Maximum Dry Density (SMDD). For backfilling confined excavations such as service trenches, a similar compaction to engineered fill should be adhered to, but if light compaction equipment is used then the layer thickness should be limited to 100mm loose thickness.

For battered fill embankments, in order to achieve adequate edge compaction, we recommend that the outer edge of each fill layer extend a horizontal distance of at least 1m beyond the design geometry. The roller must extend over the edge of each placed layer in order to seal the batter surface. On completion of filling, the excess under-compacted edge fill should be trimmed back to the design geometry.

The existing residual clay and weathered sandstone and mudstone may also be used as engineered fill, provided they are free of deleterious materials and particles in excess of 75mm. Such material should be compacted strictly between 98% and 102% of Standard Maximum Dry Density (SMDD) and within ±2% of Standard Optimum Moisture Content (SOMC). If the residual clay soils are to be adopted for use as an engineered fill the following need to be carefully considered:

- Where clays have moisture contents greater than the plastic limit they will require drying out prior to their use as engineered fill or where clays are dry moisture will need to be added. This may result in additional time being required for the earthworks.
- Where reactive clay or extremely to highly weathered mudstone are used as an engineered fill, they will undergo greater shrink-swell movements with changes in moisture content than the in-situ reactive clays. Therefore, consideration needs to be given to the effect that greater shrink-swell movements will have on the performance of structures founded within the engineered fill.

Density testing should be regularly carried out on any engineered fill to confirm that the project specification has been met. Supervision and regular density testing in accordance with Level 1 requirements of AS3798-2007 'Guidelines on Earthworks for Commercial and Residential Developments' is recommended if engineered fill is required to support structural loads from buildings or retaining walls. In pavement or landscaped areas, or where fill is placed as form fill below buildings, Level 2 testing may be carried out. Due to a potential conflict of interest, the geotechnical inspection and testing authority (GITA) should be directly engaged by the Project Manager or Head Contractor, and not by the earthworks sub-contractor.

5.6 Footings

5.6.1 Main Buildings

Following excavation to the proposed bulk excavation levels and any filling, we anticipate that a combination of engineered fill, residual silty clay and weathered bedrock will be exposed below each of the proposed main buildings for Stage 1 i.e. Buildings A to C. In this regard, we recommend that all footings for new buildings be uniformly founded within the weathered bedrock. Where bedrock is exposed at or near the surface then high-level pad and/or strip footings should be feasible, depending on the structural loads. However, consideration will need to be given to the potential for differential settlements between different sized footings, even if founded within the same stratum. Footings founded in sandstone or mudstone of at least very low strength can be designed for allowable bearing pressures of 1,000kPa.

Where piles are required, bored piers should be feasible, provided significant groundwater seepage does not occur into the pier holes. In those circumstances the side walls of bored piles may collapse and temporary liners would be required. If the piles are poured shortly after drilling this will reduce the risk of seepage entering the pier holes.

Low or low to medium strength bedrock was encountered in each of the boreholes, except BH2, BH3 and BH5, at relatively shallow depths. Although medium or higher strength sandstone and mudstone bedrock also appears to have been encountered at moderate depths in a majority of the boreholes this stratum has not been proven. Higher bearing pressures would be feasible within the medium or higher strength bedrock however we recommend that, unless further investigation is completed, piles be designed using the parameters below for the low or low to medium strength bedrock. Should it be preferred to found footings within the medium or higher strength bedrock then additional cored boreholes must be completed to confirm the depth and continuity of this material, though the existing information may be used as a guide for preliminary design.

The design of footings founded with an embedment of at least 0.5m within low or higher strength sandstone or mudstone bedrock may be based on the parameters provided within the table below. The allowable shaft adhesion (in compression) outlined in the table below may be adopted below a nominal 0.5m socket length. For allowable shaft adhesions (in tension) the compression values should be halved.

Footing Design Parameters

Rock Class	Allowable End Bearing Pressure (kPa)	Ultimate End Bearing Pressure (MPa)	Allowable Shaft Adhesion in Compression (kPa)	Ultimate Shaft Adhesion (kPa)	Elastic Modulus (MPa)	Poisson's Ratio
Low to Medium Strength Bedrock	1,200	3	120	300	200	0.25

The bedrock ranges from very low to high strength. Therefore, considering the bedrock profile and the likely large diameter piles required to carry the column loads, this will necessitate the use of moderate to large piling rigs with rock drilling equipment. We recommend that any potential piling contractors be provided with a copy of this geotechnical report and they should be requested to confirm that their equipment is suitable to penetrate the rock and achieve the required depths.

Where allowable bearing pressures and skin friction values are adopted, settlement of footings will typically be less than 1% of the pile diameter at the toe of the pile. However where ultimate end bearing and skin friction values are adopted, settlements will be greater and therefore once column loads are known, some detailed settlement analysis of piles is recommended to check that predicted settlements are within acceptable limits.

Where ultimate end bearing and skin friction values are adopted, then the ultimate values recommended in the table above must be reduced by an appropriate geotechnical reduction factor. The geotechnical reduction factor should be based on the risk assessment procedure set out in Table 4.3.2 (A) of AS2159-2009, but should not be greater than 0.4, unless the risk factors producing a higher geotechnical reduction factor can be fully justified. Consideration should also be given to the pile testing requirements when determining a suitable geotechnical strength reduction factor. The use of ultimate values will result in higher settlements and therefore specific analysis of the footing settlements must be carried out to confirm that it is consistent with the required structural performance.

In order to achieve the recommended skin friction values nominated in the table above, it is essential that the rock sockets be cleaned of any clay smear and suitably roughened using a side wall grooving tool, and that they be at least as rough as Roughness Class R2. We note that an R2 roughness is equivalent to grooves 1mm to 4mm deep and grooves 2mm wide, which are spaced at 50mm to 200mm down the socket length. It will be the responsibility of the piling contractor to ensure that he has the appropriate equipment and methodology to satisfy this roughness criteria.

Where piling rigs are set up at bulk excavation level, we anticipate that the subgrade will generally be suitable, but at least a nominal 0.3m thick working platform should be provided where residual clay or clay fill is present to protect the subgrade from deterioration during inclement weather. The specific requirements for any working platforms should be determined once the piling rig and the loading conditions are known and a thickness of more than 0.3m may be required. An inspection of the subgrade should be completed by the geotechnical engineer to confirm the suitability of the material and identify any soft spots requiring remediation. As a guide, the wearing surface material could comprise a DGB20 or similar granular material, such as recycled crushed concrete. The DGB20 material must be compacted using a medium sized static roller to at least 98% SMDD. The compacted wearing surface should extend at least 2m outside the working area of the pilling rig.

5.6.2 Lightweight Structures

Lightly loaded structures may be designed to be supported on footings found on the residual soils, extremely weathered rock or engineered fill. However, if excavations are carried out and rock is exposed in one area of a building footprint then all footings should be founded within the rock to reduce the risk of differential settlements. Where footings are founded within the rock the allowable bearing pressures provided in Section 4.6.1 may be used.

Shallow pad/strip footings or stiffened raft slabs would be feasible. Provided the structures are within the scope of AS2870-2011 'Residential Slabs and Footings', the footing systems may be designed in accordance with that code. Other structures outside the scope of AS2870-2011, will need to be designed on the basis of engineering principles, taking into account the reactivity of the soils and the site conditions.

Shallow footings may be designed based on an allowable bearing pressure of 100kPa for controlled, engineered fill, 150kPa for residual silty clays of at least very stiff strength or 300kPa for extremely weathered sandstone/mudstone.

For footings founded within reactive clay fill or residual clay, these will need to be designed to accommodate the shrink-swell movements of the engineered fill or residual silty clay, which will depend on the material used as fill, the excavations carried out and the depth to the underlying rock. All of these factors will need to be taken into account to determine the appropriate shrink-swell movements for each structure as it may vary in different areas of the site. Reference should be made to Section 4.2 above on likely shrink-swell movements. Particular consideration will also need to be given to the effect of reactive engineered fill as greater surface movements may apply. Reference should also be made to Appendix B of AS2870-2011 which provides further guidance on foundation performance and maintenance for structures on reactive silty clay soils.

5.6.3 Footing Inspections

We recommend that the geotechnical engineers inspect piles during drilling to confirm the above recommended bearing pressures and skin frictions are being achieved. Where the lower strength rock is adopted as the founding material, we consider that only a selection of piles will need to be inspected by the geotechnical engineers. However, if the higher quality rock is adopted as the founding material, then all piles should be inspected by the geotechnical engineers. Inspection of piles will require the geotechnical engineer to be on site during the drilling process so that they can inspect both the material being drilled and check the pile's consistency with nearby borehole logs. It is important to note that the geotechnical engineers can only 'sign off' on piles which they have inspected.

Where footings are founded within engineered fill certification will need to be provided by the Geotechnical Inspection and Testing Authority (GITA) that the fill has been compacted and tested in accordance with the earthworks specification under Level 1 inspection and testing in accordance with AS3798-2007. High level footings to be founded on soil or weathered rock should all be inspected by a geotechnical engineer.

Prior to pouring concrete, piles/footings will need to be dewatered, cleaned of all loose debris from the base, inspected and approved by the geotechnical engineers. We recommend the base of piles are cleaned with a cleaning bucket. Piles/footings will need to be poured as soon as possible after drilling/excavation. If piles are left open overnight, they must be redrilled prior to pouring concrete to remove any softened or other debris from the base of the pile.

5.7 Ground Floor Slabs

Following bulk excavation and earthworks, the subgrade is likely to comprise a combination of weathered bedrock, residual silty clay or engineered fill. Options for support of ground floor slabs include:

- Constructing the slabs on grade, or
- Designing the slabs as fully suspended.

Where the residual silty clays are encountered at subgrade level, and slabs on grade are proposed, we recommend that the subgrade be prepared in accordance with the recommendations outlined in Section 4.5 above. Similarly, if slabs on-grade are proposed and site levels are to be raised, then the fill below the slabs must comprise engineered fill. Where existing uncontrolled fill is present, and this fill is not removed, then the floor slabs will need to be constructed as suspended slabs.

Wherever slabs on-grade are supported on soils, the slabs should be separated from the structural footings and columns supported on the bedrock to allow relative movement (i.e. designed as floating slabs). These movements will likely largely be due to shrink-swell movements where the slabs are underlain by residual clay or clay fill. The extent of shrink-swell movements, as noted in Section 4.2 will depend on the earthworks completed at each building location and should be assessed following confirmation of the cut and fill depths and material to be used as engineered fill. To reduce the differential movements between the floor slabs and the building structure consideration could be given to replacing the residual clay subgrade with a non-reactive fill material and using such material where engineered fill is required to raise site levels.

For suspended slabs, the slabs will need to be founded on piers supported on the underlying bedrock as recommended above. For the portion of suspended slabs above a clay subgrade will need to be underlain by degradable void formers of at least 50mm thickness to reduce the risk of swelling soils 'jacking' the slabs off the piles. Where fill is used to raise site levels and the slabs are designed as suspended slabs then the fill would not need to be placed as engineered fill.

5.8 Pavements

Following subgrade preparation in accordance with the recommendations in Section 4.5, pavements will need to be designed on the basis of the material at the final subgrade level. Where the subgrade comprises the residual silty clay or excavated clay from site used as engineered fill, design should be based on a CBR of 2%, or an estimated modulus of subgrade reaction of 20kPa/mm (750mm plate), based on the testing carried out to date. Where pavements overlie areas of engineered fill imported to site, CBR testing of the engineered fill subgrade will be required to confirm the appropriate design parameters.

Given the low CBR value, consideration could be given to the use of a select subgrade material or stabilisation of the subgrade as part of the overall pavement design in order to reduce the thickness of the overlying pavement material. A select layer comprising a minimum 300mm of good quality granular material, such as ripped and crushed sandstone with a CBR value of at least 10%, may be used below the pavement layers. Alternatively, the clay subgrade may be stabilised by the addition of lime to reduce the reactivity and increase subgrade strength. The effect and quality of lime required would need to be determined by laboratory testing, but as a guide the addition of say 2% to 4% of lime by dry weight may result in a soaked CBR of the treated material in the order of 6% to 8%. This higher CBR layer may then be considered as part of the pavement design.

Concrete pavements should be underlain by a 150mm thick layer of lean-mix concrete subbase and the pavements be designed based on an effective subgrade strength of CBR 5%, correlating with a long-term

Young's Modulus of 20MPa and short-term Young's Modulus of 33MPa. Slab joints should be designed to resist shear forces but not bending moments by providing dowelled or keyed joints.

Surface and subsoil drainage should be provided on the high side of the pavements to reduce moisture ingress into the subgrade and pavement. The subsoil drains should extend to a depth of at least 0.3m below the adjacent subgrade level and the drains should have adequate falls to reduce ponding in the drains. In addition, the surface of the adjacent pavement subgrade should be provided with a uniform cross fall towards the subsoil drain to assist with drainage.

5.9 Exposure Classification

The soil aggression test results have indicated the residual silty clay and sandstone ranges from slightly alkaline to moderately acidic and have low sulphate and chloride contents. In accordance with Table 4.8.1 of AS3600:2018 'Concrete Structures', the exposure classification to the concrete elements is 'A2'. In accordance with Table 6.4.2(C) of AS2159-2009 'Piling – design and installation' the exposure classification for concrete piles is 'Mild'. For steel piles an exposure classification of 'Non-aggressive' would be appropriate in accordance with Table 6.5.2(C) of AS2159-2009.

5.10 Earthquake Design Parameters

The following parameters can be adopted for earthquake design in accordance with AS1170.4:2024 'Structural Design Actions, Part 4: Earthquake Actions in Australia':

- Hazard factor (Z) = 0.08
- Site Subsoil Class = Class Ce

Where excavation is carried out for a building such that weathered bedrock (with a compressive strength between 1MPa and 50MPa) is exposed at, or within a distance less than 3m, from bulk excavation level then the site sub-soil classification for the building may be reclassified to Class Be.

5.11 Further Geotechnical Input

The following is a summary of the further geotechnical input which is required and which has been detailed in the preceding sections of this report:

- Drilling of additional cored boreholes to confirm the depth to and consistency of medium to high strength bedrock suitable for higher bearing pressures, if adopted as the foundation stratum.
- Laboratory testing of mudstone and sandstone bedrock to assess reactivity potential for further advice on reuse of these materials as less reactive fill below buildings.
- Confirmation of likely shrink-swell movements for ground floor slabs if proposed as slab on-grade.
- CBR testing of engineered fill material to confirm design CBR values.
- Inspection of temporary and permanent batter excavations.

- Inspection of proof rolling by an experienced geotechnical engineer or geotechnician.
- In-situ density testing of all materials placed as engineered fill to confirm that it complies with the earthworks specification.
- Inspection of the subgrade prior to mobilising piling rigs and design of working platforms for the specific rigs proposed.
- Inspection of pile drilling and footing excavations to confirm that material adequate for the design bearing pressures has been encountered.

6 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the design and construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the advice presented in this report is not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long-term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

Occasionally, the subsurface conditions between the completed boreholes may be found to be different (or may be interpreted to be different) from those expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

This report provides advice on geotechnical aspects for the proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

A waste classification is required for any soil and/or bedrock excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), Excavated Natural Material (ENM), General Solid, Restricted Solid or Hazardous Waste. Analysis can take up to seven to ten working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) could be expected. We strongly recommend that this requirement is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

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SOIL TEST SERVICES

ABN 43 002 145 173

TABLE A
MOISTURE CONTENT, ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client:	JK Geotechnics	**Report No.:**	37083LT - A
Project:	Proposed Bungendore High School	**Report Date:**	5/11/2024
Location:	Birchfield Drive, Bungendore, NSW	**Page 1 of 1**	

AS 1289	**TEST METHOD**	**2.1.1**	**3.1.2**	**3.2.1**	**3.3.1**	**3.4.1**
BOREHOLE NUMBER	**DEPTH m**	**MOISTURE CONTENT %**	**LIQUID LIMIT %**	**PLASTIC LIMIT %**	**PLASTICITY INDEX %**	**LINEAR SHRINKAGE %**
6	0.50 - 0.95	27.8	57	29	28	14.5*
8	0.50 - 0.95	20.2	44	20	24	8.5*
12	0.50 - 0.95	20.4	55	26	29	12.5*
16	1.65 - 1.95	20.8	53	13	40	11.0
22	0.50 - 0.95	22.9	65	26	39	15.0
25	0.80 - 1.35	20.1	35	21	14	5.5*
28	0.80 - 0.95	12.7	45	23	22	6.5*
32	0.50 - 0.95	13.3	34	15	19	8.5*

Notes:
- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions
- Date of receipt of sample: 24/10/2024.
- Sampled and supplied by client. Samples tested as received.
- * Denotes Linear Shrinkage cracked.

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05/11/2024
Authorised Signature / Date
(D. Treweek)

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SOIL TEST SERVICES

ABN 43 002 145 173

TABLE B
FOUR DAY SOAKED CALIFORNIA BEARING RATIO TEST REPORT

Client:	JK Geotechnics	**Report No.:**	37083LT - B
Project:	Proposed Bungendore High School	**Report Date:**	5/11/2024
Location:	Birchfield Drive, Bungendore, NSW	**Page 1 of 1**	

BOREHOLE NUMBER		BH 31	BH 32	BH 33
DEPTH (m)		0.00 - 1.00	0.00 - 1.00	1.00 - 1.50
Surcharge (kg)		4.5	4.5	4.5
Maximum Dry Density (t/m^3)		1.82 STD	1.75 STD	1.65 STD
Optimum Moisture Content (%)		14.6	17.8	18.5
Moulded Dry Density (t/m^3)		1.78	1.71	1.61
Sample Density Ratio (%)		98	98	98
Sample Moisture Ratio (%)		100	98	102
Moisture Contents				
Insitu (%)		16.2	16.2	14.9
Moulded (%)		14.5	17.5	18.9
After soaking and				
After Test, Top 30mm(%)		19.7	22.6	32.6
Remaining Depth (%)		16.9	18.8	28.1
Material Retained on 19mm Sieve (%)		0	1*	0
Swell (%)		0.0	0.5	4.5
C.B.R. value:	@2.5mm penetration	6		2.0
	@5.0mm penetration		5	

NOTES: Sampled and supplied by client. Samples tested as received.

- Refer to appropriate Borehole logs for soil descriptions
- Test Methods : AS 1289 6.1.1, 5.1.1 & 2.1.1.
- Date of receipt of sample: 24/10/2024.
- * Denotes not used in test sample.

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

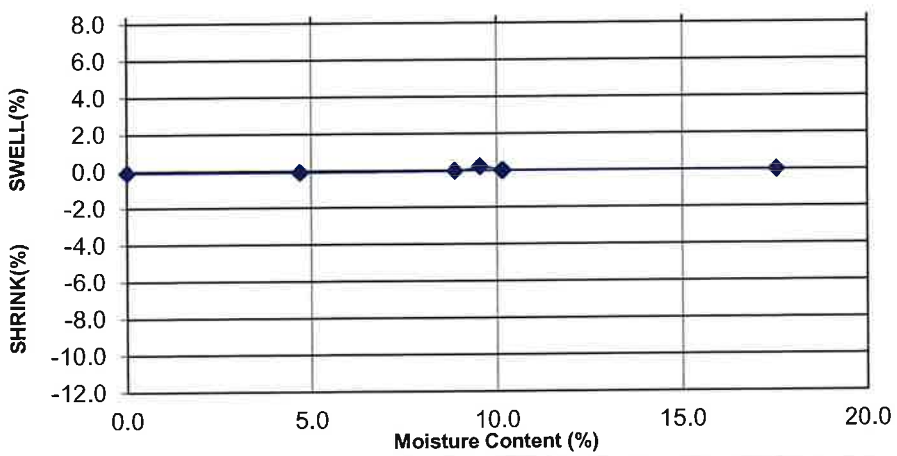
Client: JK Geotechnics
Project: Proposed Bungendore High School
Location: Birchfield Drive, Bungendore, NSW

Report No.: 37083LT - C
Report Date: 14/11/2024
Page 1 of 3

Borehole No.: 1		Depth: 0.20 - 0.35m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
10.1%	17.5%	>500 kPa	270 kPa

LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-1.4%	0.0%	0.1%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
0.04 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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Authorised Signature / Date
(D. Treweek)
14/11/24

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SOIL TEST SERVICES
ABN 43 002 145 173

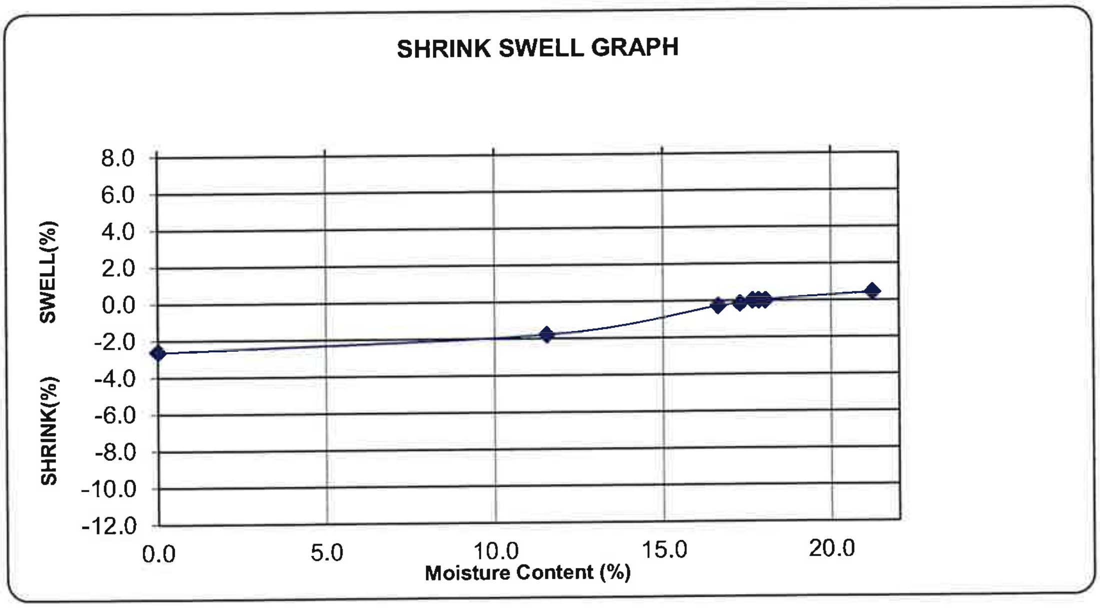
TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed Bungendore High School
Location: Birchfield Drive, Bungendore, NSW

Report No.: 37083LT - C
Report Date: 14/11/2024

Borehole No.: 5	Depth: 1.00 - 1.40m		
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
17.7%	21.2%	>500 kPa	>500 kPa

LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	-0.7%	0.4%	2.5%



SHRINK SWELL INDEX
1.53 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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NATA Accredited Laboratory Number:1327

Authorised Signature / Date
(D. Treweek)
14/11/24

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SOIL TEST SERVICES

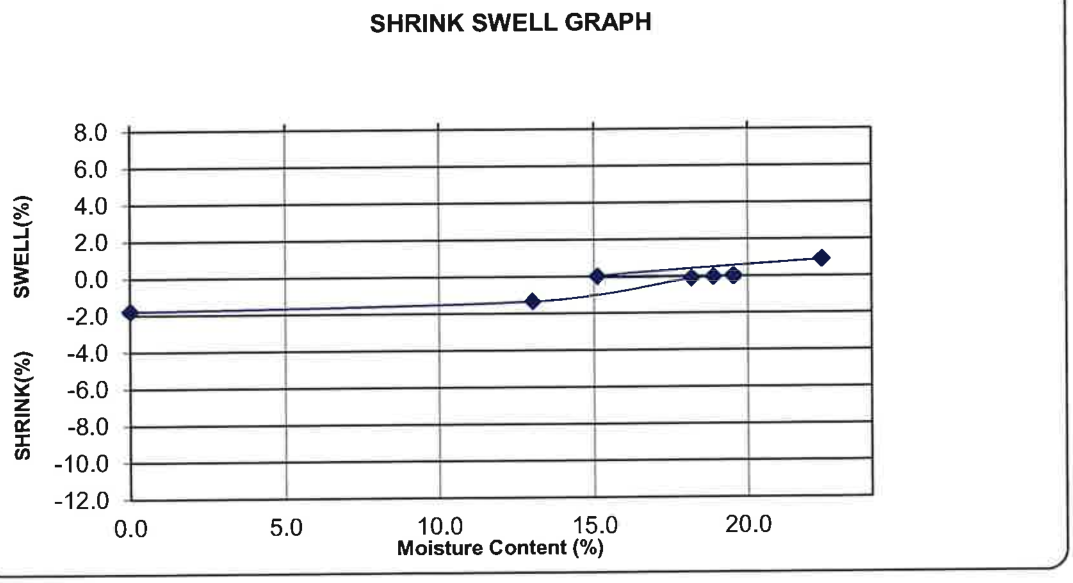
ABN 43 002 145 173

TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client: JK Geotechnics
Project: Proposed Bungendore High School
Location: Birchfield Drive, Bungendore, NSW

Report No.: 37083LT - C
Report Date: 14/11/2024

Borehole No.: 25		Depth: 0.50 - 0.80m		
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH		
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST	
15.1%	22.4%	>500 kPa	>350 kPa	
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION		SWELL ON SATURATION	SHRINKAGE
25	-0.8%		0.9%	1.7%



SHRINK SWELL INDEX
1.21 %/pF

Notes: Sampled and supplied by client. Sample tested as received.
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Visually estimated inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 24/10/2024.

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14/11/24

TABLE D
POINT LOAD STRENGTH INDEX TEST REPORT

Client: School Infrastructures NSW

Ref No: 37083LT

Project: Proposed Bungendore High School

Report: D

Location: Birchfield Drive, BUNGENDORE, NSW

Report Date: 23/10/24

BOREHOLE NUMBER	DEPTH (m)	$I_{S (50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
8	6.96 - 6.98	0.2	4	A
	7.26 - 7.29	0.2	4	A
	7.78 - 7.82	0.4	8	A
	8.67 - 8.71	0.5	10	A
	9.11 - 9.15	1.1	22	A
	9.53 - 9.56	1.9	38	A
	10.26 - 10.28	0.4	8	A
11	5.52 - 5.56	0.2	4	A
	6.68 - 6.71	0.6	12	A
	6.91 - 6.93	0.4	8	A
	7.41 - 7.44	0.6	12	A
	7.83 - 7.87	0.5	10	A
	8.15 - 8.18	0.2	4	A
	8.40 - 8.43	0.08	2	A
	8.75 - 8.78	0.3	6	A
	9.36 - 9.38	0.3	6	A
	9.85 - 9.87	0.2	4	A
17	2.90 - 2.93	0.2	4	A
	3.31 - 3.34	0.6	12	A
	4.06 - 4.10	0.8	16	A
	4.32 - 4.36	1.3	26	A
	5.16 - 5.18	0.6	12	A
	5.63 - 5.65	1.2	24	A
	6.23 - 6.26	0.8	16	A
	6.94 - 6.97	1.5	30	A

NOTE: SEE PAGE 3

TABLE D
POINT LOAD STRENGTH INDEX TEST REPORT

Client: School Infrastructures NSW **Ref No:** 37083LT

Project: Proposed Bungendore High School **Report:** D

Location: Birchfield Drive, BUNGENDORE, NSW **Report Date:** 23/10/24

BOREHOLE NUMBER	DEPTH (m)	$I_{S(50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
17	7.03 - 7.07	1.5	30	A
	7.50 - 7.54	1.2	24	A
19	3.35 - 3.36	0.4	8	A
	3.66 - 3.68	0.5	10	A
	4.25 - 4.27	0.4	8	A
	4.57 - 4.59	0.1	2	A
	4.70 - 4.72	0.4	8	A
	6.12 - 6.15	0.3	6	A
	6.50 - 6.53	0.3	6	A
	7.11 - 7.13	1	20	A
	7.40 - 7.44	0.6	12	A
26	2.55 - 2.58	0.3	6	A
	2.76 - 2.77	0.3	6	A
	3.21 - 3.25	0.4	8	A
	3.88 - 3.92	0.2	4	A
	4.86 - 4.89	0.4	8	A
	5.46 - 5.49	0.3	6	A
	5.85 - 5.87	0.4	8	A
	6.27 - 6.30	0.5	10	A
	6.67 - 6.71	0.4	8	A
	7.08 - 7.10	0.3	6	A
	7.61 - 7.63	0.4	8	A
28	2.50 - 2.53	0.3	6	A
	3.70 - 3.73	0.6	12	A
	4.26 - 4.28	0.6	12	A

NOTE: SEE PAGE 3

TABLE D
POINT LOAD STRENGTH INDEX TEST REPORT

Client: School Infrastructures NSW
Ref No: 37083LT

Project: Proposed Bungendore High School
Report: D

Location: Birchfield Drive, BUNGENDORE, NSW
Report Date: 23/10/24

BOREHOLE NUMBER	DEPTH (m)	$I_{S\ (50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
28	4.64 - 4.68	0.7	14	A
	4.96 - 4.99	1	20	A
	5.27 - 5.30	0.9	18	A
	5.66 - 5.68	0.7	14	A
	5.93 - 5.96	0.6	12	A
	6.21 - 6.24	0.4	8	A
	6.64 - 6.66	0.6	12	A
	6.72 - 6.74	0.3	6	A
	7.12 - 7.13	0.5	10	A
	7.38 - 7.40	0.6	12	A

NOTES

1. In the above table, testing was completed in test direction A for the axial direction, D for the diametral direction, B for the block test and L for the lump test.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1MPa, or to one significant figure if less than 0.1MPa.
5. The estimated Unconfined Compressive Strength was calculated from the Point Load Strength Index based on the correlation provided in AS1726:2017 'Geotechnical Site Investigations' and rounded off to the nearest whole number: U.C.S. = 20 $I_{S(50)}$.

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CERTIFICATE OF ANALYSIS 364911

Client Details

Client	JK Environments
Attention	A Billingham
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**37083LT Bungendore**
Number of Samples	9 Soil
Date samples received	28/10/2024
Date completed instructions received	28/10/2024

Analysis Details

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

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

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

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

Report Details

Date results requested by	04/11/2024
Date of Issue	08/11/2024
Reissue Details	This report replaces R00 created on 04/11/2024 due to: registration error

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Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By
Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		364911-1	364911-2	364911-3	364911-4	364911-5
Your Reference	UNITS	7	11	13	17	18
Depth		0.5-0.95	0.1-0.3	1.6-2.0	0.2-0.3	1.2-1.4
Date Sampled		15/10/2024	14/10/2024	14/10/2024	15/10/2024	16/10/2024
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	30/10/2024	30/10/2024	30/10/2024	30/10/2024	30/10/2024
Date analysed	-	30/10/2024	30/10/2024	30/10/2024	30/10/2024	30/10/2024
pH 1:5 soil:water	pH Units	6.4	6.0	7.0	5.1	6.8
Chloride, Cl 1:5 soil:water	mg/kg	<10	<10	<10	<10	24
Sulphate, SO4 1:5 soil:water	mg/kg	10	20	<10	10	<10
Resistivity in soil*	ohm m	560	190	460	250	230

Misc Inorg - Soil					
Our Reference		364911-6	364911-7	364911-8	364911-9
Your Reference	UNITS	24	28	27	1
Depth		0.5-0.95	0.5-0.8	1.8-1.95	0.3-0.4
Date Sampled		17/10/2024	15/10/2024	17/10/2024	16/10/2024
Type of sample		Soil	Soil	Soil	Soil
Date prepared	-	30/10/2024	30/10/2024	30/10/2024	30/10/2024
Date analysed	-	30/10/2024	30/10/2024	30/10/2024	30/10/2024
pH 1:5 soil:water	pH Units	7.1	6.9	7.4	7.5
Chloride, Cl 1:5 soil:water	mg/kg	<10	<10	10	10
Sulphate, SO4 1:5 soil:water	mg/kg	10	21	10	<10
Resistivity in soil*	ohm m	380	270	300	290

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
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	364911-2
Date prepared	-			30/10/2024	1	30/10/2024	30/10/2024		30/10/2024	30/10/2024
Date analysed	-			30/10/2024	1	30/10/2024	30/10/2024		30/10/2024	30/10/2024
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	1	6.4	6.2	3	100	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	<10	<10	0	108	94
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	1	10	10	0	110	94
Resistivity in soil*	ohm m	1	Inorg-002	<1	1	560	520	7	98	[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

Tests PH/EC have exceeded the recommended technical holding times, Envirolab Group form 347 "Recommended Preservation and Holding Times" can be provided on request (available on the Envirolab website)

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BOREHOLE LOG

Borehole No.
1
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 724.9 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record: DRY ON COMPLETION

Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	CL-CI	Silty CLAY: low to medium plasticity, brown and grey, trace of fine to medium grained quartz and ironstone gravel.	w<PL	Hd		RESIDUAL
N = 30 12,12,18	CH	as above, but high plasticity and orange brown.			>600 >600 >600	
	CL	Silty CLAY: low plasticity, grey and yellow brown.	w>PL	VSt	220 240 260	
N = 28 6,8,20	CH	as above, but high plasticity, with fine to coarse grained quartz and ironstone gravel.		Hd	520 600 580	
	-	Extremely Weathered silty sandstone: silty CLAY, low plasticity, light grey.	XW	Hd		ABERCROMBIE FORMATION VERY LOW 'TC' BIT RESISTANCE
		Silty SANDSTONE: fine grained, light grey.	DW	M		MODERATE RESISTANCE
		END OF BOREHOLE AT 3.70 m				'TC' BIT REFUSAL GROUNDWATER MONITORING WELL INSTALLED TO 3.7m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 0.7m TO 3.0m. CASING 0m TO 0.7m. 2mm SAND FILTER PACK 0m TO 0.5m. BENTONITE SEAL 0m TO 0.5m.

RL (m AHD): 724, 723, 722, 721, 720, 719, 718
Depth (m): 1, 2, 3, 4, 5, 6

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 37083LT BUNGENDORE.GPJ <<DrawingFile>> 13/11/2024 15:39 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

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BOREHOLE LOG

Borehole No.
2
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 735.3 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	ES		735	0		CH	Silty CLAY: high plasticity, red brown and brown, trace of fine to medium grained ironstone and quartz gravel, and root fibres.	w<PL	Hd		GRASS COVER RESIDUAL
	ES, DS	N = 13 4,7,6								>600 >600 >600	
			734	1			as above, but red brown and grey.				
	DS	N = 21 5,9,12	733	2						>600 >600 >600	
			732	3			END OF BOREHOLE AT 3.00 m				
			731	4							
			730	5							
			729	6							

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BOREHOLE LOG

Borehole No.
3
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT | **Method:** SPIRAL AUGER | **R.L. Surface:** 737.1 m
Date: 15/10/24 | **Datum:** AHD
Plant Type: JK308 | **Logged/Checked By:** K.R./A.B.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			737	0		CH	Silty CLAY: high plasticity, red brown and brown, trace of fine to medium grained ironstone and quartz gravel, ash and root fibres.	w<PL	Hd		GRASS COVER RESIDUAL
		N = 16 5,8,8					as above, but without root fibres.			>600 >600 >600	
			736	1							
		N = 14 3,5,9					Silty CLAY: high plasticity, red brown, orange brown and grey, trace of fine to medium grained ironstone gravel.	w<PL		>600 >600 >600	
			735	2							
						-	Extremely Weathered sandstone: silty CLAY, low plasticity, orange brown and grey, with fine to medium grained sand.	XW	(Hd)		ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
			734	3			END OF BOREHOLE AT 3.00 m				TOO FRIABLE FOR HP TESTING
			733	4							
			732	5							
			731	6							

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BOREHOLE LOG

Borehole No.
4
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 735.0 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION							FILL: Silty clay, high plasticity, red brown and brown, trace of fine to medium grained ironstone and quartz gravel, ash and root fibres.	w<PL			GRASS COVER
		N = 16 5,7,9	734	1		CH	Silty CLAY: high plasticity, red brown and light brown, trace of fine to medium grained ironstone gravel.	w<PL	Hd	>600 >600 >600	RESIDUAL
		N = 21 5,7,14					Silty CLAY: high plasticity, red brown and grey, trace of fine to medium grained ironstone and quartz gravel.				
			733	2		-	Extremely Weathered sandstone: silty CLAY, low plasticity, orange brown and grey, trace of fine to medium grained quartz gravel.	XW			ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
							SANDSTONE: fine grained, orange brown and light grey.	DW	L - M M		MODERATE TO HIGH RESISTANCE HIGH RESISTANCE 'TC' BIT REFUSAL
			732	3			END OF BOREHOLE AT 2.70 m				
			731	4							
			730	5							
			729	6							

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BOREHOLE LOG

Borehole No.
5
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 739.5 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION				0		CH	Silty CLAY: high plasticity, red brown and brown, trace of fine to medium grained quartz gravel, and root fibres.	w<PL	Hd		GRASS COVER RESIDUAL
		N = 8 3,4,4	739							>600 >600 >600	
				1							
		N > 33 7,14,19/ 100mm REFUSAL	738			-	Extremely Weathered sandstone: silty CLAY, low plasticity, light grey and orange brown, trace of fine to medium grained quartz gravel.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
				2							
			737								
				3			END OF BOREHOLE AT 3.00 m				
			736								
				4							
			735								
				5							
			734								
				6							
			733								

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 37083LT BUNGENDORE.GPJ <<DrawingFile>> 13/11/2024 15:40 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

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BOREHOLE LOG

Borehole No.
6
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 735.3 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		735		CH	Silty CLAY: high plasticity, red brown and brown, with fine to medium grained quartz gravel, trace of fine to medium grained ironstone gravel, and root fibres.	w<PL	Hd		GRASS COVER RESIDUAL
	N = 15 6,8,7							>600 >600 >600	
		734	1		as above, but red brown, grey and orange brown, without root fibres.				
	N = 18 3,6,12							>600 >600 >600	
		733	2	-	Extremely Weathered sandstone: silty CLAY, low plasticity, orange brown and light grey, trace of fine to medium grained ironstone and quartz gravel.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
					SANDSTONE: fine to medium grained, orange brown and grey, with extremely weathered and iron indurated bands and fine to medium grained quartz gravel.	HW	L		
		732	3		SANDSTONE: fine to medium grained, light grey, grey and orange brown, trace of fine to medium grained quartz gravel.	DW	M		MODERATE RESISTANCE
		731	4						MODERATE TO HIGH RESISTANCE
		730	5				H		HIGH RESISTANCE
		729	6		END OF BOREHOLE AT 5.60 m				'TC' BIT REFUSAL GROUNDWATER MONITORING WELL INSTALLED TO 5.58m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 2.8m TO 5.58m. CASING 0m TO 2.8m. 2mm SAND FILTER PACK 2.5m TO 5.58m. BENTONITE SEAL 1.0m TO 2.5m. BACKFILLED WITH SAND TO THE SURFACE.

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BOREHOLE LOG

Borehole No. 7

1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 738.8 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		N = 18 3,4,14	738			CH	Silty CLAY: high plasticity, red brown and orange brown, with fine to medium grained ironstone gravel.	w<PL	Hd	>600 >600 >600	GRASS COVER RESIDUAL
			737	1 2		-	Extremely Weathered sandstone: silty CLAY, low plasticity, light grey and orange brown, with fine to medium grained ironstone and quartz gravel.	XW	(Hd)		ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE TOO FRIABLE FOR HP TESTING
			736	3			SANDSTONE: fine to medium grained, light brown and orange brown, with fine to medium grained quartz gravel, and occasional extremely weathered and iron indurated bands.	DW	L - M M - H		MODERATE RESISTANCE HIGH RESISTANCE
			735 734 733 732	4 5 6			END OF BOREHOLE AT 3.20 m				'TC' BIT REFUSAL

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BOREHOLE LOG

Borehole No. 8

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 743.8 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING						CI	Silty CLAY: medium plasticity, light brown and orange brown, trace of root fibres.	w~PL	Hd		GRASS COVER RESIDUAL
		N = 14 5,6,8	743	1						>600 >600 >600	
		N = 17 4,5,12					as above, but light brown, orange brown and grey.				TOO FRIABLE FOR HP TESTING
			742	2		-	Extremely Weathered sandstone: silty CLAY, low plasticity, orange brown mottled light grey, trace of fine to medium grained quartz gravel.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION
			741	3			SANDSTONE: fine to medium grained, orange brown and light grey, trace of fine to medium grained quartz and ironstone gravel, and extremely weathered bands.	DW	L		VERY LOW TO LOW 'TC' BIT RESISTANCE
			740	4					L - M		BANDED LOW TO MODERATE RESISTANCE
			739	5							
			738	6			REFER TO CORED BOREHOLE LOG				
			737								

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CORED BOREHOLE LOG

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Core Size:** NMLC **R.L. Surface:** 743.8 m
Date: 14/10/24 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK308 **Bearing:** N/A **Logged/Checked By:** K.R./A.B.

Water Loss\Level	RL (m AHD)	Depth (m)	CORE DESCRIPTION (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS – DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) – Specific	Formation
			START CORING AT 5.57m					
10% RETURN	738	6	NO CORE 1.10m					
	737	7	SANDSTONE: fine to medium grained, light brown and grey, bedded at 0-20°.	HW	L	0.20 0.20	(6.69m) XWS, 0°, 30 mm.t (6.77m) Be, 15°, P, S, Fe Sn (6.79m) Be, 15°, P, R, Fe Ct (7.12m) J, 30°, P, S, Clay Vn (7.30m) Be, 20°, P, R, Fe Ct (7.37m) Be, 0°, P, S, Clay Ct (7.39m) J, 80°, Un, S, Fe Ct (7.47m) J, 45°, P, S, Cn	Abercrombie Formation
	736 735	8 9	as above, but light brown, grey and orange brown, with occasional iron staining.	MW	M	0.40 0.50	(7.52m) XWS, 0°, 60 mm.t (7.62m) Be, 0°, P, S, Fe Ct (7.73m) J, 25°, Un, S, Fe Ct (7.87m) Be x 2, 5°, P, R, Fe Sn (7.91m) J, 30°, Ir, R, Fe Ct (8.00m) J, 80°, Ir, R, Fe Ct (8.10m) XWS, 70 mm.t (8.23m) Jh, 60°, Fe FILLED (8.28m) Be, 0°, P, S, Fe Ct (8.38m) J, 60°, P, S, Fe Ct (8.43m) Jh, 80°, Fe FILLED (8.49m) Be, 20°, Un, S, Fe Ct (8.55m) Be x 2, 15°, P, S, Fe Ct (8.63m) Be, 20°, P, S, Fe Ct (8.86m) Jh, 70°, Fe FILLED (8.95m) J, 90°, P, S, Fe Ct (9.00m) XWS, 0°, 20 mm.t	
					H	1.1	(9.17m) Be, 10°, P, S, Fe Ct (9.23m) XWS, 5°, 25 mm.t	
	734	10	SANDSTONE: fine to medium grained, grey, light grey and orange brown, bedded at 0-20°, with occasional quartz inclusions.		H	1.9	(9.33m) Be, 0°, P, S, Fe Ct (9.41m) J, 60°, P, S, Qz FILLED (9.47m) Ji, 30°, P, S, Fe Ct (9.50m) Be, 15°, P, R, Fe Ct (9.56m) Be, 5°, P, R, Fe Sn (9.66m) Be, 0°, P, S, Fe Ct (9.80m) J, 80°, P, S, Fe Ct (9.96m) XWS, 0°, 40 mm.t	
					M	0.40	(10.11m) J, 90°, P, S, Fe Ct (10.22m) J, 50°, P, R, Fe Sn (10.31m) Be, 15°, P, S, Fe Sn (10.36m) Cr, 5°, 50 mm.t (10.48m) Cr, 0°, 80 mm.t (10.55m) XWS, 0°, 60 mm.t	
	733 732	11	END OF BOREHOLE AT 10.59 m					

Column headings: Water Loss\Level; Barrel Lift; RL (m AHD); Depth (m); Graphic Log; CORE DESCRIPTION; Weathering; Strength; POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH); DEFECT DETAILS: SPACING (mm) (600, 200, 60, 20); DESCRIPTION – Specific, General; Formation.

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 37083LT
Borehole No: BH8
Depth: 5.57m to 10.59m
KODAK Gray Scale
KODAK Color Control Patches
37083LT BH8 START CORING AT 5.57m
5
NO CORE 1.10m
6
7
8
9
10
END OF BOREHOLE AT 10.59m

JKGeotechnics

BOREHOLE LOG

Borehole No.
9
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 740.9 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 15 5,7,8	740	0 – 1	CH	Silty CLAY: high plasticity, red brown and brown, trace of fine to medium grained ironstone and quartz gravel.	w<PL	Hd	>600 >600 >600	GRASS COVER RESIDUAL
	N=SPT 15/ 100mm REFUSAL	739	1 – 2	-	Extremely Weathered sandstone: silty CLAY, low plasticity, light grey and orange brown, with fine to medium grained ironstone and quartz gravel.	XW	(Hd)		ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
		738	2 – 3		SANDSTONE: fine to medium grained, light brown and orange brown, with extremely weathered and iron indurated bands, trace of fine to medium grained ironstone and quartz gravel.	DW	L M		LOW TO MODERATE RESISTANCE MODERATE RESISTANCE
		737, 736, 735, 734	3 – 6		END OF BOREHOLE AT 3.00 m				

Samples: ES | U50 | DB | DS

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BOREHOLE LOG

Borehole No.
10
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 735.9 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 13 3,6,7		FILL: Silty clay, high plasticity, red brown and brown, trace of fine to medium grained quartz gravel, ash and root fibres.	w<PL			GRASS COVER APPEARS WELL COMPACTED
			FILL: Silty clay, low plasticity, dark brown, trace of fine grained ironstone gravel, fine to medium grained sand, and ash.				
	N > 25 7,15,10/ 50mm REFUSAL N > 23 4,9,14/ 100mm REFUSAL	CH	Silty CLAY: high plasticity, grey, red brown and orange brown, trace of fine to medium grained quartz and ironstone gravel.	w<PL	Hd	>600 >600 >600 490 470 530	RESIDUAL
		-	Extremely Weathered sandstone: silty CLAY, low plasticity, orange brown and grey, with fine to medium grained ironstone gravel, trace of fine to medium grained quartz gravel.	XW DW	(Hd) M - H		ABERCROMBIE FORMATION LOW 'TC' BIT FORMATION MODERATE TO HIGH RESISTANCE
			SANDSTONE: fine to medium grained, orange brown and light grey, with fine to medium grained quartz gravel.				HIGH RESISTANCE 'TC' BIT REFUSAL
			END OF BOREHOLE AT 3.90 m				

RL (m AHD): 735, 734, 733, 732, 731, 730, 729
Depth (m): 1, 2, 3, 4, 5, 6

SAMPLES: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No.
11

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 745.6 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record: DRY ON COMPLETION OF AUGERING

Depth (m)	Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
0 – 1.4	N = 16 6,7,9	CH	Silty CLAY: high plasticity, orange brown, trace of fine to medium grained quartz and ironstone gravel.	w<PL	Hd	>600 >600 >600	RESIDUAL
1.4 – 1.8	N > 6 11,6/ 50mm REFUSAL	-	Extremely Weathered sandstone: sandy CLAY, low plasticity, light brown, fine to medium grained sand.	XW	(Hd)		ABERCROMBIE FORMATION
1.8 – 4.0			SANDSTONE: fine to medium grained, light grey and light brown.	DW	L		VERY LOW 'TC' BIT RESISTANCE LOW RESISTANCE
4.0			REFER TO CORED BOREHOLE LOG				

Samples (ES, U50, DB, DS) are shown graphically against depth.

RL (m AHD)	745	744	743	742	741	740	739
Depth (m)	1	2	3	4	5	6	

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CORED BOREHOLE LOG

Borehole No.
11

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Core Size:** NMLC **R.L. Surface:** 745.6 m
Date: 14/10/24 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK500 **Bearing:** N/A **Logged/Checked By:** C.A.R./A.B.

Water Loss\Level: 90% RETURN

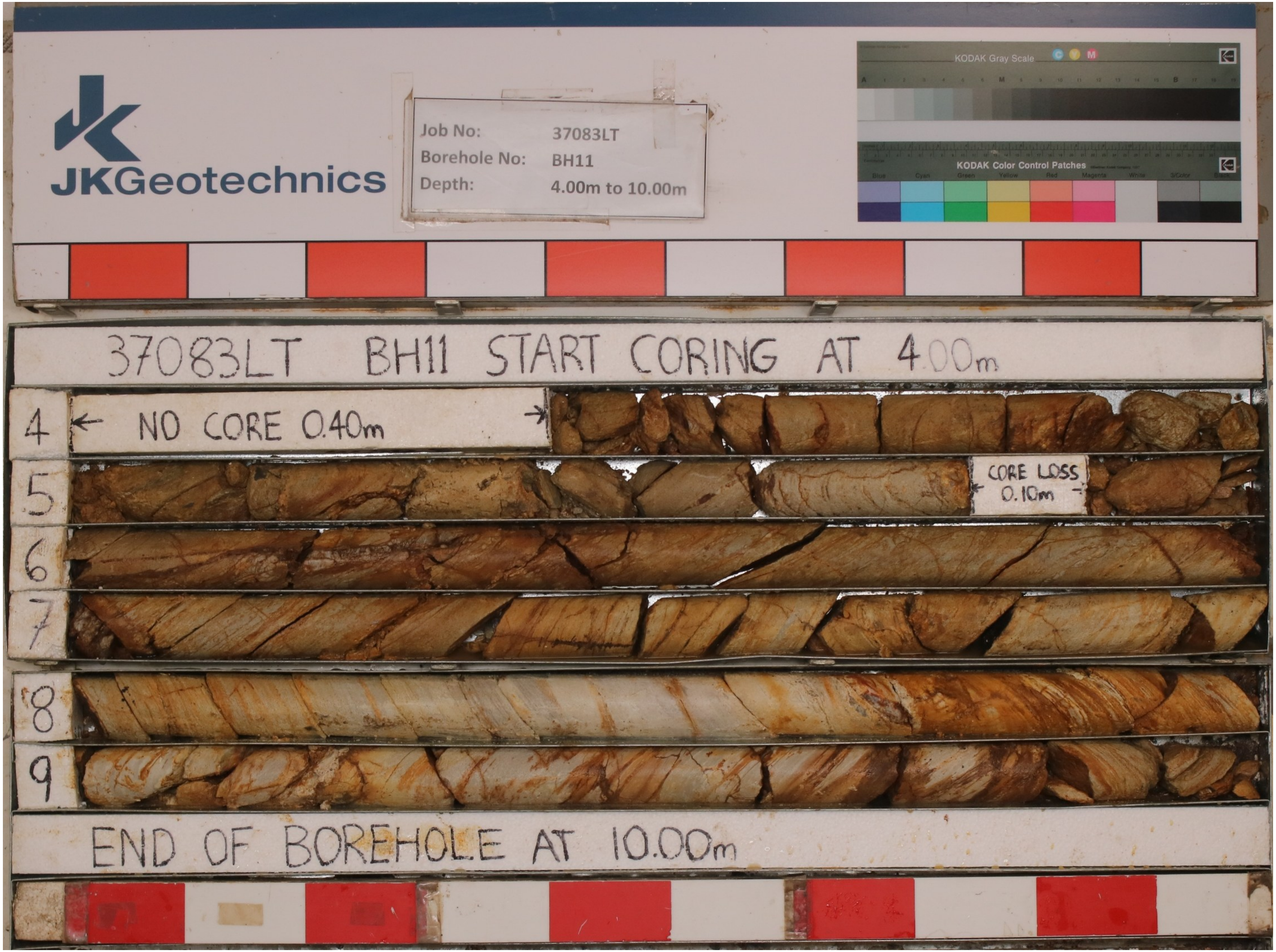
START CORING AT 4.00m

Depth (m)	CORE DESCRIPTION (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components)	Weathering	Strength	Point Load Strength Index $I_s(50)$	Defect Details – Description (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness)	Formation
4.00–4.40	NO CORE 0.40m					
4.40–5.75	SANDSTONE: fine to medium grained, light brown, grey and orange, with occasional quartz veins, foliated at 50-65°.	HW	L - M	0.20	(4.48m) J, 80°, P, R, Clay Sn (4.59m) J, 70°, P, R, Fe Ct (4.61m) Be, 50°, P, R, Fe Ct (4.74m) Ji, 30°, C (4.78m) J, 0°, P, R, Fe Ct (4.87m) J, 70°, P, R, Fe Ct (4.95m) J, 70°, P, R, Cn (5.18m) XWS, 5°, 10 mm.t (5.25m) J, 80°, P, R, Fe Ct (5.30m) XWS, 10°, 140 mm.t (5.48m) Be, 50°, P, R, Fe Sn (5.67m) Ji, 90°, P	Abercrombie Formation
5.75–5.85	NO CORE 0.10m					
5.85–7.40	SANDSTONE: fine to medium grained, light brown, grey and orange, with occasional quartz veins, foliated at 50-65°.	HW	M	0.60 0.40	(5.96-6.33m) Jh, 80°, P (6.20m) J, 30°, P, R, Fe Sn (6.40m) J x 3, 40 - 60°, P, R, Fe Ct (6.60m) Be, 65°, P (6.81m) Be, 50°, P, R, Fe Sn (6.92m) Jh, 40°, P (7.00m) J, 45°, P, R, Qz FILLED (7.12m) Be x 2, 50°, P, R, Clay Ct, 1 mm.t (7.20m) Be, 55°, P, R, Fe Ct (7.27m) Be, 50°, P, R, Fe FILLED, 3 mm.t	Abercrombie Formation
7.40–8.00	as above, but foliated at 30-40°.	HW	M	0.60 0.50	(7.48m) J, 5°, P, R (7.56m) Be, 40°, P, R, Fe Ct (7.64m) Be, 40°, P, R, Fe Ct (7.72m) J, 50°, C, R, Fe Ct (7.80m) Be, 40°, P, R, Fe Ct (7.94m) J, 20°, P, R, Cn (8.00m) Be, 30°, P, R, Fe Ct	Abercrombie Formation
8.00–10.00	SANDSTONE: fine to medium grained, light grey, orange brown and dark brown, with occasional quartz veins, foliated at 30-55°.	HW	L	0.20 0.080 0.30 0.30 0.20	(8.69m) XWS, 30°, 10 mm.t (8.86m) Be, 35°, P, R, Clay (8.89m) J, 55°, P, R, Fe Ct, 5 mm.t (9.03m) J, 90°, Ir, R, Fe Sn (9.16m) J x 2, 70°, P, R, Clay Ct (9.31m) J, 30°, P, R, Fe Ct (9.50m) Ji, 0°, Ir/P, R, Fe Ct (9.71m) Be, 30°, P, R, Fe Sn (9.84m) Be, 45°, P, R, Fe Sn (9.95m) J x 2, 45°, P, R, Cn	Abercrombie Formation

END OF BOREHOLE AT 10.00 m

RL (m AHD) scale: 741, 740, 739, 738, 737, 736, 735
Point load scale: VL -0.1, L -0.3, M -1, H -3, VH -10, EH
Spacing (mm) scale: 600, 200, 60, 20

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 37083LT
Borehole No: BH11
Depth: 4.00m to 10.00m
KODAK Gray Scale
KODAK Color Control Patches
37083LT BH11 START CORING AT 4.00m
4
NO CORE 0.40m
5
CORE LOSS 0.10m
6
7
8
9
END OF BOREHOLE AT 10.00m

JKGeotechnics

BOREHOLE LOG

Borehole No.
12
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 742.0 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 13 4,7,6	741	1	CH	Silty CLAY: high plasticity, red brown and light brown, trace of fine to medium grained ironstone gravel, and root fibres.	w<PL	Hd	>600 >600 >600	GRASS COVER RESIDUAL
	N > 5 10,5/ 50mm REFUSAL			-	Extremely Weathered sandstone: silty CLAY, low plasticity, grey and orange brown, trace of fine to medium grained ironstone gravel.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION
		740	2		SANDSTONE: fine to medium grained, brown and grey, with extremely weathered and iron indurated bands.	DW	L - M		LOW TO MODERATE 'TC' BIT RESISTANCE
		739	3		END OF BOREHOLE AT 3.00 m				
		738	4						
		737	5						
		736	6						

JKGeotechnics

BOREHOLE LOG

Borehole No.
13
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 737.4 m
Date: 14/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 19 6,8,11	737	0 – 1	CI-CH	Silty CLAY: medium to high plasticity, orange brown, trace of fine to medium grained ironstone and quartz gravel.	w<PL	Hd	>600 >600 >600	RESIDUAL
	N=SPT 3/ 0mm REFUSAL	736	1 – 1.6	-	SANDSTONE: fine to medium grained, grey and brown, with iron indurated bands.	DW	L		ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
		735, 734	1.6 – 3.6		as above, but light grey and light brown.		M		MODERATE RESISTANCE HIGH RESISTANCE
			3.6		END OF BOREHOLE AT 3.60 m				'TC' BIT REFUSAL

Samples columns: ES, U50, DB, DS.

JKGeotechnics

BOREHOLE LOG

Borehole No.
14
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 735.0 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		N = 15 4,7,8	734	1			Silty CLAY: high plasticity, red brown and light brown, trace of fine to medium grained quartz gravel, and root fibres.	w<PL	Hd	>600 >600 >600	GRASS COVER RESIDUAL
			733	2		-	SANDSTONE: fine to medium grained, orange brown and brown, trace of fine to medium grained quartz gravel.	DW	L - M		ABERCROMBIE FORMATION LOW TO MODERATE 'TC' BIT RESISTANCE
							as above, but orange brown and light grey.		M		HIGH RESISTANCE 'TC' BIT REFUSAL
			732	3			END OF BOREHOLE AT 2.90 m				
			731	4							
			730	5							
			729	6							

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BOREHOLE LOG

Borehole No.
15

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 738.8 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION						CH	Silty CLAY: high plasticity, red brown and orange brown, trace of root fibres.	w<PL	Hd		GRASS COVER RESIDUAL
		N = 16 8,8,8	738	1						>600 >600 >600	
							as above, but red brown, orange brown and grey, without root fibres.				
		N=SPT 5/ 100mm REFUSAL	737	2		-	SANDSTONE: fine to medium grained, orange brown and brown, with extremely weathered bands, trace of fine to medium grained quartz gravel.	DW	L		ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
							SANDSTONE: fine to medium grained, light brown and grey, trace of fine to medium grained quartz gravel.		M - H		MODERATE TO HIGH RESISTANCE HIGH RESISTANCE
							END OF BOREHOLE AT 2.40 m				'TC' BIT REFUSAL
			736	3							
			735	4							
			734	5							
			733	6							
			732								

JKGeotechnics

BOREHOLE LOG

Borehole No.
16

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 737.1 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 12 4,4,8	737			FILL: SIlty clay, medium plasticity, red brown and brown, trace of fine to medium grained ironstone gravel, ash and root fibres.	w~PL			GRASS COVER APPEARS MODERATELY COMPACTED
		736	1	CH	Silty CLAY: high plasticity, red brown and orange brown, trace of fine to medium grained quartz gravel.	w~PL	Hd	>600 >600 >600	RESIDUAL
	N = 33 7,13,20	735	2		as above, but orange brown, grey and light grey.	w>PL		>600 >600 >600	
	N = 29 5,12,17	734	3		as above, but orange brown, red brown, grey and light grey.	w<PL		>600 >600 >600	
		733	4	-	MUDSTONE: fine to medium grained, brown and grey.	DW	H		ABERCROMBIE FORMATION HIGH 'TC' BIT RESISTANCE
					END OF BOREHOLE AT 3.80 m				'TC' BIT REFUSAL
		732	5						
		731	6						

SAMPLES: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No.
17

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 744.2 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING	N = 14 8,7,7	744 743	1	CH	Silty CLAY: high plasticity, ornage brown, trace of fine to medium grained ironstone and quartz gravel.	w<PL	Hd	>600 540 560	RESIDUAL
		742	2	-	SANDSTONE: fine to medium grained, brown and grey.	DW	L		ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
		741 740 739 738	3 4 5 6		REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 7.75m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.0m TO 7.75m. CASING 0m TO 3.0m. 2mm SAND FILTER PACK 2.1m TO 7.75m. BENTONITE SEAL 0.2m TO 2.1m. BACKFILLED WITH SAND TO THE SURFACE. STICKING OUT OF GROUND FOR VISIBILITY.

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
17

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT | **Core Size:** NMLC | **R.L. Surface:** 744.2 m
Date: 15/10/24 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK500 | **Bearing:** N/A | **Logged/Checked By:** C.A.R./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL-0.1, L-0.3, M-1, H-3, VH-10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS: DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) — Specific / General	Formation
		742			START CORING AT 2.50m						
90% RETURN		741	3		SANDSTONE: fine to medium grained, light brown and grey, foliated at 40-50°.	MW	L	0.20		(2.58m) J, 90°, Ir, R, Clay Ct (2.64m) XWS, 0°, 40 mm.t (2.74m) J, 80°, Ir, R, Fe Ct	Abercrombie Formation
							M	0.60		(3.06m) XWS, 40°, 8 mm.t (3.60m) Be, 45°, P, R, Clay Ct (3.62m) XWS, 0°, 30 mm.t (3.73m) Be, 40°, St, R, Clay Ct	
		740	4		MUDSTONE: grey and light brown, foliated at 35-50°.		M - H	0.80 1.3 0.60		(3.89m) J, 90°, Ir, R, Clay FILLED, 2 mm.t (4.00m) J, 30°, P, R, Clay FILLED, 1 mm.t (4.39m) J, 30°, P, R, Clay FILLED, 2 mm.t (4.46m) J, 30°, P, R, Clay FILLED, 2 mm.t (4.50m) J, 30°, P, R, Clay FILLED, 8 mm.t (4.60m) J, 70°, St, R, Qz FILLED, 4 mm.t (4.64m) XWS, 30°, 6 mm.t (4.65-4.87m) Closely spaced Ji, J and XWS, <10mm spacing (5.16m) Be, 35°, P, R, Fe Ct (5.25m) Be, 35°, P, R, Fe Ct	
		739 738	5 6		Interbedded MUDSTONE: grey and light brown, and SANDSTONE: fine grained, light brown and grey, foliated at 40-50°.			1.2 0.80 1.5		(5.51m) Be, 35°, P, R, Clay FILLED, 2 mm.t (5.60m) J, 0°, Ir, R, Clay Ct (5.89m) J x 2, 60°, P, R, Fe Ct (6.15m) Be, 40°, P, R, Fe Ct (6.18m) Ji, 70°, P (6.52m) XWS, 30°, 20 mm.t (6.84m) J, 80°, Ir, R, Fe Ct	
		737	7		SANDSTONE: fine grained, grey brown, foliated at 40-50°.		H	1.5 1.2		(7.03m) Be, 30°, P, R, Fe Ct (7.17m) Ji, 80°, Un (7.32m) Be, 40°, P, R, Fe Ct (7.42m) Be, 40°, P, R, Fe Ct (7.54m) Be, 40°, P, R, Fe Ct (7.67m) J, 70°, P, R, Fe Ct	
		736	8		END OF BOREHOLE AT 7.75 m						

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 37083LT
Borehole No: BH17
Depth: 2.50m to 7.75m
KODAK Gray Scale
KODAK Color Control Patches
37083LT BH17 START CORING AT 2.50m
2
3
4
5
6
7
END OF BOREHOLE AT 7.75m

JKGeotechnics

BOREHOLE LOG

Borehole No.
18
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 743.7 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		N = 13 4,7,6	743	1		CH	Silty CLAY: high plasticity, red brown and light brown.	w<PL		>600 >600 >600	GRASS COVER RESIDUAL
			742 741	2 3		-	SANDSTONE: fine to medium grained, brown and grey, with extremely weathered bands and iron indurated bands.	DW	L - M		ABERCROMBIE FORMATION BANDED LOW TO MODERATE 'TC' BIT RESISTANCE MODERATE TO HIGH RESISTANCE
							as above, but grey and orange brown.		M - H		HIGH RESISTANCE
			740 739 738 737	4 5 6			END OF BOREHOLE AT 3.60 m				'TC' BIT REFUSAL

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 37083LT BUNGENDORE.GPJ <<DrawingFile>> 13/11/2024 15:41 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

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BOREHOLE LOG

Borehole No.
19

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 740.6 m
Date: 15/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING	N = 12 5,6,6; N = 33 4,15,18	740, 739	0–1.7	CH	Silty CLAY: high plasticity, orange brown and red brown, trace of fine to medium grained ironstone and quartz gravel.	w<PL	Hd; VSt	>600 >600 >600; 280 300 330	RESIDUAL
			1.7–2.0	-	Extremely Weathered sandstone: silty CLAY, medium plasticity, brown and grey.	XW	(Hd)		ABERCROMBIE FORMATION
		738	2.0–2.6		SANDSTONE: fine to medium grained, light brown and grey.	DW	L		LOW 'TC' BIT RESISTANCE
		738–734	2.6–7		REFER TO CORED BOREHOLE LOG				

Samples: ES, U50, DB, DS

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
19

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT | **Core Size:** NMLC | **R.L. Surface:** 740.6 m
Date: 15/10/24 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK500 | **Bearing:** N/A | **Logged/Checked By:** C.A.R./A.B.

Water Loss\Level: 90% RETURN (from 2.60m to 7.52m)

RL (m AHD)	Depth (m)	CORE DESCRIPTION (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components)	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS – DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) – Specific	Formation
738	2.60	START CORING AT 2.60m					
738 – 737	2.60 – 3.32	SANDSTONE: fine to medium grained, light brown and grey, foliated at 40-70°.	MW	M		(2.97m) J x 2, 60°, P, R, Cn (3.11m) Jh, 70°, P, Clay FILLED, 2 mm.t (3.21m) CS, 0°, 80 mm.t	Abercrombie Formation
737 – 735.6	3.32 – 4.95	MUDSTONE: grey and light brown, foliated at 40-70°, with occasional fine grained sandstone bands and quartz veins.	MW	M	0.40 0.50 0.40 0.10 0.40	(3.42m) Be, 5°, P, R, Fe Sn (3.46m) Be, 50°, P, R, Fe Ct (3.59m) Be, 40°, P, R, Fe Ct (3.81m) Be, 5°, P, R, Fe Ct (3.87m) Be, 40°, Ir, R, Clay Ct (3.96m) XWS, 0°, Qz FILLED, 200 mm.t (4.32m) Cr, 0°, Qz FILLED, 50 mm.t (4.45m) Jh, 60°, P, R, Clay FILLED, 1 mm.t (4.65m) J, 60°, P, S, Clay Ct (4.82m) J, 50°, P, R, Clay FILLED, 4 mm.t	Abercrombie Formation
	4.95 – 5.27	NO CORE 0.32m					
735	5.27 – 5.90	Extremely Weathered sandstone: silty CLAY, low plasticity, light brown, with quartz veins and very low strength sandstone bands.	XW	(Hd)			
	5.90 – 6.00	NO CORE 0.10m					
734 – 733	6.00 – 7.52	SANDSTONE: fine to medium grained, light brown and grey, with occasional mudstone bands, foliated at 30-50°.	MW	L - M (to 6.9m), M	0.30 0.30 1.0 0.60	(6.06m) Jh x 2, 70°, C, Clay FILLED, 1 mm.t (6.27m) J, 60°, P, S, Clay FILLED, 2 mm.t (6.44m) J, 70°, P, Clay FILLED, 2 mm.t (6.57m) J, 20°, Ir, R, Fe Sn (6.68m) XWS, 30°, 100 mm.t (6.89m) J, 90°, Ir, R, Fe Ct (7.36m) XWS, 20°, 30 mm.t	Abercrombie Formation
733 – 732	7.52	END OF BOREHOLE AT 7.52 m					

Point load strength classes: VL -0.1, L -0.3, M -1, H -3, VH -10, EH. Spacing (mm): 600, 200, 60, 20.

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 37083LT
Borehole No: BH19
Depth: 2.62m to 7.52m
KODAK Gray Scale
KODAK Color Control Patches
37083LT BH19 START CORING AT 2.62m
2
3
4
5
CORE LOSS 0.32m
CORE LOSS 0.10m
6
7
END OF BOREHOLE AT 7.52m

JKGeotechnics

BOREHOLE LOG

Borehole No. 20

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 743.2 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		N = 18 5,9,9	743	0		CH	Silty CLAY: high plasticity, orange brown, trace of fine to coarse grained quartz gravel, and root fibres.	w<PL	Hd	>600 >600 >600	RESIDUAL
			742	1		-	Extremely Weathered sandstone: silty CLAY, medium plasticity, brown and light brown.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION
		N=SPT 10/ 100mm REFUSAL	741	2			SANDSTONE: fine grained, brown and light brown.	DW	L - M		LOW 'TC' BIT RESISTANCE
									M		MODERATE RESISTANCE
			740	3			END OF BOREHOLE AT 3.00 m				
			739	4							
			738	5							
			737	6							

JKGeotechnics

BOREHOLE LOG

Borehole No.
21
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 741.5 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	SAMPLES ES / U50 / DB / DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		N = 18 7,10,8	741			CH	Silty CLAY: high plasticity, orange brown, trace of fine to medium grained ironstone gravel, and root fibres.	w<PL	Hd	>600 >600 >600	RESIDUAL
		N > 25 5,9,16/ 100mm REFUSAL	740	1		-	Extremely Weathered sandstone: silty CLAY, medium plasticity, light brown, brown and grey, with very low strength sandstone bands.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION
			739	2			SANDSTONE: fine grained, brown and light brown.	DW	L - M		LOW 'TC' BIT RESISTANCE
									M		MODERATE RESISTANCE
			738	3			END OF BOREHOLE AT 3.00 m				
			737	4							
			736	5							
			735	6							

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 37083LT BUNGENDORE.GPJ <<DrawingFile>> 13/11/2024 15:41 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

JKGeotechnics

BOREHOLE LOG

Borehole No.
22
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 739.7 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION									CH	Silty CLAY: high plasticity, light brown and orange brown, trace of fine to medium grained ironstone and quartz gravel, and root fibres.	w<PL	Hd		GRASS COVER RESIDUAL
					N = 18 3,6,12	739							440 470 430	
							1							
									-	MUDSTONE: fine grained, brown and grey brown.	HW	M - H		ABERCROMBIE FORMATION MODERATE TO HIGH 'TC' BIT RESISTANCE HIGH RESISTANCE
						738				END OF BOREHOLE AT 1.70 m				'TC' BIT REFUSAL
							2							
						737								
							3							
						736								
							4							
						735								
							5							
						734								
							6							
						733								

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 37083LT BUNGENDORE.GPJ <<DrawingFile>> 13/11/2024 15:41 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

JKGeotechnics

BOREHOLE LOG

Borehole No.
23
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT | **Method:** SPIRAL AUGER | **R.L. Surface:** 742.0 m
Date: 17/10/24 | **Datum:** AHD
Plant Type: JK500 | **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 18 9,8,10		0	CH	Silty CLAY: high plasticity, orange brown, trace of root fibres.	w<PL	Hd	>600 >600 >600	RESIDUAL
	N > 6 10,6/ 50mm REFUSAL	741	1	-	Extremely Weathered sandstone: silty CLAY, low plasticity, light brown and brown.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION VERY LOW 'TC' BIT RESISTANCE
		740	2		SANDSTONE: fine grained, light brown and brown.	DW	L - M		LOW TO MODERATE RESISTANCE
		739	3		END OF BOREHOLE AT 3.00 m				
		738	4						
		737	5						
		736	6						

SAMPLES: ES, U50, DB, DS

JKGeotechnics

BOREHOLE LOG

Borehole No.
24
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 741.8 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION					N = 10 4,5,5	741	1		CH	Silty CLAY: high plasticity, red brown and orange brown, trace of root fibres.	w<PL	VSt	320 260 310	GRASS COVER RESIDUAL
									-	SANDSTONE: fine grained, brown and orange brown.	MW	M H		ABERCROMBIE FORMATION MODERATE 'TC' BIT RESISTANCE HIGH RESISTANCE
						740 739 738 737 736 735	2 3 4 5 6			END OF BOREHOLE AT 1.80 m				'TC' BIT REFUSAL

JKGeotechnics

BOREHOLE LOG

Borehole No.
25
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 740.1 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			740	0		CI	Silty CLAY: medium plasticity, red brown, orange brown and grey, trace of fine to medium grained quartz gravel, and fine to medium grained sand.	w<PL	Hd		GRASS COVER RESIDUAL TOO FRIABLE FOR HP TESTING
		N = 17 5,8,9	739	1							
						-	MUDSTONE: fine grained, brown and grey brown.	DW	M		ABERCROMBIE FORMATION MODERATE 'TC' BIT RESISTANCE
			738	2			as above, but with red brown.				
			737	3					M - H		HIGH RESISTANCE
			736	4			END OF BOREHOLE AT 3.90 m				'TC' BIT REFUSAL
			735	5							
			734	6							

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BOREHOLE LOG

Borehole No. 26

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 739.0 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING			0	CH	Silty CLAY: high plasticity, orange brown, trace of fine to medium grained quartz gravel, and ash.	w<PL	Hd		RESIDUAL
	N = 19 6,8,11							>600 >600 >600	
		738	1						
					Silty CLAY: high plasticity, light brown and grey.				
	N = 16 4,6,10							420 500 470	
		737	2						
				-	MUDSTONE: fine grained, light brown and grey.	DW	M		ABERCROMBIE FORMATION
					REFER TO CORED BOREHOLE LOG				MODERATE 'TC' BIT RESISTANCE
		736	3						
		735	4						
		734	5						
		733	6						

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CORED BOREHOLE LOG

Borehole No.
26

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT	**Core Size:** NMLC	**R.L. Surface:** 739.0 m
Date: 16/10/24	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK500	**Bearing:** N/A	**Logged/Checked By:** C.A.R./A.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS – DESCRIPTION (Specific): Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness	Formation
					START CORING AT 2.52m					
90% RETURN					SANDSTONE: fine to medium grained, brown, foliated at 40-50°.	HW	L - M	0.30	(2.59m) Ji, 80°, P	Abercrombie Formation
					MUDSTONE: brown and grey, with occasional fine grained sandstone bands, foliated at 40-50°.			0.30	(2.69m) CS, 40°, 15 mm.t	
									(2.87m) XWS, 40°, 40 mm.t	
									(2.97m) Be, 40°, P, R, Clay Ct	
		736	3						(3.05m) J, 60°, P, S, Cn	
								0.40	(3.35m) XWS, 30°, 50 mm.t	
									(3.52m) J, 60°, C, R, Cn	
									(3.63m) J, 50°, St, R, Fe Sn	
									(3.71m) J, 70°, Ir, R, Cn	
		735	4					0.20	(3.93-4.64m) J/Ji, 90°, P, S, Clay Ct	
									(4.68m) J, 10°, C, R, Clay FILLED, 2 mm.t	
								0.40	(4.81m) CS, 30°, 20 mm.t	
		734	5						(5.02m) CS, 30°, 18 mm.t	
									(5.11m) CS, 30°, 55 mm.t	
									(5.22m) CS, 30°, 170 mm.t	
								0.30	(5.45m) Be, 40°, P, R, Fe Ct	
									(5.48m) Be, 40°, P, S, Fe Ct	
						MW	M		(5.60m) J, 80°, C, R, Clay Ct	
								0.40	(5.79m) J, 30°, P, R, Fe Ct	
		733	6						(5.91m) J, 20°, C, R, Fe Ct	
									(6.19m) Be, 40°, P, S, Fe Sn	
								0.50	(6.36m) Be x 2, 40°, P, S, Fe Ct	
									(6.40m) Be, 40°, P, R, Fe Ct	
									(6.46m) Be, 40°, P, R, Fe Ct	
								0.40	(6.72m) Be, 50°, P, R, Fe Ct	
									(6.80m) J, 35°, P, R, Fe Ct	
		732	7						(6.97m) J, 90°, P, R, Fe Ct	
								0.30	(7.15m) CS, 20°, 10 mm.t	
					SANDSTONE: fine to medium grained, light grey brown and orange brown, with occasional quartz veins, foliated at 40-50°.				(7.22m) J, 0°, Ir, R, Fe Ct	
									(7.28m) Be, 25°, P, R, Fe Ct	
									(7.31m) Jh, 60°, P	
									(7.40m) Jh, 55°, P	
									(7.44m) Jh, 65°, P, Cn	
								0.40	(7.53m) J, 60°, P, R, Fe Ct	
									(7.68m) Be, 50°, P, R, Fe Ct	
									(7.72m) Be, 50°, P, R, Clay Ct	
									(7.74m) XWS, 20°, 20 mm.t	
									(7.78m) J, 90°, P, R, Fe Ct	
		731	8		END OF BOREHOLE AT 7.83 m					

Point load strength scale: VL -0.1, L -0.3, M -1, H -3, VH -10, EH
Spacing (mm): 600, 200, 60, 20

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 37083LT
Borehole No: BH26
Depth: 2.52m to 7.83m
KODAK Gray Scale
KODAK Color Control Patches
37083LT BH26 START CORING AT 2.52m
2
3
4
5
6
7
END OF BOREHOLE AT 7.83m

JKGeotechnics

BOREHOLE LOG

Borehole No.
27
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 739.7 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		N = 6 3,3,3 N = 10 3,4,6	739 738	1		CH	Silty CLAY: high plasticity, orange brown, trace of fine to medium grained ironstone gravel, roots and root fibres.	w<PL w>PL	VSt St	200 220 250 180 200 190	RESIDUAL
			737	2 3		-	Extremely Weathered sandstone: silty CLAY, low plasticity, light grey and light brown, with iron indurated bands.	XW	VSt	300 280 220	ABERCROMBIE FORMATION
							SANDSTONE: fine grained, light grey and brown.	DW	M		MODERATE 'TC' BIT RESISTANCE HIGH RESISTANCE
			736 735 734 733	4 5 6			END OF BOREHOLE AT 3.20 m				'TC' BIT REFUSAL

JKGeotechnics

BOREHOLE LOG

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 740.7 m
Date: 16/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING	N = 13 4,5,8	CI	Silty CLAY: medium plasticity, orange bronw, trace of fine to medium grained ironstone gravel.	w<PL	Hd	>600 >600 >600	RESIDUAL
	N = 27 8,12,15	-	Extremely Weathered sandstone: silty CLAY, medium plasticity, light brown and grey.	XW	(Hd)		ABERCROMBIE FORMATION VERY LOW 'TC' BIT RESISTANCE TOO FRIABLE FOR HP TESTING
			SANDSTONE: fine to medium grained, brown and grey.	DW	L - M		LOW TO MODERATE RESISTANCE
			REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 2.42m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.0m TO 7.42m. CASIN 0m TO 3.0m. 2mm SAND FILTER PACK 2.0m TO 7.42m. BENTONITE SEAL 0m TO 2.0m.

RL (m AHD): 740, 739, 738, 737, 736, 735, 734
Depth (m): 1, 2, 3, 4, 5, 6

JKGeotechnics

CORED BOREHOLE LOG

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT | **Core Size:** NMLC | **R.L. Surface:** 740.7 m
Date: 16/10/24 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK500 | **Bearing:** N/A | **Logged/Checked By:** C.A.R./A.B.

Water Loss\Level	RL (m AHD)	Depth (m)	Core Description	Weathering	Strength	Point Load Strength Index $I_s(50)$	Defect Details – Specific	Formation
			START CORING AT 2.48m					
90% RETURN	738		Interbedded SANDSTONE: fine to medium grained, brown, and MUDSTONE: grey brown, foliated at 50-60°.	HW	M	0.30	(2.58m) Be, 40°, P, R, Clay Ct (2.67m) XWS, 0°, 25 mm.t	Abercrombie Formation
		3	Extremely Weathered sandstone: silty CLAY, low plasticity, light brown, with fine to medium grained sand.	XW	(Hd)			
	737	4	MUDSTONE: grey brown and light brown, with occasional sandstone laminae, foliated at 35-50°.	HW	M	0.60 0.60 0.70	(3.19-3.62m) J, 90°, Ir, R, Clay FILLED, 10 mm.t (3.69m) Ji, 90°, Ir (3.78m) J, 80°, St, R, Clay Ct (4.20m) J, 10°, Ir, R, Clay Ct (4.28m) J, 20°, P, R, Clay Ct (4.38m) Be, 35°, C, Clay Ct (4.44m) J x 2, 20°, C, R, Clay Ct (4.50m) XWS, 0°, 70 mm.t	
	736	5	as above, but with conglomerate bands and quartz gravel.			1.0 0.90 0.70	(4.83m) J, 20°, Ir, R, Qz FILLED (4.92m) J, 10°, St, R, Fe Ct (5.06m) Ji, 70°, P (5.18m) J, 90°, St, R, Fe Ct (5.34m) J, 80°, St, R, Clay Ct (5.37m) CS, 20°, 10 mm.t (5.53m) J, 90°, Ir, R, Qz FILLED (5.76m) J, 60°, St, R, Qz FILLED	
	735 734	6 7	MUDSTONE: brown and grey, with fine grained sandstone bands, foliated at 30-50°.			0.60 0.40 0.60 0.30 0.50 0.60	(5.93m) J, 20°, C, S, Fe Ct (6.07m) J, 10°, P, R, Clay Ct (6.16m) Be, 40°, P, R, Clay Ct (6.21m) Be, 40°, P, R, Clay Ct (6.30m) Be, 30°, P, R, Clay Ct (6.40m) J, 60°, C, R, Fe Ct (6.55m) Be, 50°, P, R, Clay Ct (6.60m) Be, 50°, P, R, Clay Ct (6.72m) Be, 50°, P, R, Clay Ct (6.79m) Be, 40°, P, R, Clay Ct (6.86m) Be, 35°, C, R, Fe Ct (6.90m) XWS, 15°, 25 mm.t (7.03m) Be, 30°, P, R, Clay Ct (7.10m) Be, 30°, P, R, Clay Ct (7.26m) J, 70°, P, R, Fe Ct	
	733 732	8	END OF BOREHOLE AT 7.42 m					

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 37083LT
Borehole No: BH28
Depth: 2.48m to 7.45m
KODAK Gray Scale
KODAK Color Control Patches
37083LT BH28 START CORING AT 2.48m
2
3
CORE LOSS 0.14m
4
5
6
7
END OF BOREHOLE AT 7.45m

JKGeotechnics

BOREHOLE LOG

Borehole No.
29
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 737.8 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 17 6,8,9	CH	Silty CLAY: high plasticity, orange brown and light brown, trace of root fibres.	w<PL	Hd	540 570 570	GRASS COVER RESIDUAL
	N > 23 7,11,12/ 50mm REFUSAL		as above, but orange brown and grey, without root fibres.	w~PL	VSt	330 310 340	
		-	Extremely Weathered sandstone: silty CLAY, low plasticity, orange brown and grey.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
			SANDSTONE: fine grained, brown and grey, with extremely weathered and iron indurated bands.	DW	L		
					M		MODERATE TO HIGH RESISTANCE
			as above, but without extremely weathered and iron indurated bands.		H		HIGH RESISTANCE
			END OF BOREHOLE AT 3.70 m				'TC' BIT REFUSAL

RL (m AHD): 737, 736, 735, 734, 733, 732, 731
Depth (m): 1, 2, 3, 4, 5, 6

SAMPLES: ES, U50, DB, DS

JKGeotechnics

BOREHOLE LOG

Borehole No.
30
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 738.8 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		N = 14 5,7,7	738	1		CH	Silty CLAY: high plasticity, red brown and orange brown, trace of fine to medium grained ironstone gravel.	w<PL	Hd	>600 >600 >600	GRASS COVER RESIDUAL
						-	SANDSTONE: fine grained, orange brown and light grey.	DW	H		ABERCROMBIE FORMATION HIGH 'TC' BIT RESISTANCE
			737	2			END OF BOREHOLE AT 1.70 m				'TC' BIT REFUSAL
			736	3							
			735	4							
			734	5							
			733	6							
			732								

JK 9.02.4 LIB.GLB Log JK AUGERHOLE - MASTER 37083LT BUNGENDORE.GPJ <<DrawingFile>> 13/11/2024 15:42 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20

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BOREHOLE LOG

Borehole No.
31
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 736.7 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 16 6,7,9	736	0–1	CH	Silty CLAY: high plasticity, orange brown, trace of fine to medium grained ironstone and quartz gravel, and root fibres.	w<PL	Hd	>600 >600 530	RESIDUAL
	N = 9 4,5,4	735	1–2.5		as above, but without gravel and root fibres.	w~PL		450 420 470	
		734	2.5–3	-	SANDSTONE: fine to medium grained, brown and light brown.	DW	L - M		ABERCROMBIE FORMATION LOW TO MODERATE 'TC' BIT RESISTANCE
		733–730	3		END OF BOREHOLE AT 3.00 m				

SAMPLES: ES, U50, DB, DS

JKGeotechnics

BOREHOLE LOG

Borehole No.
32

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 737.4 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			737			CL	Silty CLAY: low plasticity, orange brown, trace of fine to medium grained ironstone and quartz gravel.	w<PL	Hd		RESIDUAL
		N = 11 5,5,6		1						>600 520 530	
		N = 10 4,4,6	736						VSt	300 310 270	
				2		-	Extremely Weathered mudstone: silty CLAY: low plasticity, light grey and light brown, with iron indurated bands.	XW	(Hd)		ABERCROMBIE FORMATION
			735				MUDSTONE: fine grained, brown and light brown, with iron indurated bands.	DW	M		LOW TO MODERATE 'TC' BIT RESISTANCE
				3			END OF BOREHOLE AT 3.00 m				
			734	4							
			733	5							
			732	6							
			731								

JKGeotechnics

BOREHOLE LOG

Borehole No.
33

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 738.4 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK500 **Logged/Checked By:** C.A.R./A.B.

Groundwater Record	Field Tests	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	N = 18 7,9,9	CI	Silty CLAY: medium plasticity, orange brown, trace of fine to medium grained ironstone and quartz gravel, and root fibres.	w<PL	Hd	>600 >600 >600	RESIDUAL
	N=SPT 6/ 20mm REFUSAL	-	MUDSTONE: fine grained, brown and light brown, with quartz bands.	DW	M		ABERCROMBIE FORMATION MODERATE 'TC' BIT RESISTANCE HIGH RESISTANCE
			END OF BOREHOLE AT 2.50 m				'TC' BIT REFUSAL

SAMPLES: ES, U50, DB, DS. RL (m AHD): 738, 737, 736, 735, 734, 733, 732. Depth (m): 1, 2, 3, 4, 5, 6. Graphic Log.

JKGeotechnics

BOREHOLE LOG

Borehole No.
34
1 / 1

Client: SCHOOL INFRASTRUCTURE NSW
Project: PROPOSED BUNGENDORE HIGH SCHOOL
Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT **Method:** SPIRAL AUGER **R.L. Surface:** 735.2 m
Date: 17/10/24 **Datum:** AHD
Plant Type: JK308 **Logged/Checked By:** K.R./A.B.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION					FILL: Silty clay, low plasticity, brown, trace of ash and root fibres.	w<PL			GRASS COVER
	N = 15 5,7,8	735		CH	Silty CLAY: high plasticity, red brown and brown, trace of fine to medium grained quartz and ironstone gravel.	w<PL	Hd	540 600 590	RESIDUAL
	N = 25 7,9,16	734	1	CI	Silty CLAY: medium plasticity, orange brown and grey.	w~PL	VSt	240 310 320	
		733	2	-	Extremely Weathered mudstone: silty CLAY, low plasticity, orange brown and grey, trace of fine to medium grained quartz gravel.	XW	Hd		ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
					MUDSTONE: fine to medium grained, grey brown and brown, with extremely weathered and iron indurated bands.	DW	L		
		732	3		END OF BOREHOLE AT 3.00 m				
		731, 730, 729	4, 5, 6						

SAMPLES: ES, U50, DB, DS; Graphic Log

JKGeotechnics

BOREHOLE LOG

Borehole No.
35
1 / 1

Client:	SCHOOL INFRASTRUCTURE NSW
Project:	PROPOSED BUNGENDORE HIGH SCHOOL
Location:	BIRCHFIELD DRIVE, BUNGENDORE, NSW

Job No.: 37083LT	**Method:** SPIRAL AUGER	**R.L. Surface:** 735.3 m
Date: 17/10/24		**Datum:** AHD
Plant Type: JK308	**Logged/Checked By:** K.R./A.B.	

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION	ES; DS; ES	N = 12 5,6,6	735, 734	0 – 1		CI	Silty CLAY: medium plasticity, light brown and red brown, trace of fine to medium grained quartz gravel, and root fibres.	w<PL	Hd	>600 >600 >600	GRASS COVER RESIDUAL
	DS	N > 21 6,16,5/ 0mm REFUSAL									
				2		-	Extremely Weathered mudstone: silty CLAY, low plasticity, grey and orange brown, trace of fine to medium grained sandstone gravel.	XW	Hd	>600 >600 >600	ABERCROMBIE FORMATION LOW 'TC' BIT RESISTANCE
	DS		733				MUDSTONE: fine grained, brown and grey, with extremely weathered and iron indurated bands.	DW	M		MODERATE TO HIGH RESISTANCE
			732, 731, 730, 729	3 – 6			END OF BOREHOLE AT 3.00 m				

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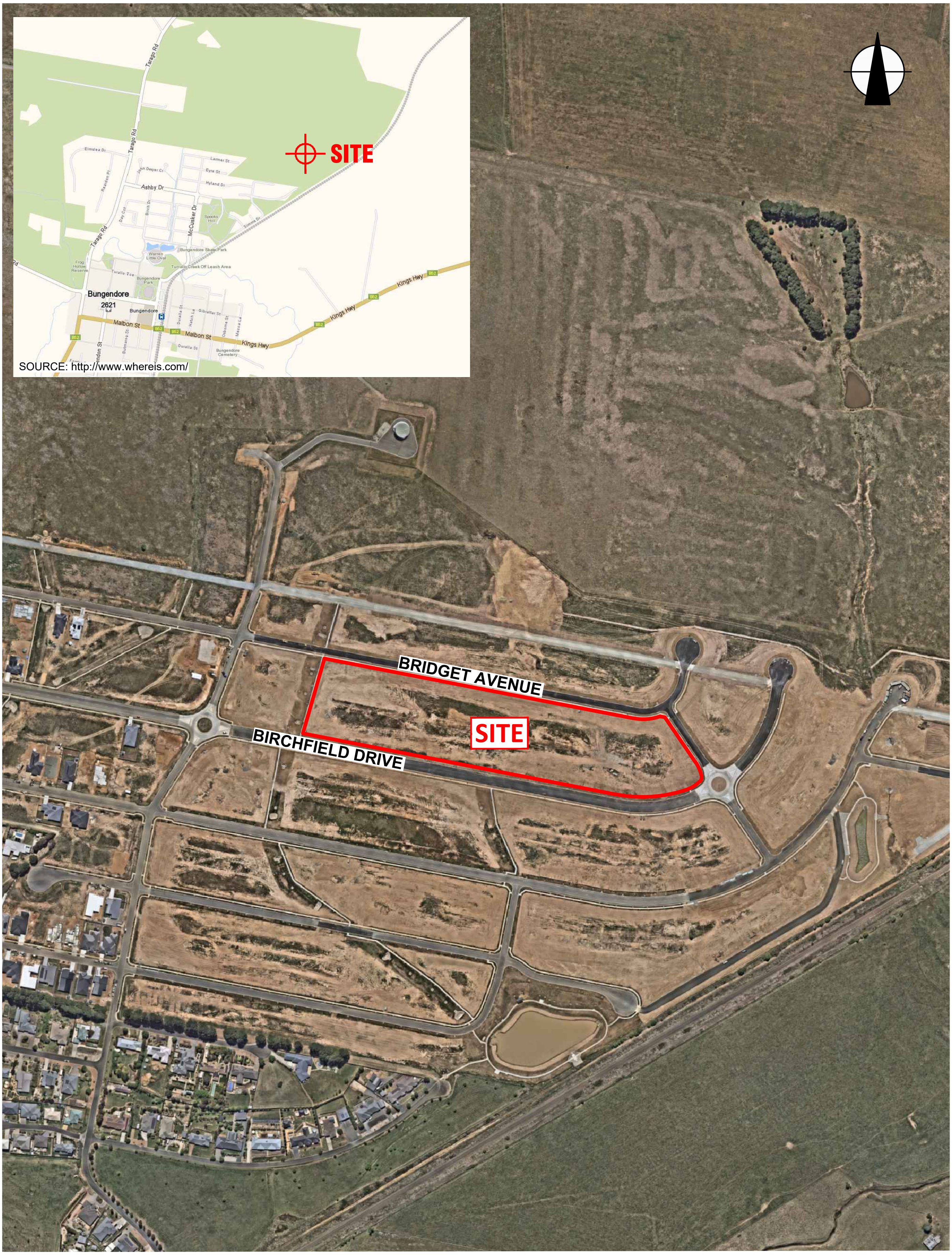


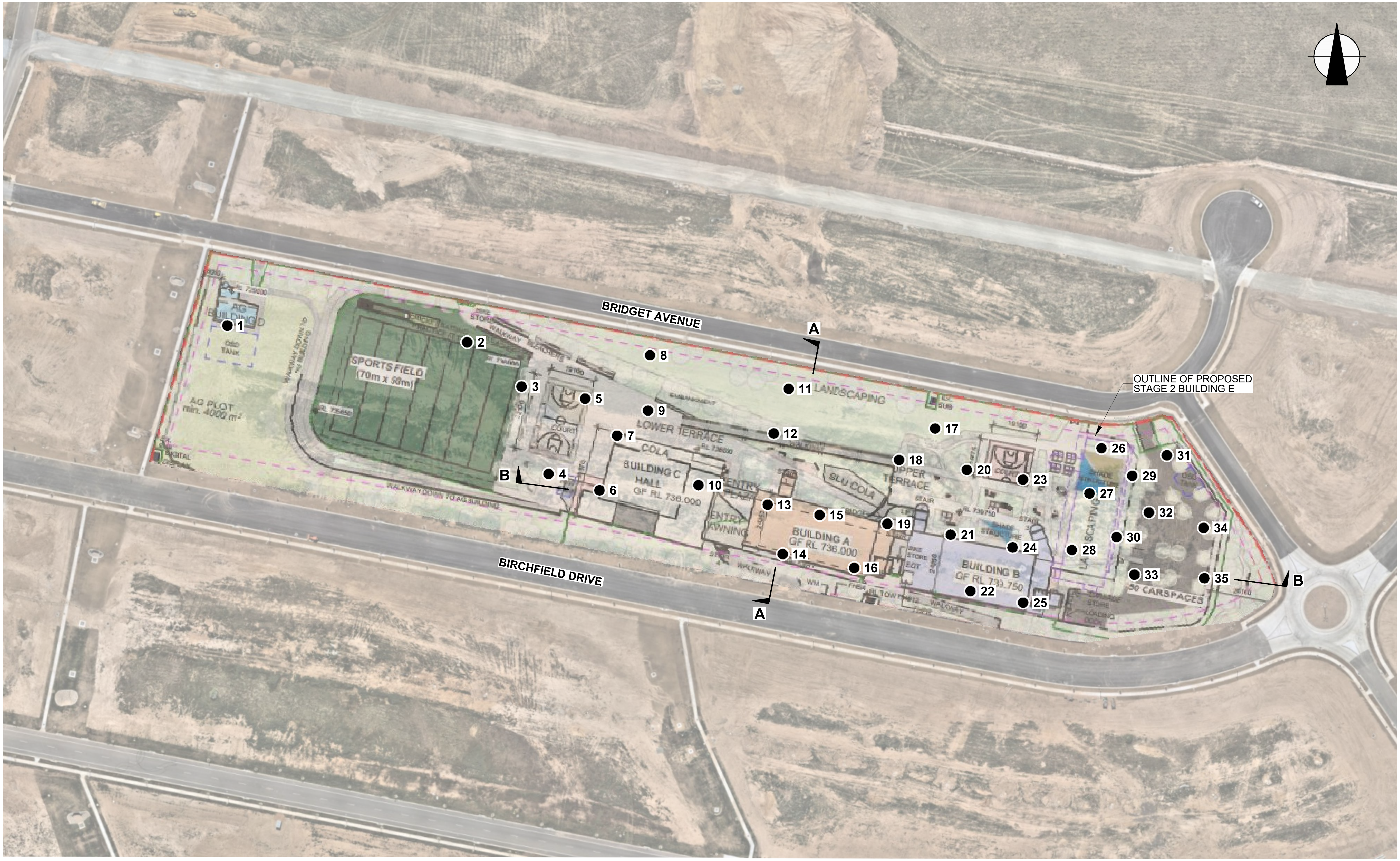
AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

This plan should be read in conjunction with the JK Geotechnics report.

Title:	SITE LOCATION PLAN
Location:	BIRCHFIELD DRIVE, BUNGENDORE, NSW
Report No: 37083LT	Figure No: 1

JKGeotechnics

PLOT DATE: 13/11/2024 2:31:29 PM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37083LT BUNGENDORE\CAD ZONE55\37083LT.DWG



NOTES:
1. REFER TO FIGURE 4 FOR CROSS SECTION A-A.
2. REFER TO FIGURE 5 FOR CROSS SECTION B-B.

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

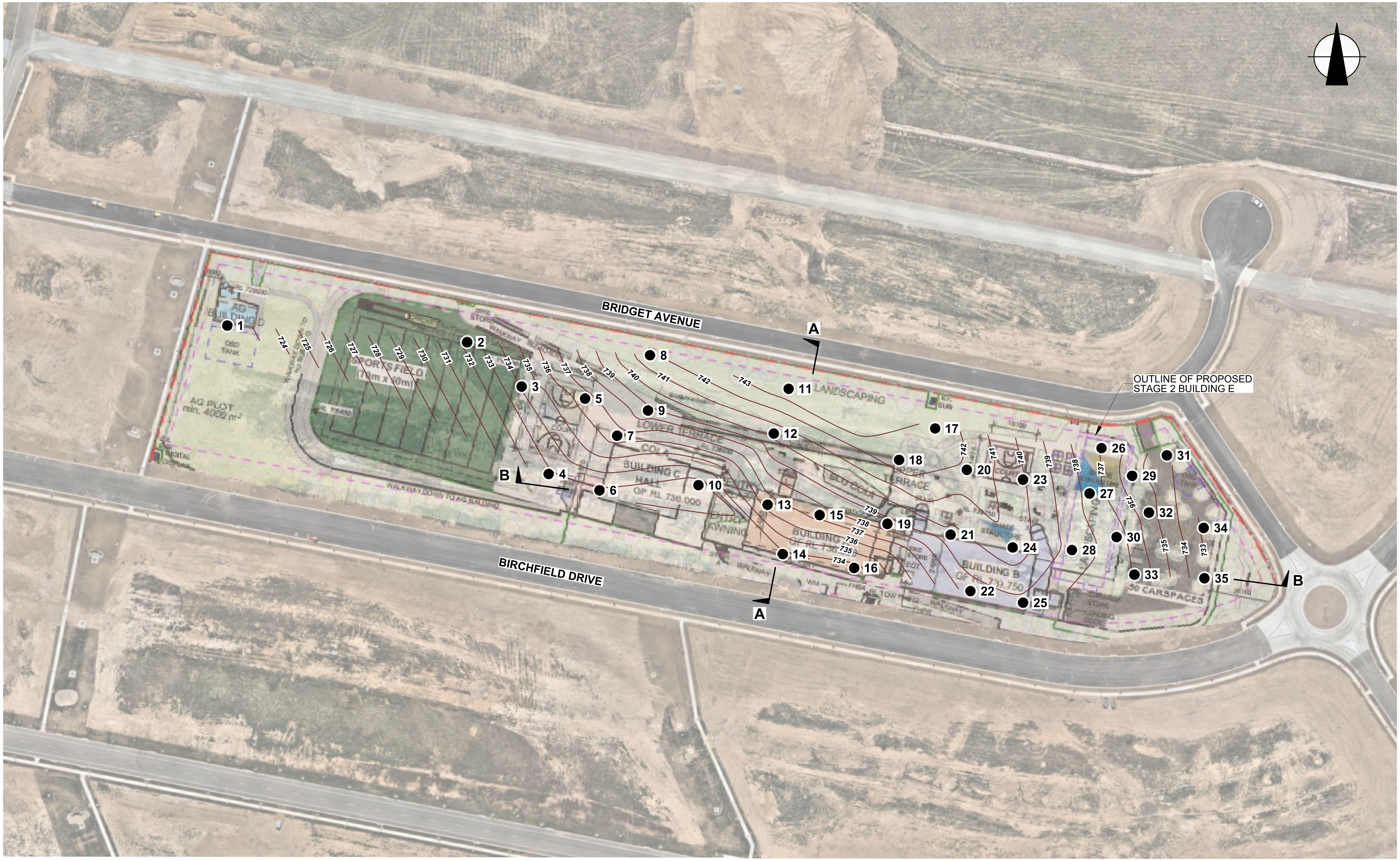
0 15 30 45 60 75
SCALE 1:1500 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title:	BOREHOLE LOCATION PLAN
Location:	BIRCHFIELD DRIVE, BUNGENDORE, NSW
Report No:	37083LT
Figure No:	2

JKGeotechnics

PLOT DATE: 4/02/2025 10:39:26 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37083LT BUNGENDORE\CAD ZONE55\37083LT.DWG



LEGEND

731 BEDROCK CONTOUR INTERVALS (RL mAHD)

NOTES:
1. REFER TO FIGURE 4 FOR CROSS SECTION A-A.
2. REFER TO FIGURE 5 FOR CROSS SECTION B-B.

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

0 15 30 45 60 75

SCALE 1:1500 @A3 METRES

This plan should be read in conjunction with the JK Geotechnics report.

Title: **BEDROCK CONTOUR PLAN**

Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW

Report No: 37083LT

Figure No: 3

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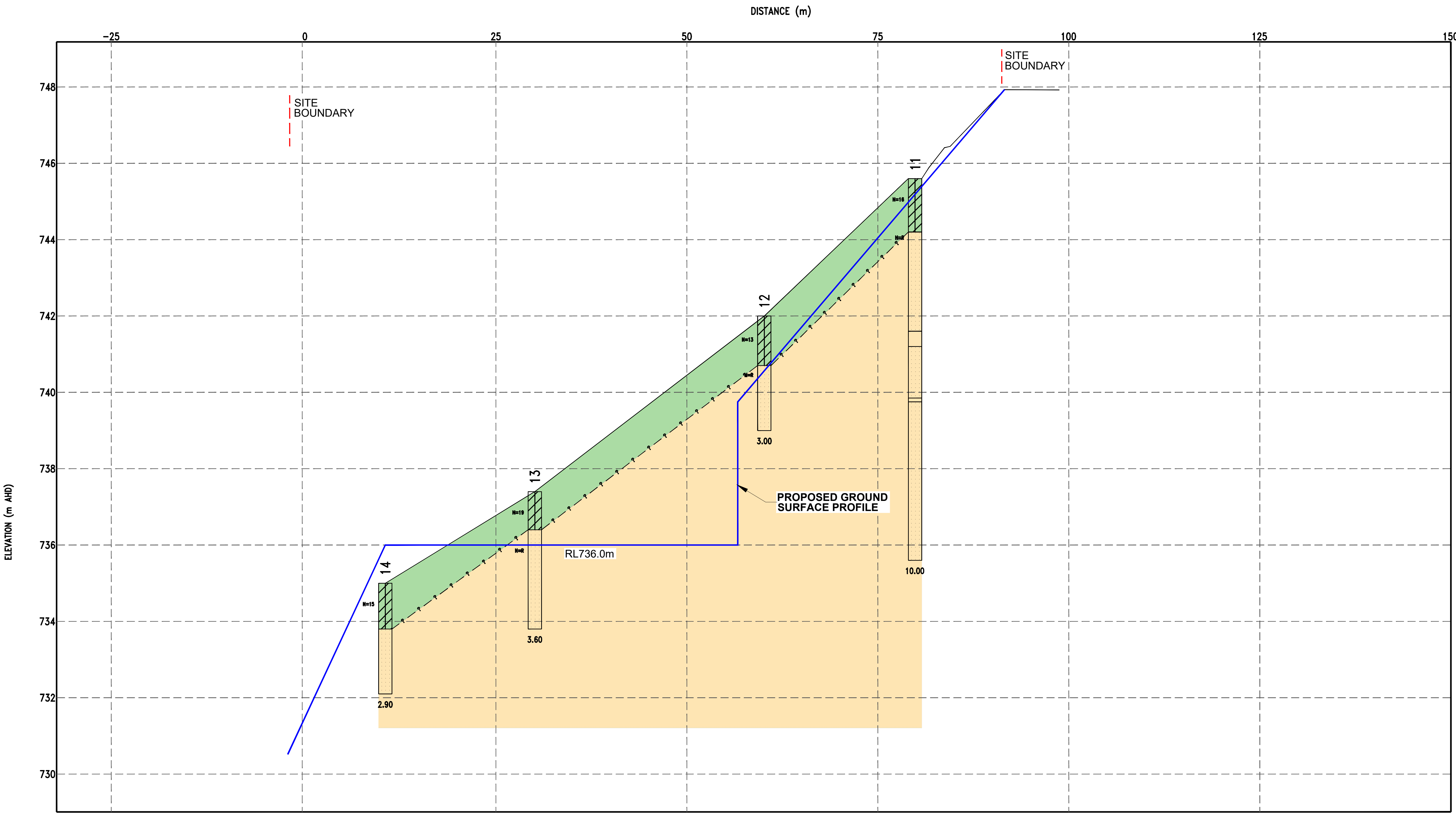
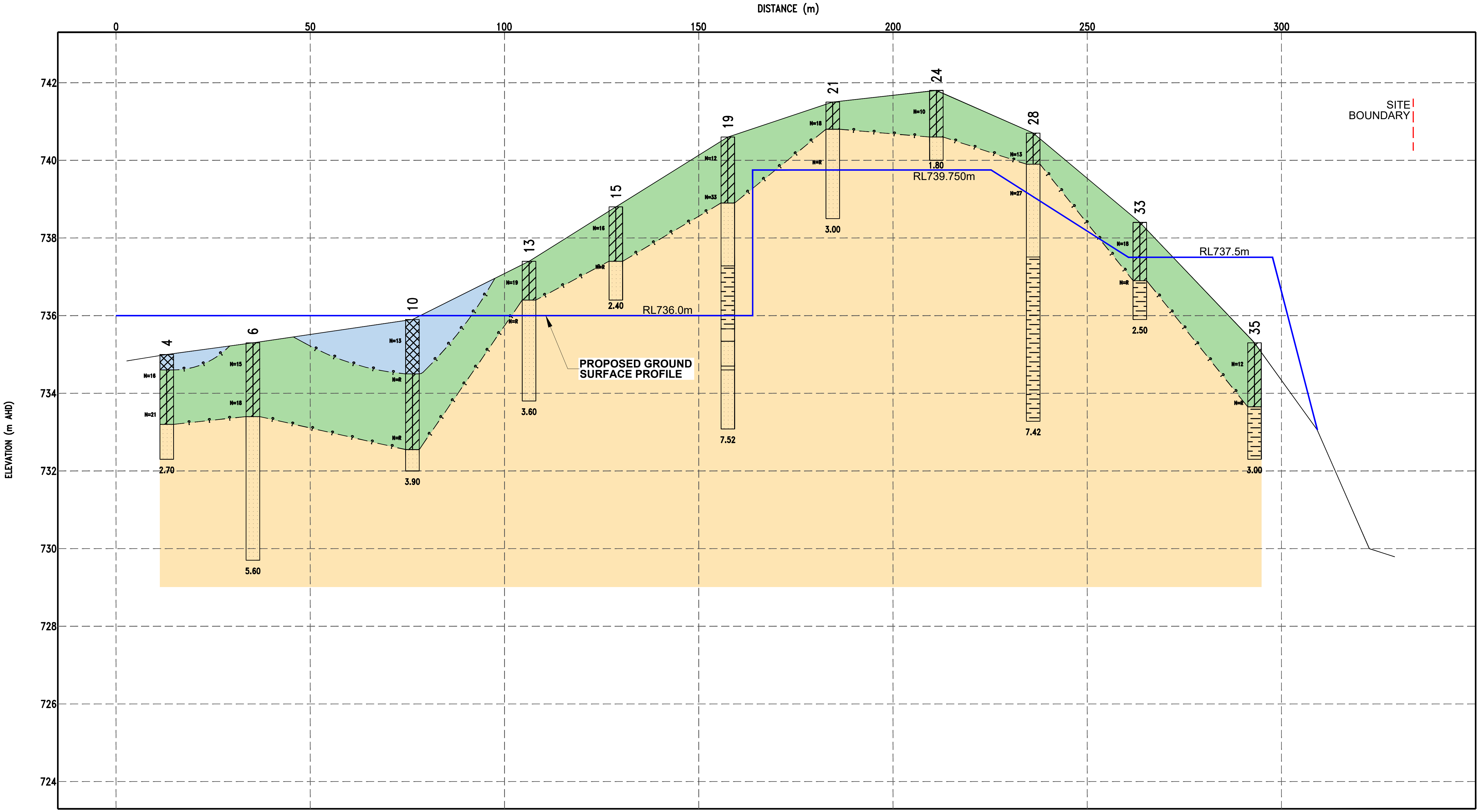


MATERIAL GRAPHIC

- SILTY CLAY (CL, CI, CH)
- SANDSTONE

H:SCALE 1:500 @A3 METRES (0, 5, 10, 15, 20, 25)	Title: GRAPHICAL BOREHOLE SUMMARY SECTION A-A
V:SCALE 1:100 @A3 METRES (0, 1, 2, 3, 4, 5)	Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW
	Report No: 37083LT — Figure No: 4
This plan should be read in conjunction with the JK Geotechnics report.	JKGeotechnics

PLOT DATE: 4/02/2025 11:32:31 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37083LT BUNGENDORE\CAD ZONE55\37083LT.DWG



MATERIAL GRAPHIC

- NO CORE
- SILTY CLAY (CL, CI, CH)
- FILL
- SANDSTONE
- SHALE, MUDSTONE

H:SCALE 1:1000 @A3 METRES (0 10 20 30 40 50)	Title: **GRAPHICAL BOREHOLE SUMMARY SECTION B-B**
V:SCALE 1:100 @A3 METRES (0 1 2 3 4 5)	Location: BIRCHFIELD DRIVE, BUNGENDORE, NSW
This plan should be read in conjunction with the JK Geotechnics report.	Report No: 37083LT — Figure No: 5

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PLOT DATE: 29/01/2025 10:04:55 AM DWG FILE: J:\6F GEOTECHNICAL JOBS\37000'S\37083LT BUNGENDORE\CAD ZONE55\37083LT.DWG

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726:2017 *'Geotechnical Site Investigations'*. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached soil classification table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	< 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2.36mm
Gravel	2.36 to 63mm
Cobbles	63 to 200mm
Boulders	> 200mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose (VL)	< 4
Loose (L)	4 to 10
Medium dense (MD)	10 to 30
Dense (D)	30 to 50
Very Dense (VD)	> 50

Cohesive soils are classified on the basis of strength (consistency) either by use of a hand penetrometer, vane shear, laboratory testing and/or tactile engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength (kPa)	Indicative Undrained Shear Strength (kPa)
Very Soft (VS)	≤ 25	≤ 12
Soft (S)	> 25 and ≤ 50	> 12 and ≤ 25
Firm (F)	> 50 and ≤ 100	> 25 and ≤ 50
Stiff (St)	> 100 and ≤ 200	> 50 and ≤ 100
Very Stiff (VSt)	> 200 and ≤ 400	> 100 and ≤ 200
Hard (Hd)	> 400	> 200
Friable (Fr)	Strength not attainable – soil crumbles	

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'shale' is used to describe fissile mudstone, with a weakness parallel to bedding. Rocks with alternating inter-laminations of different grain size (eg. siltstone/claystone and siltstone/fine grained sandstone) is referred to as 'laminite'.

SAMPLING

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

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shrink-swell behaviour, strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All methods except test pits, hand auger drilling and portable Dynamic Cone Penetrometers require the use of a mechanical rig which is commonly mounted on a truck chassis or track base.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and 'weaker' bedrock if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for a large excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Refusal of the hand auger can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of limited reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock cuttings. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be assessed from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg. from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, NMLC or HQ triple tube core barrels, which give a core of about 50mm and 61mm diameter, respectively, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as NO CORE. The location of NO CORE recovery is determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the bottom of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils, as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289.6.3.1–2004 (R2016) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – Standard Penetration Test (SPT)'*.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63.5kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

  N = 13
  4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

  N > 30
  15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

A modification to the SPT is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as 'N_c' on the borehole logs, together with the number of blows per 150mm penetration.

Cone Penetrometer Testing (CPT) and Interpretation: The cone penetrometer is sometimes referred to as a Dutch Cone. The test is described in Australian Standard 1289.6.5.1–1999 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Static Cone Penetration Resistance of a Soil – Field Test using a Mechanical and Electrical Cone or Friction-Cone Penetrometer'*.

In the tests, a 35mm or 44mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm or 165mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck. The CPT does not provide soil sample recovery.

As penetration occurs (at a rate of approximately 20mm per second), the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa. There are two scales presented for the cone resistance. The lower scale has a range of 0 to 5MPa and the main scale has a range of 0 to 50MPa. For cone resistance values less than 5MPa, the plot will appear on both scales.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

  The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between CPT and SPT values can be developed for both sands and clays but may be site specific.

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

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

There are limitations when using the CPT in that it may not penetrate obstructions within any fill, thick layers of hard clay and very dense sand, gravel and weathered bedrock. Normally a 'dummy' cone is pushed through fill to protect the equipment. No information is recorded by the 'dummy' probe.

Flat Dilatometer Test: The flat dilatometer (DMT), also known as the Marchetti Dilometer comprises a stainless steel blade having a flat, circular steel membrane mounted flush on one side.

The blade is connected to a control unit at ground surface by a pneumatic-electrical tube running through the insertion rods. A gas tank, connected to the control unit by a pneumatic cable, supplies the gas pressure required to expand the membrane. The control unit is equipped with a pressure regulator, pressure gauges, an audio-visual signal and vent valves.

The blade is advanced into the ground using our CPT rig or one of our drilling rigs, and can be driven into the ground using an SPT hammer. As soon as the blade is in place, the membrane is inflated, and the pressure required to lift the membrane (approximately 0.1mm) is recorded. The pressure then required to lift the centre of the membrane by an additional 1mm is recorded. The membrane is then deflated before pushing to the next depth increment, usually 200mm down. The pressure readings are corrected for membrane stiffness.

The DMT is used to measure material index (I_D), horizontal stress index (K_D), and dilatometer modulus (E_D). Using established correlations, the DMT results can also be used to assess the 'at rest' earth pressure coefficient (K_o), over-consolidation ratio (OCR), undrained shear strength (C_u), friction angle (ϕ), coefficient of consolidation (C_h), coefficient of permeability (K_h), unit weight (γ), and vertical drained constrained modulus (M).

The seismic dilatometer (SDMT) is the combination of the DMT with an add-on seismic module for the measurement of shear wave velocity (V_s). Using established correlations, the SDMT results can also be used to assess the small strain modulus (G_o).

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod with a 20mm diameter cone end with a 9kg hammer dropping 510mm. The test is described in Australian Standard 1289.6.3.2–1997 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – 9kg Dynamic Cone Penetrometer Test'*.

The results are used to assess the relative compaction of fill, the relative density of granular soils, and the strength of cohesive soils. Using established correlations, the DCP test results can also be used to assess California Bearing Ratio (CBR).

Refusal of the DCP can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Vane Shear Test: The vane shear test is used to measure the undrained shear strength (C_u) of typically very soft to firm fine grained cohesive soils. The vane shear is normally performed in the bottom of a borehole, but can be completed from surface level, the bottom and sides of test pits, and on recovered undisturbed tube samples (when using a hand vane).

The vane comprises four rectangular blades arranged in the form of a cross on the end of a thin rod, which is coupled to the bottom of a drill rod string when used in a borehole. The size of the vane is dependent on the strength of the fine grained cohesive soils; that is, larger vanes are normally used for very low strength soils. For borehole testing, the size of the vane can be limited by the size of the casing that is used.

For testing inside a borehole, a device is used at the top of the casing, which suspends the vane and rods so that they do not sink under self-weight into the 'soft' soils beyond the depth at which the test is to be carried out. A calibrated torque head is used to rotate the rods and vane and to measure the resistance of the vane to rotation.

With the vane in position, torque is applied to cause rotation of the vane at a constant rate. A rate of 6° per minute is the common rotation rate. Rotation is continued until the soil is sheared and the maximum torque has been recorded. This value is then used to calculate the undrained shear strength. The vane is then rotated rapidly a number of times and the operation repeated until a constant torque reading is obtained. This torque value is used to calculate the remoulded shear strength. Where appropriate, friction on the vane rods is measured and taken into account in the shear strength calculation.

LOGS

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

The terms and symbols used in preparation of the logs are defined in the following pages.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than 'straight line' variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

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

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- 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 be washed out of the hole or 'reverted' chemically if reliable water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after the groundwater level has stabilised at intervals ranging from several days to 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 perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg. bricks, steel, etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably assess the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soils for Engineering Purposes'* or appropriate NSW Government Roads & Maritime Services (RMS) test methods. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

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

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.
- Details of the development that the Company could not reasonably be expected to anticipate.

If these occur, the Company will be pleased to assist with investigation or advice to resolve any problems occurring.

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, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Where information obtained from this investigation 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. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. Licence to use the documents may be revoked without notice if the Client is in breach of any obligation to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed <u>or</u> where only a limited investigation has been completed <u>or</u> where the geotechnical conditions/constraints are quite complex, it is prudent to have a joint design review which involves an experienced geotechnical engineer/engineering geologist.

SITE INSPECTION

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types and appropriate footing or pile founding depths, or

iii) full time engineering presence on site.

SYMBOL LEGENDS

SOIL

- FILL
- TOPSOIL
- CLAY (CL, CI, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CI, CH)
- SILTY CLAY (CL, CI, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CI, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML, MH)
- PEAT AND HIGHLY ORGANIC SOILS (Pt)

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE/MUDSTONE
- SILTSTONE
- CLAYSTONE
- COAL
- LAMINITE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

OTHER MATERIALS

- BRICKS OR PAVERS
- CONCRETE
- ASPHALTIC CONCRETE

CLASSIFICATION OF COARSE AND FINE GRAINED SOILS

Major Divisions		Group Symbol	Typical Names	Field Classification of Sand and Gravel	Laboratory Classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND (more than half of coarse fraction is smaller than 2.36mm)	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	N/A
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	

Major Divisions		Group Symbol	Typical Names	Field Classification of Silt and Clay			Laboratory Classification
				Dry Strength	Dilatancy	Toughness	% < 0.075mm
ine grained soils (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Laboratory Classification Criteria

A well graded coarse grained soil is one for which the coefficient of uniformity $Cu > 4$ and the coefficient of curvature $1 < C_c < 3$. Otherwise, the soil is poorly graded. These coefficients are given by:

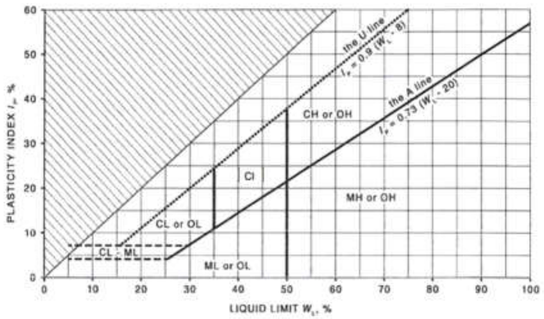
$$C_U = \frac{D_{60}}{D_{10}} \quad \text{and} \quad C_C = \frac{(D_{30})^2}{D_{10}\,D_{60}}$$

Where D_{10}, D_{30} and D_{60} are those grain sizes for which 10%, 30% and 60% of the soil grains, respectively, are smaller.

NOTES:

1. For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.
2. Where the grading is determined from laboratory tests, it is defined by coefficients of curvature (C_c) and uniformity (C_u) derived from the particle size distribution curve.
3. Clay soils with liquid limits > 35% and ≤ 50% may be classified as being of medium plasticity.
4. The U line on the Modified Casagrande Chart is an approximate upper bound for most natural soils.

Modified Casagrande Chart for Classifying Silts and Clays according to their Behaviour



LOG SYMBOLS

Log Column	Symbol	Definition
Groundwater Record		Standing water level. Time delay following completion of drilling/excavation may be shown.
	C	Extent of borehole/test pit collapse shortly after drilling/excavation.
		Groundwater seepage into borehole or test pit noted during drilling or excavation.
Samples	ES	Sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos analysis.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'Refusal' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60° solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of undrained shear strength.
	PID = 100	Photoionisation detector reading in ppm (soil sample headspace test).
Moisture Condition (Fine Grained Soils)	w > PL	Moisture content estimated to be greater than plastic limit.
	w ≈ PL	Moisture content estimated to be approximately equal to plastic limit.
	w < PL	Moisture content estimated to be less than plastic limit.
	w ≈ LL	Moisture content estimated to be near liquid limit.
	w > LL	Moisture content estimated to be wet of liquid limit.
(Coarse Grained Soils)	D	DRY – runs freely through fingers.
	M	MOIST – does not run freely but no free water visible on soil surface.
	W	WET – free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT – unconfined compressive strength ≤ 25kPa.
	S	SOFT – unconfined compressive strength > 25kPa and ≤ 50kPa.
	F	FIRM – unconfined compressive strength > 50kPa and ≤ 100kPa.
	St	STIFF – unconfined compressive strength > 100kPa and ≤ 200kPa.
	VSt	VERY STIFF – unconfined compressive strength > 200kPa and ≤ 400kPa.
	Hd	HARD – unconfined compressive strength > 400kPa.
	Fr	FRIABLE – strength not attainable, soil crumbles.
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other assessment.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** / **SPT 'N' Value Range (Blows/300mm)**
	VL	VERY LOOSE ≤ 15 / 0 – 4
	L	LOOSE > 15 and ≤ 35 / 4 – 10
	MD	MEDIUM DENSE > 35 and ≤ 65 / 10 – 30
	D	DENSE > 65 and ≤ 85 / 30 – 50
	VD	VERY DENSE > 85 / > 50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other assessment.
Hand Penetrometer Readings	300 250	Measures reading in kPa of unconfined compressive strength. Numbers indicate individual test results on representative undisturbed material unless noted otherwise.

Log Column	Symbol	Definition
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Twin pronged tungsten carbide bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.
	Soil Origin	The geological origin of the soil can generally be described as:
		RESIDUAL – soil formed directly from insitu weathering of the underlying rock. No visible structure or fabric of the parent rock.
		EXTREMELY WEATHERED – soil formed directly from insitu weathering of the underlying rock. Material is of soil strength but retains the structure and/or fabric of the parent rock.
		ALLUVIAL – soil deposited by creeks and rivers.
		ESTUARINE – soil deposited in coastal estuaries, including sediments caused by inflowing creeks and rivers, and tidal currents.
		MARINE – soil deposited in a marine environment.
		AEOLIAN – soil carried and deposited by wind.
		COLLUVIAL – soil and rock debris transported downslope by gravity, with or without the assistance of flowing water. Colluvium is usually a thick deposit formed from a landslide. The description 'slopewash' is used for thinner surficial deposits.
		LITTORAL – beach deposited soil.

Classification of Material Weathering

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>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.</td></tr>
<tr><td colspan="2">Extremely Weathered</td><td colspan="2">XW</td><td>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.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered (Note 1)</td><td>HW</td><td rowspan="2">DW</td><td>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.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>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.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition of individual minerals or colour changes.</td></tr>
</table>

NOTE 1: The term 'Distinctly Weathered' is used where it is not practicable to distinguish between 'Highly Weathered' and 'Moderately Weathered' rock. 'Distinctly Weathered' is defined as follows: *'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 weathering products in pores'*. There is some change in rock strength.

Rock Material Strength Classification

Term	Abbreviation	Uniaxial Compressive Strength (MPa)	Guide to Strength	
			Point Load Strength Index $I_{s(50)}$ (MPa)	Field Assessment
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	6 to 20	0.3 to 1	Scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Abbreviations Used in Defect Description

Cored Borehole Log Column		Symbol Abbreviation	Description
Point Load Strength Index		• 0.6	Axial point load strength index test result (MPa)
		x 0.6	Diametral point load strength index test result (MPa)
Defect Details	– Type	Be	Parting – bedding or cleavage
		CS	Clay seam
		Cr	Crushed/sheared seam or zone
		J	Joint
		Jh	Healed joint
		Ji	Incipient joint
		XWS	Extremely weathered seam
	– Orientation	Degrees	Defect orientation is measured relative to normal to the core axis (ie. relative to the horizontal for a vertical borehole)
	– Shape	P	Planar
		C	Curved
		Un	Undulating
		St	Stepped
		Ir	Irregular
	– Roughness	Vr	Very rough
		R	Rough
		S	Smooth
		Po	Polished
		Sl	Slickensided
	– Infill Material	Ca	Calcite
		Cb	Carbonaceous
		Clay	Clay
		Fe	Iron
		Qz	Quartz
		Py	Pyrite
	– Coatings	Cn	Clean
		Sn	Stained – no visible coating, surface is discoloured
		Vn	Veneer – visible, too thin to measure, may be patchy
		Ct	Coating ≤ 1mm thick
		Filled	Coating > 1mm thick
	– Thickness	mm.t	Defect thickness measured in millimetres