REPORT

TO
CONRAD GARGETT ANCHER MORTLOCK WOOLLEY

ON
GEOTECHNICAL INVESTIGATION

FOR
PROPOSED SCHOOL

AT
3A AND 3B SMALLS ROAD, RYDE, NSW

2 May 2017
Ref: 30275LBrpt

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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed school at 3A and 3B Smalls Road, Ryde, NSW. The location of the site is shown on Figure 1. The investigation was commissioned by Ms Jane McGarry of Conrad Gargett Ancher Mortlock Woolley by email dated 6 March 2017 and was carried out in accordance with our proposal, Ref. P44013L.

As shown on the supplied architectural drawings by Conrad Gargett Ancher Mortlock Woolley (Project No. 16321, dated 10/4/17) a public school is proposed within No 3B, with the existing Cerebral Palsy Alliance building within 3A to remain. The existing buildings within No. 3B will be demolished and a circular school building constructed at the approximate location as shown on Figure 2. The circular school building will have three levels with the ground floor at about RL74.0m, which will require excavation to a maximum depth of about 3m at the south-western end of the building and fill to a maximum of about 2m at the north-eastern end. The existing playing fields to the north-east and east of the new building will remain, although some resurfacing may be carried out. The area to the south-east of the building will be landscaped at this time, with possible future development at a later date. The existing car park in the western corner of the site will remain.

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

2 INVESTIGATION PROCEDURE

Boreholes BH1 to BH12 were drilled using our track mounted JK205 and JK300 drill rigs to total depths ranging from 6m to 11.16m below the existing ground surface. BH1, BH4 to BH6, BH8 and BH10 to BH12 were auger drilled only to depths ranging from 6m to 9m. BH2, BH3, BH7 and BH9 were auger drilled to depths ranging from 5.76m to 8.79m and were then continued to depths ranging from 10.11m to 11.16m by diamond coring techniques, using an NMLC core barrel with water flush.

The borehole locations, as shown on Figure 2, were set out using a trundle wheel and were positioned as close as practical to the locations nominated by MYD Consulting Engineers Pty Ltd (the structural engineers). The final borehole locations were dictated by the existing site development and the location of buried services. The approximate surface levels, as shown on the borehole logs, were estimated by interpolation between spot levels and contours shown on the supplied survey plan by RPS Australia East Pty Ltd (Job No. PR133183, Sheets 1 to 5, Issue B, dated 8/12/16). The datum of the levels is the Australian Height Datum (AHD).

The apparent compaction of the fill and the strength of the natural clays was assessed from the Standard Penetration Test (SPT) 'N' values, augmented by hand penetrometer readings on cohesive samples recovered in the SPT split tube sampler. Within the augered portions of the boreholes, the strength of the weathered shale was assessed by observation of the drilling resistance of a Tungsten Carbide (TC) bit attached to the auger, together with examination of the recovered rock chip samples, and subsequent correlation with laboratory moisture content test result. The strength of the cored shale was assessed from laboratory Point Load Strength Index ($I_{S(50)}$) test results. The point load strength index test results are summarised in the attached STS Table D and on the cored borehole logs.

Groundwater observations were made during auger drilling and on completion of drilling. Within the cored boreholes the use of water for core drilling limited further meaningful measurements of groundwater levels. No longer term monitoring of groundwater levels was carried out.

Our geotechnical engineer, Mr Arthur Kourtesis, set out the borehole locations, nominated the sampling and testing locations, and prepared logs of the subsurface conditions encountered. The borehole logs 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 samples were returned to Soil Test Services Pty Ltd (STS) and Envirolab Services Pty Ltd, both NATA accredited laboratories, for testing to determine moisture contents, Atterberg limits, linear shrinkages, shrink/swell index, standard compaction properties, four day soaked CBR values, point load strength index values, pH, sulphate content, chloride content and resistivity. The results of the laboratory testing are summarised in the attached STS Tables A to D and Envirolab Certificate of Analysis 164525.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located in gently undulating topography and on a hillside that slopes down to the north-east at about 3°. The site itself follows the hillside slope, but has been formed into local level areas for buildings and playing fields, with batters at about 15° to 25° and of about 1m to 2m in height locally running roughly north-west to south-east.

The south-western half of the site contained one and two storey brick buildings, surrounded by asphaltic concrete (AC) or concrete driveways and car parks. Several medium to large sized trees are scattered in between the buildings and pavements. The buildings were generally in good external condition and the pavements were generally in fair to good condition. The north-eastern half of the site contained grassed playing fields.

The site is bound to the north-west by Smalls Road and surrounded on the remaining sides by residential allotments containing one and two storey houses. The houses were generally located about 5m to 10m from the common boundaries, with ground surface levels across the boundaries similar to those within the subject site.

3.2 <u>Subsurface Conditions</u>

Reference to the Sydney 1:100,000 Geological Series Sheet indicates that the site is underlain by Ashfield Shale of the Wianamatta Group. The boreholes encountered pavements and/or surficial fill overlying residual silty clays that graded into weathered shale bedrock. Further comments on the subsurface conditions encountered are provided below. Graphical summaries of the borehole information within the proposed building area are provided as Figures 3 and 4. Reference should be made to the borehole logs for detailed descriptions of the subsurface conditions encountered.

Pavement

In BH1, BH2, BH9, BH10 and BH11, asphaltic concrete was initially encountered and was 50mm to 100mm thick. In BH12, two concrete slabs 180mm and 100mm thick were encountered, with a thin clay fill layer between the two slabs.

Fill

Fill was encountered in all boreholes to depths ranging from 0.1m to 0.9m. The fill predominantly comprised silty clay with varying proportions of sand, igneous and ironstone gravel and ash. Based on the SPT 'N' values, the fill was assessed to be moderately compacted.

Residual Silty Clay

The residual silty clay was assessed to be of high plasticity and generally of very stiff to hard strength. However, some stiff clays were encountered on first contact in BH4, BH7, BH8 and BH10.

Weathered Shale

Weathered shale was encountered in all boreholes. The shale was encountered at depths ranging from 0.8m to 2.2m within the boreholes where the building is proposed (BH1 to BH7, BH9 and

BH12) and deeper to the south-east and north-east (BH8, BH10 and BH11) where it was encountered at depths of 3.8m, 4.2m and 3.5m, respectively. The shale was assessed to be extremely weathered and of extremely low strength on first contact and this poor quality shale continued for some metres. Some very low strength and low strength bands were encountered, but the shale did not significantly improve until depths of about 8m to 10m where shale of at least low strength was encountered. Within the cored boreholes, the shale was assessed to be of medium or high strength below depths of about 8.5m to 9m in BH2, BH3 and BH9.

Within the cored shale defects comprised extremely weathered and clay seams, fragmented zones and joints inclined at up to 85°. Some sections of core loss were experienced, which are inferred to represent extremely weathered or clay seams.

Within each of the boreholes the shale has generally been classified in accordance with the classification system given in Pells et al (Reference 1). The table below provides depths and levels where each class of shale was encountered in each borehole. The classifications have been based on typical and similar sections of rock and may vary depending on the size and nature of footings. Therefore, these classifications should be viewed as preliminary and once footing types and sizes are determined the geotechnical engineer should be requested to review these classifications in light of the specific footing details.

Within the augered boreholes the classifications must be considered approximate only as the defects within the shale cannot be assessed in auger boreholes. Where possible some correlation has been made with the cored boreholes. Generally, we have taken shale of very low strength to represent Class IV shale.

Borehole	Depth and Level of the Start of Each Class of Shale					
	Class V		Class IV		Class III or better	
	Depth	≈RL (AHD)	Depth	≈RL (AHD)	Depth	≈RL (AHD)
1	1.6m	73.9m	5.0m	70.5m	Not Encountered	
2	1.7m	73.8m	8.3m	67.2m	8.8m	66.7m
3	2.2m	71.8m	7.2m	66.8m	8.3m	65.7m
4	2.0m	69.0m	4.2m	66.8m	Not Encountered	
5	0.8m	76.4m	4.5m	72.7m	Not Encountered	
6	2.1m	71.7m	5.5m	68.3m	Not Encountered	
7	2.0m*	68.7m*	4.1m*	66.6m*	9.7m	61.0m
8	3.8m	65.1m	5.0m	63.9m	Not Encountered	
9	2.0m	73.8m	5.5m	70.3m	8.9m	66.9m
10	4.2m	74.2m	5.5m	72.9m	Not Encountered	
11	3.5m	69.9m	5.4m	68.0m	Not Encountered	
12	1.5m	75.5m	3.5m	73.5m	Not Encountered	

* In BH7 we note that Class V shale was once again encountered below a depth of 7.4m and the classification for design of footings will depend on the type and founding level of any footings.

Groundwater

No groundwater seepage was encountered during auger drilling of the boreholes. BH1 and BH4 were left open for 2 hours and 2.5 hours following completion of drilling and no groundwater was measured within those boreholes. Some water was measured on completion of the cored boreholes, but this would have been influenced by the water added to the boreholes for core drilling.

3.3 Laboratory Test Results

Based on the Atterberg limits, linear shrinkage and shrink/swell index test results, the silty clays are of high plasticity and are assessed to have a high potential for shrink/swell movements with changes in moisture content. We note that in one test the moisture content of the silty clay from BH6 was higher than its plastic limit.

The four day soaked CBR tests on samples of the silty clay compacted to 98% of the Standard Maximum Dry Density (SMDD) gave CBR values of 1.5% to 2.0%.

The moisture content and point load strength index test results showed reasonably good correlation with our field assessment of rock strengths. The estimated Unconfined Compressive Strength (UCS) of the rock core ranged from 6MPa to 50MPa.

The soil pH values ranged from 6.1 to 4.6, indicating acidic soil conditions. The sulphate contents ranged from 10mg/kg to 280mg/kg, the chloride contents ranged from <10mg/kg to 87mg/kg and the resistivity ranged from 43ohm.m to 290ohm.m. Based on these results, the soils would be classified as 'mild' exposure classification for concrete piles in accordance with Table 6.4.2(C) of AS2159-2009 'Piling – Design and Installation'. For steel piles, the soils would be classified as 'non-aggressive' in accordance with Table 6.5.2(C) of AS2159-2009.

4 COMMENTS AND RECOMMENDATIONS

4.1 Excavation and Earthworks

We understand that earthworks for the proposed school building will comprise excavation to a maximum depth of about 3m on the south-western side and fill to a maximum of about 2m on the north-eastern side to achieve the proposed floor level at RL74.0m. Some other minor earthworks may be required for landscaped areas outside of the proposed building, for resurfacing of playing fields, or construction of future buildings, but the exact details of any such works are not known.

Excavation on the south-western side of the proposed building will encounter surface fill, residual silty clay and the upper layers of the weathered shale within the deepest excavations. Excavation of the soils and extremely low strength shale should be achievable using conventional excavation equipment, such as the buckets of hydraulic excavators. Some assistance with ripping tynes may be required to remove any harder shale layers.

We are unaware of any records of placement or compaction control for the existing fill and as such it must be considered uncontrolled. Therefore, within the proposed building area, we recommend that the existing fill be fully removed and, where required, replaced with controlled, engineered fill. This will allow the proposed floor slabs to be supported on the engineered fill. Within landscaped or pavement areas the existing fill may remain in place, but where new pavements are constructed the subgrade must be proof rolled as recommended below. If fully suspended floor slabs are adopted, then no particular subgrade preparation measures would be required, other than stripping of vegetation and any root affected soils.

Where fill is to be placed or for preparation of the subgrade for any pavements or playing fields the following procedures should be followed:

- Strip surface vegetation and root affected soils. Within the proposed building areas the existing uncontrolled fill should also be fully stripped to expose the residual silty clay.

- Proof roll the exposed subgrade with at least 7 passes of a minimum 8 tonne dead weight, smooth drum, vibratory roller. The final pass of the proof rolling should be carried out without vibration and in the presence of a geotechnical engineer or experienced geotechnician. The purpose of the proof rolling should be to improve the compaction of the near surface soils and to detect any weak or unstable areas.
- During proof rolling care should be taken to avoid damage to nearby structures and buried services by vibrations transmitted by the roller. If necessary, the vibrations should be reduced or ceased.
- Treat any unstable areas detected during proof rolling by excavation to a sound base and replacement with engineered fill or further advice should be sought from the geotechnical engineer.
- Place engineered fill to the required level in horizontal layers not greater than 300mm loose thickness (but of lesser thickness if light rollers are used).
- Any fill used to raise site levels or replace unstable areas must comprise engineered fill. Compaction of each fill layer should be carried out to the specifications provided in Section 4.2.

In view of the high reactive potential of the residual clays, particular attention should be given to providing adequate drainage both during construction and for long term site maintenance. The principal aim of the drainage should be to promote run-off and reduce ponding. Placement of a blinding layer of durable granular fill or subbase material to provide a trafficable surface during construction may be necessary or desirable. The earthworks should be carefully planned and scheduled to maintain cross-falls during construction. We recommend that reference be made to AS2870 for drainage and vegetation precautions on reactive clay sites.

From the borehole results some unstable areas may occur due to the low CBR values of the residual silty clays, where the clays are of stiff strength, or where the moisture content of the clays is close to or higher than their plastic limit. The extent of unstable areas can be reduced if good site drainage is maintained and the earthworks are carried out during fine weather. Should any soft areas be found, then further advice and inspections from the geotechnical engineer will be required to assess the most suitable method of subgrade improvement. Allowance should be made for either, tyning, aerating and drying the subgrade, or removal and replacement with a select imported fill. If the clay is exposed to prolonged periods of rainfall, softening will result and site trafficability will be poor. If soil softening occurs, the subgrade should be over-excavated to below the depth of moisture softening and the excavated material replaced with engineered fill.

Earthworks recommendations provided in this report should be complemented by reference to AS3798 and the current "Excavation Work – Code of Practice" by Safe Work Australia.

4.2 Engineered Fill and Compaction Control

Engineered fill should preferably comprise well graded granular materials, such as ripped rock or crushed sandstone, free of deleterious substances and having a maximum particle size not exceeding 75mm. Such fill should be compacted in horizontal layers of not greater than 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.

The excavated clays and weathered shale may be reused as engineered fill, but are less desirable due to the high plasticity of the clays. Any clay fill should be compacted in maximum 300mm loose thickness layers to a density strictly between 98% and 102% of SMDD and at moisture contents within 2% of Standard Optimum Moisture Content (SOMC). The use of clay fill will require a greater control of fill compaction and moisture content, time for drying out of over-wet clays, addition of moisture to dry clays, and possibly a greater overall cost for the earthworks.

Density tests should be regularly carried out on the fill to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per $500m^2$ or three tests per visit, whichever requires the most tests. Where the fill is to support building loads it should be placed under Level 1 control, as defined by AS3798. Preferably the geotechnical testing authority should be engaged directly on behalf of the client and not by the earthworks subcontractor.

4.3 Batters and Retaining Walls

Specific details on any batters or retaining walls proposed are not known, but we expect that these will be required given the earthworks needed to form the new building. The recommendations given below are for batters and retaining walls of no more than 3m in height. If batters or retaining walls higher than this are proposed then specific geotechnical advice should be obtained once details of the location and extent of such batters or walls is known.

Given the location of the proposed building sufficient space should be available for temporary batters, with permanent retaining walls built at the toe of the batters. If retaining walls are required close to site boundaries and temporary batters cannot be accommodated, properly designed in situ retention systems will need to be installed prior to the start of excavation. Suitable in situ walls would include soldier pile walls with shotcrete infill panels or contiguous pile retaining walls. If such walls are proposed further specific geotechnical advice on these walls should also be obtained.

Temporary excavation batters should be no steeper than 1 Vertical in 1 Horizontal (1V:1H). Such batters should remain stable in the short term, provided all surcharge loads, including construction loads, are kept at least a horizontal distance from the crest equal to twice the batter height.

Permanent batters should be no steeper than 1V:2H, but flatter batters in the order of 1V:3H may be preferred to allow access for maintenance of vegetation. Permanent batters should be covered with topsoil and planted with a deep rooted runner grass, or other suitable coverings, to reduce erosion. All stormwater run-off should be directed away from all temporary and permanent batters to also reduce erosion.

Permanent retaining walls constructed at the toe of temporary batters may be designed based on a triangular earth pressure distribution using an active earth pressure coefficient, K_a, of 0.35 and a bulk unit weight of $20kN/m^3$. This assumes that some resulting wall movements will be tolerable. Where movements are to be reduced, such as where walls are restrained by other structural elements in front of the wall, an 'at rest' earth pressure coefficient, K_0, of 0.6 should be used.

The above earth pressure coefficients assume horizontal backfill surfaces and where inclined backfill is proposed the coefficients would need to be increased or the inclined backfill 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.

Where batters are used, the space between the batters and the permanent retaining walls will need to be carefully backfilled to reduce future settlement of the backfill. Only light compaction equipment should be used for compaction behind retaining walls so that excessive lateral pressures are not placed on the walls. This will require the backfill to be placed in thin layers, say 100mm loose thickness, appropriate to the compaction equipment being used. The excavated clay and shale will be difficult to properly compact within the limited space available behind the walls and consideration should be given to the use of more readily compactable materials, such as a good quality durable granular material. The compaction specification for the backfill will depend on whether paving or structures are to be supported on the fill. If the fill is to support paved areas it should be compacted to a density of at least 98% of Standard Maximum Dry Density (SMDD) for granular fill materials, but if it is only to support landscaped areas a lower compaction specification, say 95% of SMDD, may be appropriate, provided the risk of future settlement and maintenance can be accepted. If clay and shale fill is to be used a greater control of fill compaction and moisture control will be required and further geotechnical advice on the use of such material should be obtained. An alternative for backfill would also be to use a uniform granular material, such as crushed concrete of 30mm to 70mm in size, surrounded in a geofabric, with a clay cap at the surface to reduce infiltration.

4.4 Footings

Fill to depths of more than 0.4m was encountered in the boreholes, and as such the site would be classified as Class 'P' in accordance with AS2870-2011. If all fill was removed to expose the residual silty clays, then based on the laboratory test results, the site may be reclassified as Class 'H1'. If earthworks involving replacement of all existing fill with controlled engineered fill is proposed, then the site would need to be further reclassified depending on the depth and reactivity of the fill used. If clay fill was used as engineered fill a reclassification to Class 'H2' would be likely.

The classification in accordance with AS2870-2011 must also take into account the presence of trees within the vicinity of any structures. This includes both existing trees and any trees proposed. The designer must assess the shrink/swell movements taking into account both the reactivity of the clays and the presence of trees. The geotechnical engineer can assist with such calculations once the final locations of all structures and trees are known. We expect that at least some trees and buildings will be removed to allow construction of the proposed school building. We recommend that the tree removal and building and slab removal be carried out as early as possible to allow the moisture content within the clays to move closer to an equilibrium moisture content before construction of the proposed building.

Care by the structural designers is essential when conducting footing designs for this site. As can be seen above the site classification and therefore the reactive movements potential will be highly dependent on the nature of any earthworks, the type and reactive nature of any fill used, and the presence of any trees. In addition, it must be remembered that footings founded on variable founding stratums may undergo the full extent of differential movement. Therefore, considering these issues along with the fact that the size of the structure is not in accordance with the requirements of AS2879-2011, all footings must be designed using sound engineering principles and structures should have adequate movement control joints and articulation.

Since we expect that shale will be encountered within the excavations on the south-western side of the proposed building, our preference is for the building to be supported on footings founded entirely within the shale to provide uniform support and reduce the risk of differential movements. The ground floor slabs of the building should be designed to be separate from the footing system to reduce the risk that swelling clays would lift the slabs off the footings.

Where shale is exposed, or is at shallow depths of less than about 1m, pad or strip footings would be appropriate. Where the depth of shale is more than about 1m, bored piers would be more practical. Given the deeply weathered profile of the shale and the size of the proposed building we expect that footings founded within the Class V shale would be the most practical foundation system for the proposed development.

The design of footings founded within the shale may be based on the parameters given in the table below. The serviceability parameters given are based on settlements of less than 1% of the pile diameter or footing width. The ultimate parameters may be used for limit state design on the understanding that settlement of the footings may be up to 5% of the pile diameter or footing width. Where ultimate limit states are adopted specific settlement calculations would be required. Appropriate load factors and geotechnical strength reduction factors, in accordance with AS2159-2009, will need to be assessed by the designer depending on the design adopted. The designer may use the modulus values given below to estimate the settlements of particular footings. Differential settlements of about half the total settlements would be expected where all footings are founded on weathered shale.

Shale Class	Allowable End Bearing Pressure	Allowable Shaft Adhesion in compression	Ultimate End Bearing Pressure	Ultimate Shaft Adhesion in Compression	Elastic Modulus
Class V	700kPa	70kPa	3000kPa	100kPa	50MPa
Class IV	1000kPa	100kPa	3000kPa	150kPa	200MPa

Where piles are adopted they should be founded with a nominal socket of at least 0.3m into the appropriate class of shale. For the design of sockets into the shale, the shaft adhesion should be ignored within the 0.3m nominal socket. For the design of piles in uplift, shaft adhesions of half the above shaft adhesions for compressive loads may be used. The shaft adhesion values assume that adequate socket roughness and cleanliness is maintained.

Higher parameters would be appropriate within the medium or high strength shale, but such shale was only encountered within three boreholes. Therefore, additional deep cored boreholes would be required to assess the quality of the shale in greater detail. We expect that given the depth to such shale and the loads of the proposed building it is unlikely to be economical to found piles within the medium to high strength shale.

At least the initial stages of the footing excavation or pile drilling should be inspected by a geotechnical engineer to confirm that the appropriate quality shale has been encountered. The need for additional inspections will depend on the class of shale required for the footings, the conditions observed during the initial inspection and the degree of certification required by the client. The geotechnical engineer can provide an opinion on the need for additional inspections during the initial footing construction. However, for footings founded within Class V or IV shale an initial inspection is likely to be sufficient.

If any minor structures are proposed away from the proposed building and excavations into the shale are not required, shallow footings founded within engineered fill or residual silty clay may be appropriate, such as stiffened raft slabs. Such footings may be designed based on an allowable bearing pressure of 100kPa for engineered fill or residual silty clay of stiff strength. Where the clays are of at least very stiff strength an allowable bearing pressure of 200kPa would be appropriate. These footings would also need to be designed to accommodate the shrink/swell reactivity of the fill and residual silty clay and will need to be specifically assessed depending on the subsurface profile at the building location as discussed above. Based on the results of this investigation, we expect shrink/swell movements similar to a Class 'H1' or 'H2' site.

Based on the subsurface conditions encountered, the site would be classified for earthquake design as Class C_e in accordance with Section 4 of AS1170.4-2007. Given that the site is located within the Sydney region, a Hazard Factor, Z, of 0.08 would be appropriate in accordance with Table 3.2 of AS1170.4-2007. Given the subsurface profile of residual silty clay grading into weathered shale, liquefaction would not be an issue for this site.

4.5 Pavements

The supplied architectural drawings do not show any new pavements, only retention of the existing car park within the western corner of the site. Therefore, the recommendations given below are of a general nature and should be reviewed once any specific details of proposed pavements are known.

Provided pavement subgrades are prepared in accordance with the recommendations given in Section 4.1, they may be designed based on the measured soaked CBR value of 1.5%, or an estimated modulus of subgrade reaction of 15kPa/mm (750mm plate). Where fill is used to raise site levels, or replace unsuitable subgrade by the appropriate depth, pavement design may reflect the thickness and four day soaked CBR value of the imported material.

The measured CBR values are very low and consideration should be given to some form of subgrade improvement to reduce the overall thickness of the pavement materials. Such works may comprise the provision of a select subgrade layer of good quality granular material, such as crushed sandstone with a soaked CBR of at least 10%. Such a layer should have a minimum thickness of 0.3m. Alternatively, the clay subgrade could be stabilised by the addition of lime to the top 0.2m to 0.3m of the subgrade. Lime stabilisation reduces the plasticity of the clays and improves the overall strength. However, such works can be quite messy and the effect of the lime becoming wind-born and affecting adjoining properties should be considered. The amount of lime required should be determined by laboratory testing, but as a guide we expect about 2% to 3% lime by dry weight may result in an increase of the CBR to about 6% to 8%.

Surface and subsoil drainage should be provided on the high side of the pavements to prevent moisture ingress into the subgrade and pavement. The subsoil drains should have an invert level of at least 300mm below the adjacent subgrade level and be excavated with a uniform longitudinal fall to appropriate discharge points so as to reduce the risk of ponding in the base of the drain. 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.

Concrete pavements should have a subbase layer of at least 100mm thickness of crushed rock to RMS QA specification 3051 (2013) unbound base material (or similar good quality and durable fine crushed rock), which is compacted to at least 100% of SMDD. Concrete pavements should be designed with an effective shear transmission at all joints by way of either doweled or keyed joints.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the 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 construction phase recommendations presented in this report are 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 will need to be assigned to any soil excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous Waste. Analysis takes seven to 10 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) should be expected. We strongly recommend that this issue 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.

References:

1 Pells et al, 1998, "Foundations on Sandstone and Shale in the Sydney Region", Australian Geomechanics, December 1998.

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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
Project: Proposed School
Location: 3A & 3B Smalls Road, Ryde, NSW

Ref No: 30275L
Report: A
Report Date: 19/04/2017
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 %
1	4.00-4.50	8.6				
2	0.50-0.95	19.8	73	31	42	16.5
2	1.70-2.00	13.0				
2	4.30-4.50	8.2				
2	5.60-5.70	6.4				
3	2.20-2.50	11.1				
3	6.50-7.00	12.4				
3	7.90-8.00	8.7				
4	4.50-5.00	9.1				
5	2.50-3.00	8.0				
5	4.50-5.00	8.8				
5	8.00-8.50	6.0				
6	0.50-0.60	36.0	68	32	36	16.0
7	2.50-3.00	14.7				
7	4.10-4.50	9.9				
7	7.00-7.20	8.9				
8	3.80-4.30	12.2				
9	0.70-0.90	25.0	51	27	24	13.0
9	2.50-3.00	13.2				
9	4.90-5.20	14.2				
9	7.00-7.50	6.4				
10	4.20-4.50	13.4				
11	3.50-4.00	10.2				

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: 29/3/17

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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
Project: Proposed School
Location: 3A & 3B Smalls Road, Ryde, NSW

Ref No: 30275L
Report: B
Report Date: 19/04/2017
Page 1 of 1

BOREHOLE NUMBER	1	10	11
DEPTH (m)	0.85 - 1.50	0.50 - 1.50	0.50 - 1.50
Surcharge (kg)	4.5	4.5	4.5
Maximum Dry Density (t/m^3)	1.62 STD	1.63 STD	1.52 STD
Optimum Moisture Content (%)	20.3	20.6	26.0
Moulded Dry Density (t/m^3)	1.59	1.60	1.49
Sample Density Ratio (%)	98	98	98
Sample Moisture Ratio (%)	100	98	101
Moisture Contents			
Insitu (%)	18.4	24.7	27.9
Moulded (%)	20.3	20.2	26.2
After soaking and After Test, Top 30mm(%)	33.1	31.2	37.8
Remaining Depth (%)	26.1	25.7	33.3
Material Retained on 19mm Sieve (%)	0	0	0
Swell (%)	4.0	4.5	4.0
C.B.R. value: @2.5mm penetration		1.5	
@5.0mm penetration	2.0		1.5

NOTES:

- Refer to appropriate Borehole logs for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1
- Date of receipt of sample:29/3/17

NATA Accredited Laboratory Number:1327

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(A. Tatikonda) 19/4/17

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SOIL TEST SERVICES
ABN 43 002 145 173

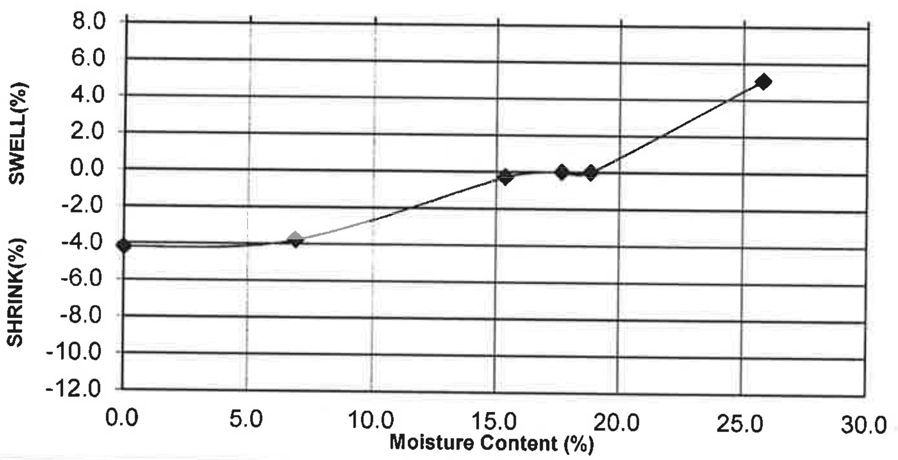
TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client:	JK Geotechnics	**STS Job No:**	30275L
Project:	Proposed School	**Report:**	C
Location:	3A & 3B Smalls Road, Ryde, NSW	**Report Date:**	19/04/2017
		Page :	1 of 4

BOREHOLE NO.: 2		DEPTH: 1.00-1.40 m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
18.8%	25.8%	> 600 kPa	450 , 400 kPa

LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	0.0%	5.1%	4.2%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
3.75 %/pF

Notes:
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Inert Inclusions by volume = 5-10%
- Shrinkage Cracking = Light
- Soil Crumbling = none
- Date of receipt of sample: 29/3/17

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NATA Accredited Laboratory
Number:1327

Authorised Signature / Date
(A. Tatikonda) 19/4/17

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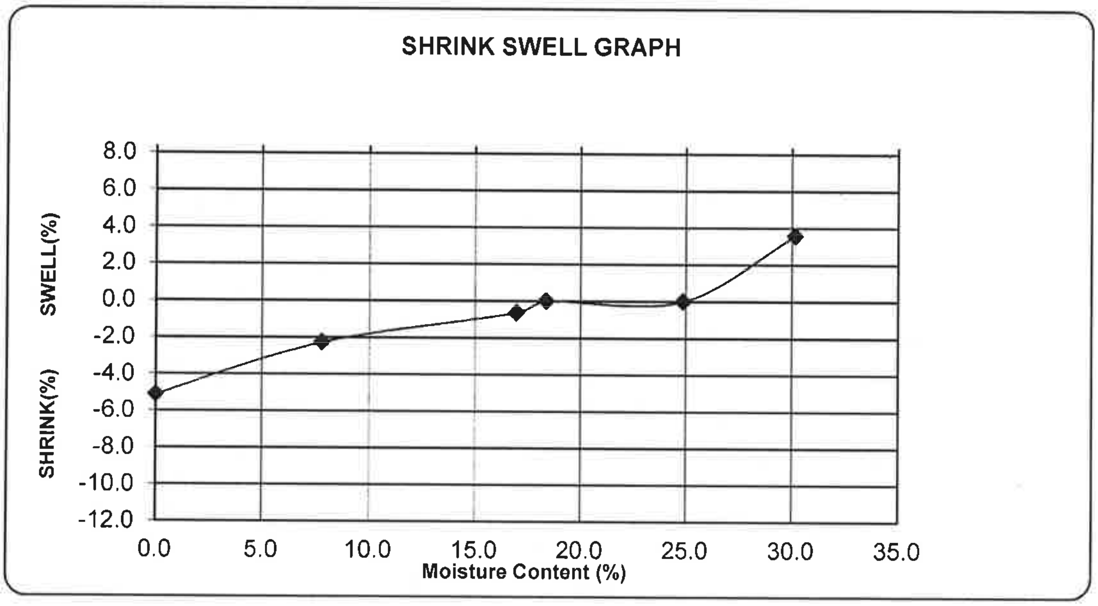
SOIL TEST SERVICES

ABN 43 002 145 173

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

Client:	JK Geotechnics	**STS Job No:**	30275L
Project:	Proposed School	**Report:**	C
Location:	3A & 3B Smalls Road, Ryde, NSW	**Report Date:**	19/04/2017
		Page :	2 of 4

BOREHOLE NO.:6		DEPTH: 1.00-1.30m		
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH		
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST	
24.9%	30.1%	350 , 320 , 300 kPa	220 , 220 kPa	
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION		SWELL ON SATURATION	SHRINKAGE
25	0.0%		3.6%	5.1%



SHRINK SWELL INDEX
3.83 %/pF

Notes:

- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Inert Inclusions by volume = 5-10%
- Shrinkage Cracking = Heavy
- Soil Crumbling = none
- Date of receipt of sample:29/3/17

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SOIL TEST SERVICES
ABN 43 002 145 173

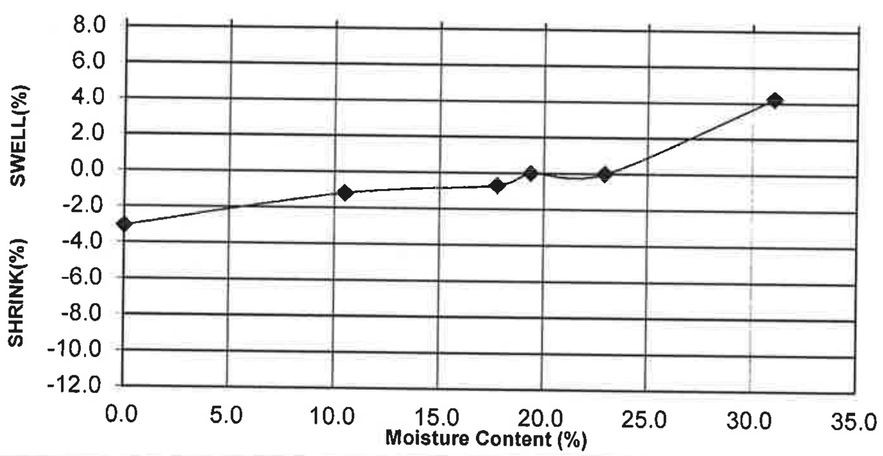
TABLE C
SHRINK - SWELL TEST REPORT
TEST METHOD: AS1289 7.1.1

Client:	JK Geotecnics	**STS Job No:**	30275L
Project:	Proposed School	**Report:**	C
Location:	3A & 3B Smalls Road, Ryde, NSW	**Report Date:**	19/04/2017
		Page	3 of 4

BOREHOLE NO.:9		DEPTH: 1.00-1.40 m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
23.0%	31.1%	550 , 520 kPa	210 , 180 , 130 kPa

LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	0.1%	4.2%	3.0%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
2.87 %/pF

Notes:

- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Inert Inclusions by volume = 0-5%
- Shrinkage Cracking = Moderate
- Soil Crumbling = none
- Date of receipt of sample: 29/3/17

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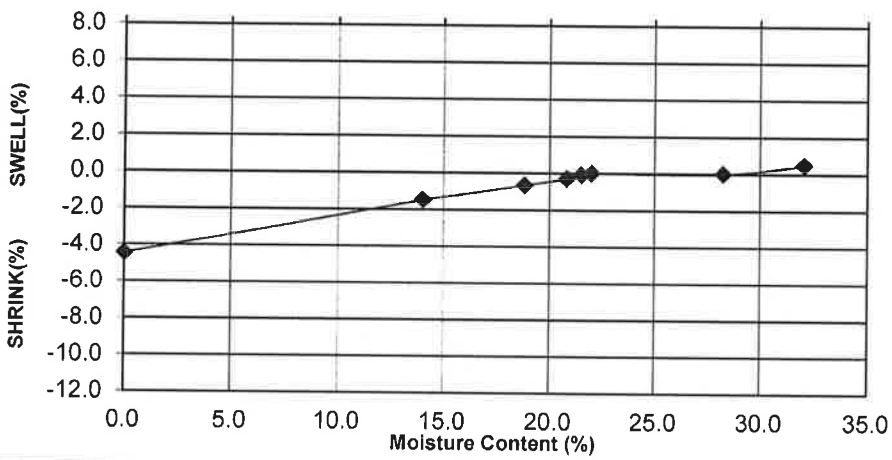
SOIL TEST SERVICES
ABN 43 002 145 173

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

Client:	JK Geotecnics	**STS Job No:**	30275L
Project:	Proposed School	**Report:**	C
Location:	3A & 3B Smalls Road, Ryde, NSW	**Report Date:**	19/04/2017
		Page	4 of 4

BOREHOLE NO.:12		DEPTH: 0.50-0.70 m	
MOISTURE CONTENT (SWELL)		ESTIMATED UNCONFINED COMPRESSIVE STRENGTH	
BEFORE TEST	AFTER TEST	BEFORE TEST	AFTER TEST
28.2%	32.1%	220, 220 kPa	210 , 220 kPa
LOAD	SETTLEMENT UNDER LOAD BEFORE SATURATION	SWELL ON SATURATION	SHRINKAGE
25	0.0%	0.5%	4.5%

SHRINK SWELL GRAPH



SHRINK SWELL INDEX
2.61 %/pF

Notes:
- Suction Value used in calculation = 1.8pF
- Volume Change Coefficient (α) was assumed = 2
- Inert Inclusions by volume = 0-5%
- Shrinkage Cracking = Heavy
- Soil Crumbling = none
- Date of receipt of sample: 29/3/17

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE D
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed School
Location: 3A & 3B Smalls Road, Ryde, NSW

Ref No: 30275L
Report: D
Report Date: 29/03/2017
Page 1 of 1

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
2	8.61-8.65	0.3	6
	9.06-9.09	1.0	20
	9.53-9.57	0.6	12
	10.04-10.07	0.6	12
	10.46-10.49	2.5	50
3	8.71-8.75	1.2	24
	8.91-8.95	2.3	46
	9.34-9.37	2.6	52
7	9.95-9.99	0.9	18
	10.19-10.22	0.6	12
	10.28-10.32	0.8	16
9	8.94-8.98	0.8	16
	9.23-9.26	1.3	26
	9.74-9.77	2.4	48
	10.27-10.30	2.1	42
	10.77-10.80	1.5	30
	11.09-11.12	1.4	28

NOTES:

1. In the above table testing was completed in the Axial direction.
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 by the following approximate relationship and rounded off to the nearest whole number :
   U.C.S. = 20 $I_{S(50)}$

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CERTIFICATE OF ANALYSIS **164525**

Client:
JK Geotechnics
PO Box 976
North Ryde BC
NSW 1670

Attention: A Kourtesis

Sample log in details:

Your Reference:	**30275L, Ryde**	
No. of samples:	6 soils	
Date samples received / completed instructions received	31/03/17	/ 31/03/17

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: / Issue Date:	7/04/17	/ 7/04/17
Date of Preliminary Report:	Not Issued	

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Results Approved By:

David Springer
General Manager

ACCREDITED FOR TECHNICAL COMPETENCE

Misc Inorg - Soil						
Our Reference:	UNITS	164525-1	164525-2	164525-3	164525-4	164525-5
Your Reference	-------------	BH1	BH3	BH6	BH6	BH7
Depth	------------	0.5-0.85	1.5-1.95	0.2-0.3	4.0-4.5	0.5-0.95
Date Sampled		20/03/2017	20/03/2017	22/03/2017	22/03/2017	21/03/2017
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	04/04/2017	04/04/2017	04/04/2017	04/04/2017	04/04/2017
Date analysed	-	04/04/2017	04/04/2017	04/04/2017	04/04/2017	04/04/2017
pH 1:5 soil:water	pH Units	5.1	4.6	6.1	5.5	4.6
Chloride, Cl 1:5 soil:water	mg/kg	26	20	<10	40	87
Sulphate, SO4 1:5 soil:water	mg/kg	110	72	10	86	280
Resistivity in soil*	ohm m	110	160	290	100	43

Misc Inorg - Soil		
Our Reference:	UNITS	164525-6
Your Reference	-------------	BH9
Depth	------------	1.5-1.9
Date Sampled		22/03/2017
Type of sample		Soil
Date prepared	-	04/04/2017
Date analysed	-	04/04/2017
pH 1:5 soil:water	pH Units	5.3
Chloride, Cl 1:5 soil:water	mg/kg	10
Sulphate, SO4 1:5 soil:water	mg/kg	27
Resistivity in soil*	ohm m	250

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.
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.

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base ll Duplicate ll %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			04/04/2017	164525-1	04/04/2017 || 04/04/2017	LCS-1	04/04/2017
Date analysed	-			04/04/2017	164525-1	04/04/2017 || 04/04/2017	LCS-1	04/04/2017
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	164525-1	5.1 || 5.1 || RPD: 0	LCS-1	102%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	164525-1	26 || 21 || RPD: 21	LCS-1	92%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	164525-1	110 || 97 || RPD: 13	LCS-1	101%
Resistivity in soil*	ohm m	1	Inorg-002	<1.0	164525-1	110 || 120 || RPD: 9	[NR]	[NR]

QUALITY CONTROL Misc Inorg - Soil	UNITS	Dup. Sm#	Duplicate Base + Duplicate + %RPD	Spike Sm#	Spike % Recovery
Date prepared	-	[NT]	[NT]	164525-2	04/04/2017
Date analysed	-	[NT]	[NT]	164525-2	04/04/2017
pH 1:5 soil:water	pH Units	[NT]	[NT]	[NR]	[NR]
Chloride, Cl 1:5 soil:water	mg/kg	[NT]	[NT]	164525-2	99%
Sulphate, SO4 1:5 soil:water	mg/kg	[NT]	[NT]	164525-2	122%
Resistivity in soil*	ohm m	[NT]	[NT]	[NR]	[NR]

Report Comments:

Asbestos ID was analysed by Approved Identifier: Not applicable for this job
Asbestos ID was authorised by Approved Signatory: Not applicable for this job

INS: Insufficient sample for this test	PQL: Practical Quantitation Limit	NT: Not tested
NR: Test not required	RPD: Relative Percent Difference	NA: Test not required
<: Less than	>: Greater than	LCS: Laboratory Control Sample

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.

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: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-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.

Measurement Uncertainty estimates are available for most tests upon request.

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
1
1 / 2

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~75.5 m
Date: 20/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION AND AFTER 2 HRS		0		ASPHALTIC CONCRETE: 100mm.t				
			-	FILL: Silty clay, low plasticity, dark grey, trace of medium grained igneous gravel.	MC<PL			APPEARS MODERATELY COMPACTED
	N = 12 4,5,7			FILL: Silty clay, medium to high plasticity, dark grey brown, trace of root fibres, and ash.				
		1	CH	SILTY CLAY: high plasticity, light grey mottled orange brown and red brown, trace of fine to medium grained ironstone gravel.	MC<PL	(H)		RESIDUAL
	N > 5 7,5/ 50mm REFUSAL		-	SHALE: light grey brown, with iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
		4		as above, but dark grey brown.	XW - DW	EL - VL		
		5			DW	VL		VERY LOW TO LOW RESISTANCE
						VL - L		

RL (m AHD) scale: 75, 74, 73, 72, 71, 70, 69. Depth (m) scale: 1, 2, 3, 4, 5, 6.

Columns also shown: SAMPLES (ES, U50, DB, DS), RL (m AHD), Graphic Log.

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 1

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~75.5 m
Date: 20/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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
						68	8			SHALE: dark grey, with iron indurated bands.	DW	VL - L		LOW RESISTANCE
						67				SHALE: dark grey.		L		
						66, 65, 64, 63, 62	9, 10, 11, 12, 13			END OF BOREHOLE AT 9.00 m				

JK_LIB_CURRENT - V8.00.GLB Log J & K AUGERHOLE - MASTER 30275L RYDE.GPJ <<DrawingFile>> 27/04/2017 11:46 Produced by gINT Professional, Developed by Datgel

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
2
1 / 2

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~75.5 m
Date: 20/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.B.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION AFTER AUGERING				0	-	ASPHALTIC CONCRETE: 50mm.t				
						FILL: Silty clay, low to medium plasticity, dark grey, trace of ash, medium grained igneous gravel, and fine to medium grained sand.	MC<PL			
	DS	N = 13 5,6,7	75		CH	SILTY CLAY: high plasticity, light grey brown and orange brown, trace of fine to medium grained ironstone gravel.	MC<PL	H	>600 >600 >600	RESIDUAL
	U50			1						
	DS	N > 9 4,9/ 50mm REFUSAL	74							
	DS			2	-	SHALE: light grey brown, with L-M strength iron indurated bands.	XW - DW	EL - VL		VERY LOW 'TC' BIT RESISTANCE WITH LOW TO MODERATE BANDS
ON COMPLETION OF CORING			73	3		as above, but with dark grey brown.				
			72	4			DW	VL - L		VERY LOW TO LOW RESISTANCE WITH MODERATE BANDS
	DS		71							LOW RESISTANCE
				5						
	DS		70			SHALE: dark grey brown.				
			69	6		REFER TO CORED BOREHOLE LOG				

Borehole No.
2

CORED BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L | **Core Size:** NMLC | **R.L. Surface:** ~75.5 m
Date: 20/3/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK205 | **Bearing:** N/A | **Logged/Checked By:** A.C.K./D.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS – DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific	General
		70			START CORING AT 5.76m						
100% RETURN		69, 68	6, 7, 8		CORE LOSS 0.06m						
					SHALE: dark grey, with grey brown bands.	XW - DW	EL - VL				
		67, 66, 65	9, 10		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	DW	L - M			(8.43m) CS, 0°, 10 mm.t (8.48m) XWS, 0°, 30 mm.t (8.58m) XWS, 0°, 25 mm.t (8.67m) CS, 0°, 25 mm.t (8.70m) XWS, 0°, 25 mm.t	
							H			(8.88m) XWS, 0°, 8 mm.t (9.01m) XWS, 0°, 7 mm.t (9.67m) J, 30°, P, R (9.71m) J, 30°, P, S (10.52m) XWS, 5°, 3 mm.t (10.55m) XWS, 0°, 8 mm.t (10.61m) XWS, 0°, 3 mm.t (10.63m) J, 40°, P, HEALED (10.69m) J, 55°, P, HEALED (10.75m) J, 65°, P, R	
		64	11		END OF BOREHOLE AT 10.82 m						


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JOB NO. 30275L BH2 START CORING AT 5.76m
CL 0.06
6
7
8
9
10
END OF BOREHOLE AT 10.82m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~74.0 m
Date: 20/3/17 TO 21/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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 AFTER AUGERING			0		FILL: Silty clay topsoil, high plasticity, dark grey brown, trace of root fibres.	MC>PL			GRASS COVER
				CH	SILTY CLAY: high plasticity, light grey mottled orange brown and red brown, trace of root fibres.	MC>PL	VSt		RESIDUAL
	N = 11 4,5,6	73	1					290 290 275	
	N = 13 3,5,8				SILTY CLAY: high plasticity, light grey.		(H)	375 270 460	
		72	2						
ON COMPLETION OF CORING				-	SHALE: light grey brown, with iron indurated bands.	XW - DW	EL - VL		VERY LOW 'TC' BIT RESISTANCE
		71	3						
		70	4						
		69	5						
		68	6						

SAMPLES: ES, U50, DB, DS

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BOREHOLE LOG

Borehole No.
3

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~74.0 m
Date: 20/3/17 TO 21/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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
									-		XW - DW	EL - VL		
										SHALE: dark grey with EL strength bands.	DW	VL - L		VERY LOW TO LOW RESISTANCE
						66	8			SHALE: dark grey.	DW	L		MODERATE RESISTANCE
										REFER TO CORED BOREHOLE LOG				
						65	9							
						64	10							
						63	11							
						62	12							
						61	13							

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CORED BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L	**Core Size:** NMLC	**R.L. Surface:** ~74.0 m
Date: 20/3/17 TO 21/3/17	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK205	**Bearing:** N/A	**Logged/Checked By:** A.C.K./D.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
					START CORING AT 8.30m						
100% RETURN		65 64	9 10		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	SW	H			(8.47m) J, 75°, P, S (8.67m) J, 70°, P, S (8.81m) J, 70°, P, R (9.08m) J, 75°, P, R (9.15m) J, 75°, P, R (9.43m) J, 80°, P, R (9.74m) J, 75°, P, S (9.92m) J, 85°, P, S	
		63 62 61 60	11 12 13 14		END OF BOREHOLE AT 10.11 m						


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JOB NO. 30275L BH3 START CORING AT 8.30m
8
9
10
END OF BOREHOLE AT 10.11m

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BOREHOLE LOG

Borehole No. 4

1 / 1

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~71.0 m
Date: 21/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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 AND AFTER 2.5 HRS					FILL: Silty clay, medium to high plasticity, dark grey brown mottled light grey and orange brown, trace of medium grained igneous gravel, and root fibres.	MC>PL			GRASS COVER
	N = 8 2,3,5	70	1	CH	SILTY CLAY: high plasticity, orange brown and brown, trace of root fibres, and fine grained ironstone gravel.	MC>PL	St - VSt (VSt)	130 200 130 250 250	RESIDUAL
	N = 28 3,9,19				SILTY CLAY: high plasticity, light grey mottled orange brown, trace of fine grained ironstone gravel.	MC<PL	H	>600	
		69 68 67	2 3 4	-	SHALE: light grey brown, with iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
		66	5		SHALE: grey brown, with iron indurated bands and clay bands.	DW	VL - L		VERY LOW TO LOW RESISTANCE
		65	6		END OF BOREHOLE AT 6.00 m				

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Borehole No.
5
1 / 2

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~77.2 m
Date: 20/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.B.

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION			77			FILL: Silty cllay topsoil, medium to high plasticity, dark grey brown, trace of root fibres.				GRASS COVER
	DS	N > 21 7,16,5/ 100mm REFUSAL			CH	SILTY CLAY: high plasticity, light grey mottled orange brown.	MC~PL	VSt - H	335 370 >600	RESIDUAL
			76	1	-	SHALE: light grey, with L-M strength iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
	DS		75, 74, 73	2, 3, 4						
	DS		72, 71	5, 6		SHALE: dark grey, with EL-VL strength bands.	DW	VL - L		VERY LOW TO LOW RESISTANCE

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
5
2 / 2

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~77.2 m
Date: 20/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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
						70				SHALE: dark grey.	DW	VL - L		VERY LOW TO LOW RESISTANCE
						69	8					L		LOW RESISTANCE
						68	9			END OF BOREHOLE AT 9.00 m				
						67	10							
						66	11							
						65	12							
						64	13							

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Borehole No.
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BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~73.8 m
Date: 22/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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			0		FILL: Silty clay, low to medium plasticity, dark grey brown, trace of root fibres.	MC~PL			GRASS COVER HAND AUGERED TO 0.8m
					FILL: Silty clay, medium to high plasticity, dark grey brown mottled orange brown and light grey, trace of ash.				
		73	1	CH	SILTY CLAY: high plasticity, light grey mottled red brown and orange brown.	MC>PL	VSt		RESIDUAL
	N = 16 3,5,11	72	2					290 280 330	
		71, 70, 69	3, 4, 5	-	SHALE: light grey and grey brown, with iron indurated bands.	XW - DW	EL - VL		VERY LOW 'TC' BIT RESISTANCE VERY LOW TO LOW RESISTANCE
		68			SHALE: dark grey.	DW	L		LOW RESISTANCE
		67	6		END OF BOREHOLE AT 6.00 m				

SAMPLES: ES, U50, DB, DS

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
7
1 / 3

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~70.7 m
Date: 21/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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 AFTER AUGERING			0		FILL: Silty clay topsoil, high plasticity, dark brown mottled orange brown, trace of root fibres.	MC>PL			GRASS COVER
	N = 7 2,2,5	70		CH	SILTY CLAY: high plasticity, light grey and orange brown and red brown, trace of medium to coarse grained ironstone gravel.	MC>PL	St - VSt	260 175 125	RESIDUAL
	N = 24 4,11,13	69	1		SILTY CLAY: high plasticity, light grey mottled red brown, trace of fine to medium grained ironstone gravel.	MC<PL	H	>600 >600 >600	
		68	2	-	SHALE: light grey, with iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
		67	3						
		66	4		SHALE: grey.	DW	VL - L		LOW RESISTANCE
		65	5		SHALE: dark grey.				
		64	6						

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BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~70.7 m
Date: 21/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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
				■					-	SHALE: dark grey.	DW	VL - L		
						63				REFER TO CORED BOREHOLE LOG				
							8							
						62								
							9							
						61								
							10							
						60								
							11							
						59								
							12							
						58								
							13							
						57								

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CORED BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L | **Core Size:** NMLC | **R.L. Surface:** ~70.7 m
Date: 21/3/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK205 | **Bearing:** N/A | **Logged/Checked By:** A.C.K./D.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS – DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific / General
					START CORING AT 7.41m					
100% RETURN		63	8		SHALE: dark grey, with brown bands.	XW - DW	EL - VL			
		62			CORE LOSS 0.15m					
			9		SHALE: dark grey, with light grey laminae, bedded at 0-25°.	DW	L			(8.93m) FRAGMENTED ZONE, 0 - 30°, 110 mm.t (9.06m) J, 90°, P, S
						XW	EL			
		61				DW	L - M			(9.62m) XWS, 0°, 60 mm.t (9.66m) J, 55°, P, S (9.94m) FRAGMENTED ZONE, 0 - 10°, 30 mm.t
			10			SW	M			(10.11m) J, 80°, P, S (10.16m) J, 40°, P, S
		60, 59, 58, 57	11, 12, 13		END OF BOREHOLE AT 10.35 m					


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JOB NO. 30275L BH7 START CORING AT 7.41m
7
8
CL: 0.15 m
9
10
END OF BOREHOLE AT 10.35 m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
8
1 / 1

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~68.9 m
Date: 22/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		0		FILL: Silty clay topsoil, low to medium plasticity, dark grey brown, trace of root fibres.	MC>PL			GRASS COVER
	N = 7 2,3,4	0.3	CH	SILTY CLAY: high plasticity, orange brown, trace of root fibres.	MC>PL	St	160 150 125	RESIDUAL
	N = 15 4,6,9	1.2	CH	SILTY CLAY: high plasticity, light grey and orange brown, with fine to medium grained ironstone gravel.		VSt	285 300 210	
	N > 27 8,13,14/ 100mm REFUSAL	2.3	CH	as above, but light grey mottled light orange brown.	MC<PL			
		3.8	-	SHALE: light grey brown.	XW - DW	EL - VL		VERY LOW 'TC' BIT RESISTANCE
		5.0		SHALE: dark grey.	DW	VL, then L		
		6.0		END OF BOREHOLE AT 6.00 m				

RL (m AHD) scale: 68, 67, 66, 65, 64, 63, 62. Samples columns: ES, U50, DB, DS.

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Borehole No.
9
1 / 3

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~75.8 m
Date: 22/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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 AFTER AUGERING			0	-	ASPHALTIC CONCRETE: 50mm.t	MC<PL			APPEARS MODERATELY COMPACTED
					FILL: Silty clay, low plasticity, dark grey brown, with fine grained sand, trace of fine grained igneous gravel.	M			
	N = 13 7,7,6	75			FILL: Clayey sand, fine to medium grained, light grey brown, trace of medium grained ironstone gravel.	MC<PL			
			1	CH	FILL: Silty clay, high plasticity, dark grey brown mottled orange brown, trace of ash.	MC<PL	H		RESIDUAL
ON COMPLETION OF CORING	N > 24 7,11,13/ 100mm REFUSAL	74			SILTY CLAY: high plasticity, orange brown mottled light grey brown, trace of root fibres, and fine grained ironstone gravel.			550 545 >600	
		73	2	-	SHALE: light grey, with iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
		72, 71	3, 4						
			5		SHALE: grey brown, with light grey bands.	XW - DW	EL - VL		VERY LOW TO LOW RESISTANCE
		70, 69	6		SHALE: dark grey brown.	DW	L		LOW TO MODERATE RESISTANCE

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
9
2 / 3

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~75.8 m
Date: 22/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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
						68	8		-	SHALE: dark grey, with brown bands.	DW	L		
												VL - L		LOW RESISTANCE
										SHALE: dark grey.		L - M		MODERATE RESISTANCE
						67	9			REFER TO CORED BOREHOLE LOG				
						66	10							
						65	11							
						64	12							
						63	13							
						62								

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

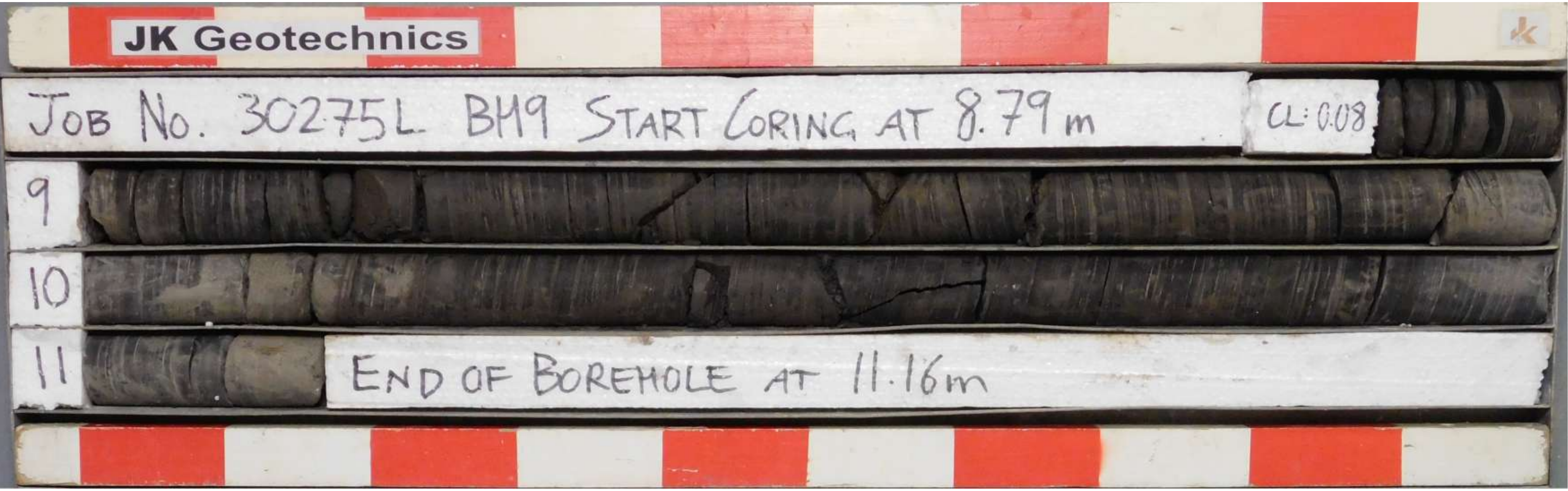
CORED BOREHOLE LOG

Borehole No.
9
3 / 3

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L	**Core Size:** NMLC	**R.L. Surface:** ~75.8 m
Date: 22/3/17	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK205	**Bearing:** N/A	**Logged/Checked By:** A.C.K./D.B.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS – DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		67			START CORING AT 8.79m					
100% RETURN			9		CORE LOSS 0.08m					
		66	10		SHALE: dark grey, with light grey laminae 5-10°.	SW	M H			(9.18m) J, 35°, P, S (9.22m) XWS, 0°, 8 mm.t (9.39m) J, 45°, P, R (9.52m) J, 30°, P, S (9.53m) J, 20°, R (9.64m) Cr, 10 - 20°, 9 mm.t (9.93m) J, 30°, P, S (9.94m) J, 50°, P, S (9.98m) J, 35°, P, R (10.43m) J, 80°, P, R (10.51m) XWS, 20°, 8 mm.t (10.57m) J, 75°
		65	11							
		64	12		END OF BOREHOLE AT 11.16 m					
		63	13							
		62	14							
		61								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JOB NO. 30275L BH9 START CORING AT 8.79m
CL: 0.08
9
10
11
END OF BOREHOLE AT 11.16m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
10
1 / 1

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~78.4 m
Date: 22/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.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						-	ASPHALTIC CONCRETE: 50mm.t	MC<PL			
							FILL: Silty gravelly clay, low plasticity, dark grey brown, fine grained igneous gravel, with fine to medium grained sand.	MC>PL			
			78			CH	FILL: Silty clay, high plasticity, light grey mottled orange brown, trace of fine grained sand.	MC>PL	St		RESIDUAL
		N = 8 2,3,5								160 140 150	
				1			SILTY CLAY: high plasticity, light grey and orange brown mottled red brown.				
			77						VSt		
		N = 15 3,5,10								325 225 165	
				2							
			76								
		N = 27 10,14,13		3						450 530 535	
			75								
				4		-	SHALE: dark grey brown, with iron indurated bands.	XW - DW	EL - VL		LOW 'TC' BIT RESISTANCE
			74								
				5							
			73						L		LOW TO MODERATE RESISTANCE
				6			END OF BOREHOLE AT 6.00 m				
			72								

JK_LIB_CURRENT - V8.00.GLB Log J & K AUGERHOLE - MASTER 30275L RYDE.GPJ <<DrawingFile>> 27/04/2017 11:47 Produced by gINT Professional, Developed by Datgel

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
11
1 / 1

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~73.4 m
Date: 22/3/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./D.B.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION		0		ASPHALTIC CONCRETE: 50mm.t				
			-	FILL: Silty clay, high plasticity, dark grey brown mottled light grey and orange brown, trace of ash, and fine to coarse grained igneous gravel.	MC~PL			
			CH	SILTY CLAY: high plasticity, light grey.	MC>PL	VSt		RESIDUAL
	N = 5 3,2,3	1					295 230 220	
	N = 7 2,3,4						220 200	
	N = 15 4,5,10	3					300 270 290	
			-	SHALE: light grey and grey, with iron indurated bands.	XW - DW	EL - VL		VERY LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
		4		SHALE: dark grey brown, with iron indurated bands.				
				SHALE: dark grey.	DW	L		MODERATE RESISTANCE
		6		END OF BOREHOLE AT 6.00 m				

RL (m AHD) scale: 73, 72, 71, 70, 69, 68, 67

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
12
1 / 1

BOREHOLE LOG

Client: CONRAD GARGETT ANCHER MORTLOCK WOOLLEY
Project: PROPOSED SCHOOL
Location: 3A & 3B SMALLS ROAD, RYDE, NSW

Job No.: 30275L **Method:** SPIRAL AUGER **R.L. Surface:** ~77.0 m
Date: 27/3/17 **Datum:** AHD
Plant Type: JK300 **Logged/Checked By:** A.C.K./D.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					CONCRETE: 180mm.t				NO OBSERVED REINFORCEMENT
				-	FILL: Silty clay, low to medium plasticity, dark grey brown, trace of fine grained ironstone gravel.	MC>PL			
					CONCRETE: 100mm.t				
	N > 10 7,10/ 100mm REFUSAL	76	1	CH	SILTY CLAY: high plasticity, light grey mottled orange brown and red brown.	MC>PL	(VSt - H)		
	N=SPT 5/ 50mm REFUSAL	75	2	-	SHALE: light grey, with iron indurated bands.	XW	EL		BANDED VERY LOW 'TC' BIT RESISTANCE
									BANDED LOW RESISTANCE
		74	3		as above, but grey brown.				
		73	4			DW	VL - L		LOW RESISTANCE
		72	5		SHALE: dark grey brown, with brown bands.				
		71	6		END OF BOREHOLE AT 6.00 m				

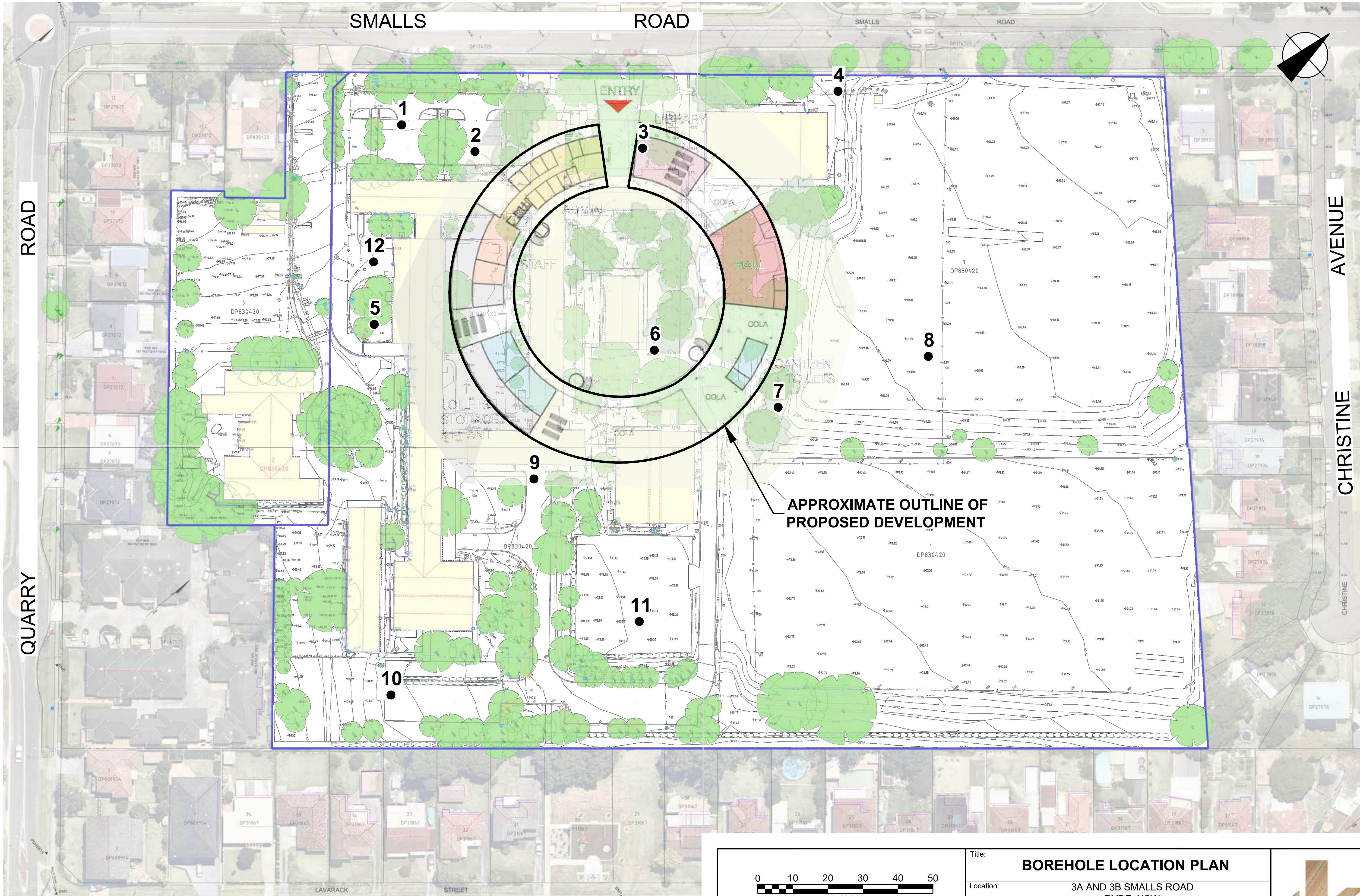
SAMPLES: ES, U50, DB, DS

AERIAL IMAGE SOURCE: GOOGLE EARTH PRO 7.1.5.1557
AERIAL IMAGE ©: 2015 GOOGLE INC.

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

Title:	**SITE LOCATION PLAN**
Location:	3A AND 3B SMALLS ROAD RYDE, NSW
Report No: 30275L	Figure No: 1
	JK **Geotechnics**

PLOT DATE: 28/03/2017 5:12:40 PM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30275L RYDE\CAD\30275L.DWG



0 10 20 30 40 50

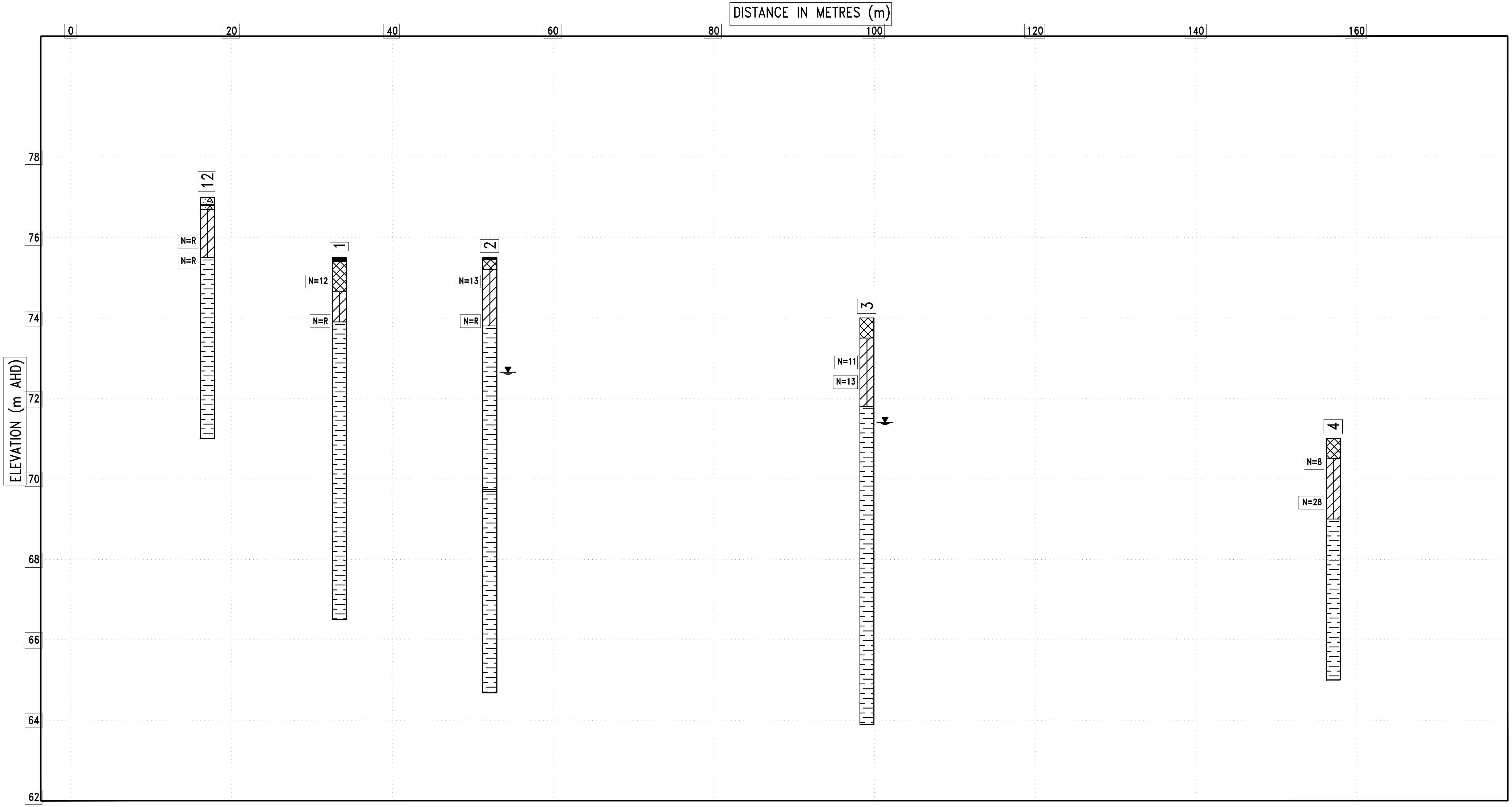
SCALE 1:1000 @A3 METRES

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

Title:	**BOREHOLE LOCATION PLAN**
Location:	3A AND 3B SMALLS ROAD RYDE, NSW
Report No:	30275L
Figure No:	2

JK **Geotechnics**

PLOT DATE: 24/04/2017 11:57:46 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30275L RYDE\CAD\30275L.DWG



ASPHALTIC CONCRETE

CONCRETE

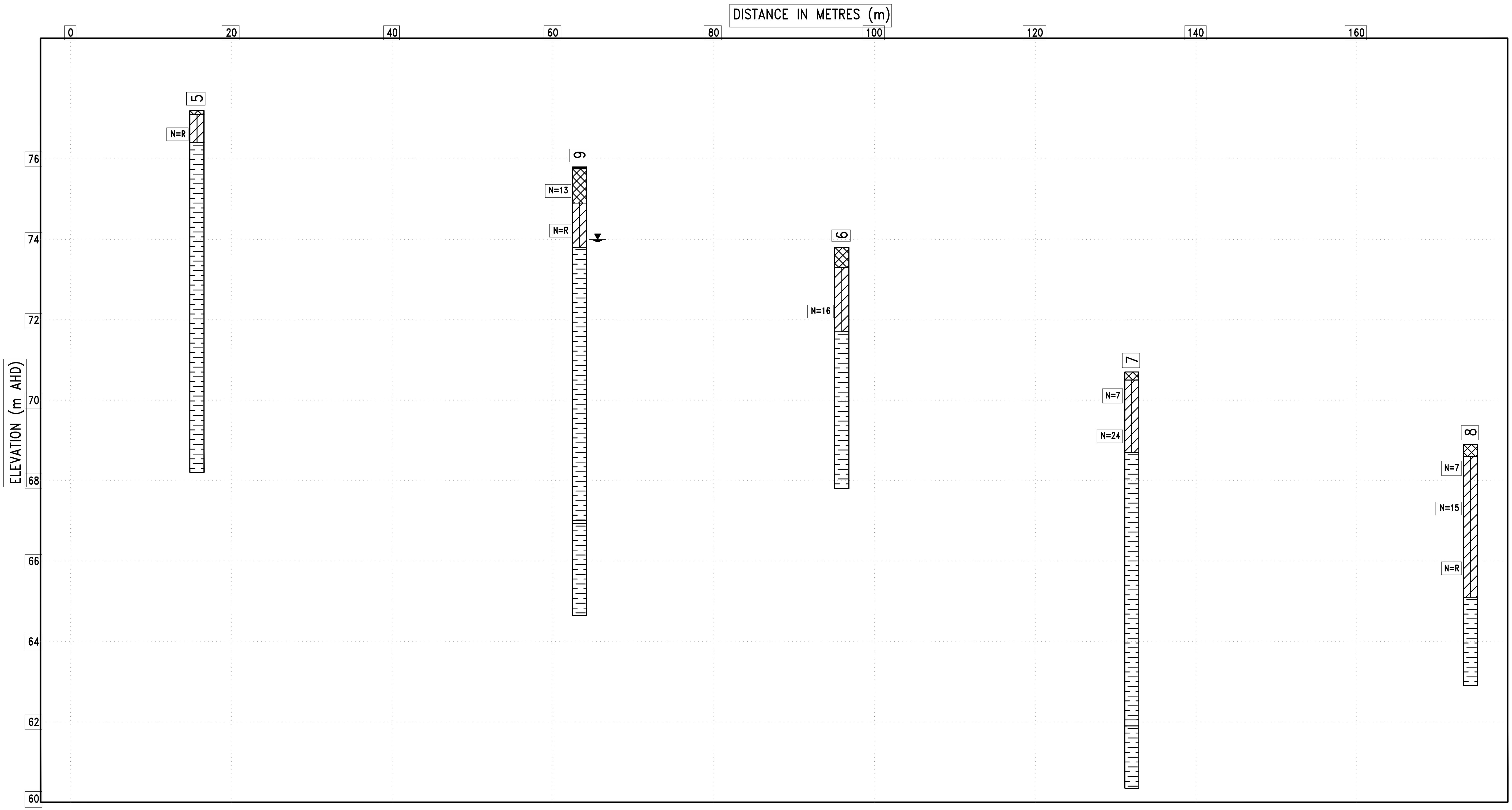
CORE LOSS

FILL

SILTY CLAY

SHALE

Scales: A3 H 1:500 V 1:100 This plan should be read in conjunction with the JK Geotechnics report.	Title: **GRAPHICAL BOREHOLE SUMMARY** Location: 3A AND 3B SMALLS ROAD RYDE, NSW Report No: 30275L Figure No: 3 JK **Geotechnics**



ASPHALTIC CONCRETE

FILL

CORE LOSS

SHALE

SILTY CLAY

Scales: A3

H 1:500
V 1:100

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

Title:
GRAPHICAL BOREHOLE SUMMARY

Location: 3A AND 3B SMALLS ROAD RYDE, NSW

Report No: 30275L

Figure No: 4

JK **Geotechnics**

PLOT DATE: 27/04/2017 1:33:19 PM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30275L RYDE\CAD\30275L.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, the SAA Site Investigation Code. 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 Unified Soil Classification Table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

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	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

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

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	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 thinly bedded to laminated siltstone.

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 shear 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 except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils 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 an 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. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, 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 relatively lower 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 fragments. 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 determined 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 such as Revert or Biogel. 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, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, 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 CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end 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, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

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 63kg 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.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test 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.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using a Cone Penetrometer Test (CPT). The test is described in Australian Standard 1289, Test F5.1.

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.

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.
- 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.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface 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 attached explanatory notes define the terms and symbols used in preparation of the logs.

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 water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising 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 determine 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 Soil for Engineering Purposes'*. 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.

Every 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.

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 that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document *'Guidelines for the Provision of Geotechnical Information in Tender Documents'*, published by the Institution of Engineers, Australia. 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. License to use the documents may be revoked without notice if the Client is in breach of any objection 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 a senior geotechnical engineer.

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 such as appropriate footing or pier founding depths, or

iii) full time engineering presence on site.

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

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

ROCK

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

DEFECTS AND INCLUSIONS

- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

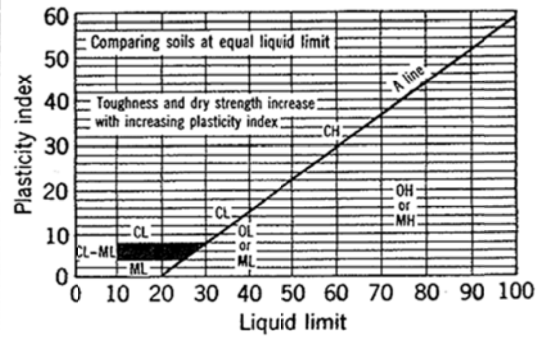
- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

Use grain size curve in identifying the fractions as given under field identification

Major Division	Fraction	Type	Field Identification Procedures (Excluding particles larger than 75 µm and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils. More than half of material is *larger* than 75 µm sieve size[b] (The 75 µm sieve size is about the smallest particle visible to naked eye)	Gravels. More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses. For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics. Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than 75 µm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols. $C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or *PI* less than 4. Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with *PI* greater than 7
	Sands. More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5. Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Identification Procedures on Fraction Smaller than 380 µm Sieve Size

Major Division	Subdivision	Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils. More than half of material is *smaller* than 75 µm sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses. For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions. Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

Note: 1 Soils possessing characteristics of two groups are designated by combinations of group symbols (eg. GW-GC, well graded gravel-sand mixture with clay fines).
2 Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record	▼	Standing water level. Time delay following completion of drilling may be shown.
	—C—	Extent of borehole collapse shortly after drilling.
	►—	Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil 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 screening.
	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. 'R' as noted below.
	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 degree 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 (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless 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 less than 25kPa
	S	SOFT – Unconfined compressive strength 25-50kPa
	F	FIRM – Unconfined compressive strength 50-100kPa
	St	STIFF – Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF – Unconfined compressive strength 200-400kPa
	H	HARD – Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
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 15-35 — 4-10
	MD	Medium Dense 35-65 — 10-30
	D	Dense 65-85 — 30-50
	VD	Very Dense >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

LOG SYMBOLS continued

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
----------------------	--------------	0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is "sugary" and friable.
----------------------	--------------	0.1	
Low:	L		A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
----------------------	--------------	0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
----------------------	--------------	1	
High:	H		A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
----------------------	---------------	3	
Very High:	VH		A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
----------------------	---------------	10	
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	