



REPORT

TO
PERUMAL PEDAVOLI PTY LTD

ON
GEOTECHNICAL INVESTIGATION

FOR
PROPOSED ALTERATIONS & ADDITIONS
TO EXISTING SCHOOL

AT
PENSHURST PUBLIC SCHOOL
CORNER FOREST ROAD AND ARCADIA STREET
PENSHURST NSW

9 February 2017
Ref: 30104Srpt



JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

PO Box 976, North Ryde BC NSW 1670
Tel: 02 9888 5000 Fax: 02 9888 5001
www.jkgeotechnics.com.au

Jeffery & Katauskas Pty Ltd, trading as
JK Geotechnics ABN 17 003 550 801



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Report prepared by:

Paul Stubbs
Principal I Geotechnical Engineer

For and on behalf of
JK GEOTECHNICS
PO Box 976
NORTH RYDE BC NSW 1670

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**STS TABLE A: POINT LOAD STRENGTH INDEX TEST REPORT
ENVIROLAB SERVICES REPORT NO: 160896**

**BOREHOLE LOGS 1 TO 5 INCLUSIVE
CORE PHOTOGRAPHS**

**FIGURE 1: SITE LOCATION PLAN
FIGURE 2: BOREHOLE LOCATION PLAN
FIGURE 3: GRAPHICAL BOREHOLE SUMMARY
REPORT EXPLANATION NOTES**



1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed alterations and additions to the existing school at the corner of Forest Road and Acadia Street, Penshurst, NSW. The investigation was commissioned by Katherine Longhurst of Perumal Pedavoli Pty Ltd by return Acceptance of Proposal, dated 8 January 2016. The commission was on the basis of our proposal, Ref: P43974S, dated 5 December 2016.

JK Geotechnics have previously completed a geotechnical investigation at within the northern portion of the site (Ref: 11772SV/a dated 9 May 1996). The borehole logs of the previous report are included within the appendix of this report.

From the Geotechnical Brief prepared by Woolacotts Consulting Engineers provided in December 2016, we understand that the proposed development may consist of up to seven storey high buildings including an asphaltic concrete carpark. The proposed footing loads will be approximately 4500kN. Since that time we have been advised that all existing buildings may be demolished and replaced with buildings of one, two and three storeys involving some excavation (email from Katherine Longhurst dated 6/2/17).

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

We were also commissioned to carry out an Environmental Site Assessment. This work was carried out by Environmental Investigation Services (EIS) in conjunction with the geotechnical investigations. Reference should be made to the EIS report, (Ref: E30104K) for further details.

2 2017 INVESTIGATION PROCEDURE

Prior to commencement of the fieldwork a 'Safe Work Method Statement' was prepared, a 'Dial Before You Dig' (DBYD) search was undertaken and the borehole locations were electromagnetically scanned by a specialist sub-contractor for buried services.

The fieldwork was carried out between 23 and 24 January 2017 and comprised the following scope of works.



- Five boreholes (BH1 to BH5) were drilled within the site. These boreholes were drilled using spiral auger techniques and a Tungsten Carbide 'TC' bit to total depths ranging from 4.5m to 10.5m below existing grade.
- Two boreholes (BH2 and BH4) were then extended to total depths ranging from 11.94m to 12.76m by diamond coring techniques using an NMLC core barrel with water flush.

The strength of the subsurface soils were assessed from Standard Penetration Test (SPT) 'N' values, augmented by hand penetrometer test results on cohesive samples returned by the SPT split tube sampler. Within the augered portions of the boreholes, the strength of the underlying shale was assessed by observation of the drilling resistance of the Tungsten Carbide (TC) bit attached to the augers, together with examination of the recovered rock chips.

Where the bedrock was core drilled, the recovered core was returned to our NATA registered laboratory (Soil Test Services) for photographing and Point Load Strength Index (I_{s50}) testing. Using established correlations the Unconfined Compressive Strength (UCS) of the bedrock was then inferred from the I_{s50} results. The Point Load Strength index test results are summarised in the attached STS Table A and are plotted on the cored borehole logs. Colour photographs of the rock core are provided with the borehole logs.

Groundwater observations were made both during drilling and after completion of the boreholes. No long term monitoring of the groundwater levels has been carried out.

The fieldwork was completed in the full time presence of our geotechnical engineer who set out the boreholes, nominated sampling and testing locations and prepared logs of the strata encountered. The borehole logs, which include field test results and groundwater observations, are attached to the report together with colour photographs of the rock core and our Report Explanation 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 to determine point load strength index, pH, sulphate content, chloride content and resistivity. The results of the testing are summarised in the STS Tables A and Envirolab report No. 160896 and 161247. Samples were also collected from the boreholes for testing as part of the environmental site assessment by EIS.



1996 INVESTIGATION PROCEDURE

The drilling for the 1996 investigation involved augered boreholes drilled with a track mounted rig, very similar techniques to the 2017 investigation. A total of seven boreholes ranging from 5m to 7m in depth were completed at the approximate locations shown on Figure 2. Reduced levels were not taken at the time of the fieldwork and we cannot interpret their reliably now as there may well have been earthworks completed in the meantime.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site lies within slightly undulating topography on a south-east facing slope of approximately 3° to 4°. The site is bound to the south by Forest Road and to the north-east by Arcadia Street. Vehicle access onto the school grounds is from Arcadia Street.

The site was occupied by two large buildings (one and two storey) along the Arcadia Street frontage and another relatively large rectangular building that extended along the western boundary in the north-western section of the site. A number of smaller buildings, including one demountable building, were located in the south-western section of the site. A demountable building was also located in the vicinity of the northern boundary.

The larger buildings appeared to be constructed of brick and concrete. Fibre cement materials may be present in parts of the larger buildings and were also observed on the façade of one of the smaller buildings.

There were no roads within the site, however the central and north-western site areas (outside the building footprints) were predominantly paved with concrete or asphaltic concrete. The northern paved area was utilised as a car park. Pavements were generally observed to be in good condition, with only minor cracks observed in some areas.

The site was fenced along the boundaries. A brick retaining wall extended along the Arcadia Street frontage and appeared to retain the site between approximately 0.2-0.8m above the adjacent footpath/grassed verge.

Considering the site and regional topography, it was considered likely that the adjacent property to the west was retained above the site levels along the western boundary.

There were no obvious signs of soil instability or erosion observed during the inspection.



To the west of the site was the two storey brick buildings associated with the adjacent Catholic Church and school grounds. To the north of the site was a series of one storey brick residential properties all appearing in good condition.

3.2 Subsurface Conditions

The 1:100,000 Geological Map of Sydney indicates the site to be underlain by Ashfield Shale of the Wianamatta Group. This subsurface profile does not take into account the soils derived from insitu weathering of the shale or earthworks (e.g. filling) that have previously been undertaken at the site.

Generally, the boreholes encountered a shallow to moderate depth cover of fill over natural silty clays which graded into shale bedrock at variable depths ranging from 1.0m to 4.5m below existing ground surface levels. A summary of the encountered subsurface profile is provided in the following. Reference should be made to the attached borehole logs for detailed descriptions of the subsurface conditions and the graphical borehole summary.

Fill

Fill was encountered from the surface or beneath the surficial asphaltic concrete layer to depths of between 0.4m and 1.6m below existing surface levels. The fill mostly comprised silty clay with minor inclusions of ironstone and shale gravel, brick fragments, fibre cement fragments and asphaltic concrete fragments. The fill was generally assessed to be moderately well compacted. This assessment is based on in-situ SPT tests, and our observations during drilling, which do not give a precise determination of in-situ densities since they are affected by friction during driving/pushing, the presence of gravel within the fill and the moisture content of the fill. Nonetheless, they provide a qualitative guide.

Natural Clays

The natural clay profile, of residual origin from the decomposition of the underlying shale bedrock, was encountered below the fill in the boreholes.

The natural profile comprised silty clays, with ironstone gravel and shale inclusions and were generally assessed to be highly plastic and generally of very stiff to hard strength.

The residual clays in some boreholes were interbedded with extremely weathered shale as a gradation zone into the continuous shale bedrock profile (which is described below).



Shale Bedrock

Shale bedrock was encountered at depths between 0.6m below ground surface in the northern portion of the site to 4.5m below ground surface at the southern end of the site. As the transition from residual clay to shale bedrock is gradational, the apparent variation of “rock” levels in the boreholes should be interpreted appropriately.

The upper section of the bedrock profile was generally extremely to distinctly weathered being extremely low (EL) to low (L) strength and this zone extended typically to around 8m depth. From about 7m to 9m there was a transition to medium strength and then high strength from around 9m to 11m depth.

Groundwater

Groundwater was encountered in BH3 and BH5 and was measured 2 hours of the completion of drilling to be at 7.15m and 7.4m below ground surface. We note that water is introduced into the borehole during coring and therefore, the water levels measured at completion of coring in BH2 and BH4 would be artificially high and should not be considered indicators of groundwater. No long term groundwater monitoring was carried out.

In the 1996 investigation there were indications of groundwater at much shallower depths of 3.3m to 4.4m and the report noted that cave-in of the boreholes was observed at similar depths in most boreholes.

3.3 Laboratory Test Results

The point load strength index test results also correlated well with the field logging strength assessments, showing the shale to have an Unconfined Compressive Strength of between 10MPa and 62MPa, but were mostly about 10MPa to 40MPa correlating with medium to high strength shale. Reference should be made to the attached Table A for specific test results.



4 COMMENTS AND RECOMMENDATIONS

4.1 Geotechnical Issues

We consider the following to be the primary geotechnical issues for the proposed development:

- The presence of uncontrolled fill up to 1.6m deep particularly in the southern part of the site.
- The proposed development might require removal of a number of trees or retention of trees from below or near the proposed buildings, and this could result in an increase in swell movements in the vicinity of the trees. The zone of influence generally ranges from 1x to 2x the height of the tree and to a depth up to about 1.5m.
- Natural clays with a moderate to high potential for shrink-swell movements with changes in moisture content.
- Potential abnormal moisture conditions as a result of existing developments and trees.
- The deeply weathered nature of the shale bedrock.
- Low CBR values for the natural clay subgrade.

The effects of the above geotechnical issues on design and construction are detailed below.

4.2 Earthworks

4.2.1 Excavation

Following the demolition of the existing structures on the site, excavation may encounter the surficial fill, residual clays and shale bedrock.

Excavation of the fill and residual soils, as well as the extremely weathered shale will be readily achievable using the buckets of conventional hydraulic excavators. If very low and low strength rock and even the more bedded and fractured medium strength rock is to be excavated, it will be able to be ripped using a Dozer (say D7 size) with ripping tyne or by using a ripping tyne fitted to a large hydraulic excavator. We do not anticipate excavations extending down as far as the competent shale bedrock.

We recommend that only excavation contractors with appropriate insurances and experience on similar projects be used. Excavation contractors should be provided with a copy of this geotechnical report, including the borehole logs and point load strength test results, so that they can make their own assessment of suitable excavation equipment.



Groundwater was measured in the boreholes at relatively deep levels in the 2017 investigation but higher levels (3m to 4.4m depth) were noted in the 1996 investigation. Therefore the groundwater table is unlikely to be encountered in the excavations unless they are of substantial depth. However, groundwater seepage will occur through defects within the rock and at the soil/rock interface and will likely be more significant during and immediately following wet weather. During construction we expect that if groundwater seepage occurs, it will be able to be controlled by conventional sump and pump techniques if gravity drainage is not possible.

4.2.2 Excavation Batters

Where space permits, temporary batter slopes will likely be feasible for most of the perimeter of the proposed excavations. Temporary batters through the residual clays and all bedrock up to and including low strength should be battered at not steeper than 1 Vertical (V) in 1 Horizontal (H). We expect that such batters would not be higher than 3m unless a berm is incorporated in the profile at mid-height. At the toe of such batters some seepage may occur and it may be necessary to flatten batters or to provide some other local toe support, where there is a risk of instability.

Surcharge loads, including construction loads, must be kept well clear of the crest of temporary batters (at least 2H from the crest, where H is the vertical height of the batter slope in metres). Temporary batter slopes are contingent on the batter slopes being inspected by a geotechnical engineer at not greater than 1.5m depth intervals.

Where temporary batters are formed, consideration needs to be given to the type of backfill to be used against the permanent basement and lower ground floor walls. Uncompacted backfill placed up against walls will result in large settlements which can have adverse effects on structures, paving or landscaping supported above. Compaction of the clay soils and weathered shale will be very difficult in confined spaces with light equipment and therefore the backfill placed against the permanent retaining walls should preferably comprise a uniform durable granular material which is surrounded in a geotextile fabric. There are cost implications of excavating and disposing of the additional soil from the batters, and importing large amounts of drainage material to backfill the permanent basement walls. It may be preferable to install a shoring system around the entire perimeter of the basement excavation to avoid the excavation of the material in the batters and replacement with higher quality material. Further details are provided in the sub-section entitled Engineered Fill below.



4.2.3 Excavation Retention

Where temporary batters cannot be accommodated within the site boundaries or temporary batter slopes are not preferred then we recommend that a properly designed shoring system installed prior to bulk excavation be constructed. Given the subsurface conditions encountered, we consider that soldier pile walls with shotcrete infill panels are suitable for this site.

Bored piles would be suitable for the shoring system and would preferably be socketed at least 1.0m below the bulk excavation level, including allowances for nearby lift pits, footing and service excavations. Greater embedment may be required for lateral stability of the shoring system.

The following characteristic parameters may be adopted for shoring wall design. The parameters outlined below are on the assumption that a soldier pile wall is constructed and that inspection of the rock face between soldier piles is completed by a geotechnical engineer at not greater than 1.5m depth intervals to check for significant adverse defects.

- Where minor movements of the shoring wall are tolerable, we recommend a rectangular lateral earth pressure distribution of $5H$ (where H is the height of soil and all rock up to and including low strength).
- Where adjoining structures or movement sensitive services are within a horizontal distance of $2H$ from the shoring wall we recommend that the magnitude of the rectangular lateral earth pressure be increased to $8H$ to reduce the risk of adverse deflections.
- Where rock of medium or higher strength is to be supported by the shoring wall we recommend a nominal lateral pressure of 10kPa be adopted to allow for the presence of small wedges of rock.
- All surcharge loads affecting the walls (e.g. nearby footings, construction loads and traffic etc) are additional to the earth pressure recommendations above and should be included in the design.
- The retaining walls should be designed as drained and measures taken to provide permanent and effective drainage of the ground behind the walls.

4.2.4 Other Retaining Walls

Retaining walls may be required to support low height cuts and/or fills. The following characteristic earth pressure coefficients and subsoil parameters may be adopted for the design of such retention systems.



- For free-standing cantilever walls located in areas where movement is of little concern (ie. where grassed or garden areas are being retained), adopt a triangular lateral earth pressure distribution and an “active” earth pressure coefficient (K_a) of 0.35 for the soil profile, assuming a horizontal backfill surface.
- For free-standing cantilever walls located in areas where movement is of concern (ie. where the walls are supporting proposed on-grade floor slabs and external pavements), adopt a triangular lateral earth pressure distribution and an “at rest” earth pressure coefficient (K_0) of 0.55 for the soil profile, assuming a horizontal backfill surface.
- For retaining walls incorporated into and supported by the proposed new buildings, adopt the above K_0 value, assuming a horizontal backfill surface.
- A bulk unit weight of 20kN/m^3 should be adopted for the soil profile.
- Any surcharge affecting the walls (eg. construction traffic, pavement and ground floor slab loads, compaction stresses during backfilling, etc.) should be allowed in the design using the appropriate above earth pressure coefficients.
- The retaining walls should be designed as permanently drained. Subsurface drains should incorporate a non-woven geotextile filter fabric such as Bidim A34 to control subsoil erosion.
- The passive lateral toe resistance for retaining walls founded in natural clay of at least stiff strength may be estimated using a “passive” earth pressure coefficient (K_p) of 3.0 (but with a Factor of Safety of at least 2.0 to limit deformations), assuming horizontal ground in front of the wall. The upper 0.3m below bulk excavation level should be ignored in the design to cater for excavation tolerances.
- Following retaining wall construction and backfilling, we recommend that a dish drain be provided immediately uphill of the walls to intercept surface water run-off. The discharge from such drains should be piped to the stormwater system.

4.2.5 Removal of Existing Trees

We note that the existing trees have likely caused localised “drying out” of the surrounding clayey soils. Removal of the trees will therefore lead to the recovery of the clay soil moisture content, resulting in differential swell movements across the site. The swell movements generated by the removal of the trees are in addition to the shrink/swell movements, which can occur in the clayey soils due to weather related natural moisture changes and by the reduction in surface evaporation subsequent to covering the site with buildings and pavements. The latter shrink/swell movements are outlined in AS2870-2011 (“Residential Slabs and Footings – Construction”).



It is likely that moisture equilibrium in the clayey soils, following removal of the tree stumps and roots, could take one to two years to develop, possibly longer if the current “drought” persists. In order to reduce the effects that removal of the trees will have on the proposed building and pavement areas, we recommend they be removed as early as possible ahead of construction.

4.2.6 Site Drainage

The clay subgrade at the site will undergo substantial loss in strength when wet and will have low soaked CBR values. Furthermore, the natural clay of medium and high plasticity is expected to have a moderate to high shrink-swell potential. Therefore, it is important to provide good and effective site drainage both during construction and for long term site maintenance. The principle aim of the drainage is to promote run-off and reduce ponding. A poorly drained clay subgrade may become untraffickable when wet. The earthworks should be carefully planned and scheduled to maintain good cross-falls during construction.

4.2.7 Subgrade Preparation

The proposed development will require demolition of existing pavements, removal of existing trees (including their root balls), stripping of grass, topsoil and root-affected soil, and any poorly compacted, deleterious or contaminated existing fill. Stripped topsoil and root affected soils should be stockpiled separately as they are not suitable for reuse as engineered fill. They may be reused at a later stage for landscaping purposes. The site can then be excavated down to design subgrade level using hydraulic excavators and dozers.

Following stripping and excavation, we recommend that the subgrade be inspected by a geotechnical engineer and any poor quality fill removed. If heavy floor loads or high quality industrial floors are anticipated then all existing fill should be removed. Some fill may be suitable for replacement as engineered fill, if it is appropriately moisture conditioned. The surface should then be proof rolled with at least eight passes of a static smooth drum roller (at least 10 tonnes deadweight). The vibratory mode on the roller should not be used in close proximity to any neighbouring structures to limit ground borne vibrations. The final two passes of proof rolling should be carried out under the direction of an experienced geotechnical engineer for the detection of unstable or soft areas.



Subgrade heaving should be expected in areas where the clayey subgrade may have become “saturated” or there are areas of poorly compacted fill. Heaving areas should be locally removed to a stable base and replaced with engineered fill, or further advice could be sought. If soil softening occurs after prolonged periods of rainfall, then the subgrade should be over-excavated to below the depth of moisture softening and replaced with engineered fill. Engineered fill should also be used where site levels need to be raised. If the clayey subgrade exhibits shrinkage cracking, then the surface should be watered and rolled until the shrinkage cracks are no longer evident.

4.2.8 Engineered Fill

The excavated clayey fill and natural clay will require strict quality control if they are to be reused as engineered fill, due to their reactive potential and moisture sensitivity. The excavated clayey soils must be free of organic matter and free of particle sizes greater than 75mm prior to reuse as engineered fill. The clayey soils may require moisture conditioning (ie. “wetting up”) prior to reuse in order to satisfy the compaction specifications set out below, but this a seasonal issue and the reverse may also occur.

Engineered fill comprising the excavated clayey soils should be compacted in maximum 200mm loose layers using a minimum 10 tonne static roller to a density strictly between 98% and 102% of SMDD and at a moisture content within 2% of SOMC.

Materials preferred for use as good quality select fill below pavements and slabs-on-grade are well graded granular materials, such as ripped or crushed sandstone, free of organic matter and free of particle sizes greater than 75mm. The select engineered fill should be compacted in maximum 200mm loose layers using a minimum 10 tonne static roller to a minimum density of 98% of SMDD.

4.3 Footings

The proposed buildings can be either uniformly supported on high level footings penetrating the existing fill and founded in the natural clays or uniformly supported on piled footings founded in the underlying shale bedrock. If high level footings are to be considered for smaller buildings (such as single storey structures akin to residential dwelling houses), then we recommend that additional geotechnical advice be sought when more detail on the structures is known.



4.3.1 High Level Footings

High level pad and strip footings must penetrate existing proof rolled fill and may be founded in natural clay of at least very stiff strength in which case they can be tentatively designed for a maximum allowable bearing pressure of 150kPa. In areas where there is existing uncontrolled fill more than 500mm in depth we do not recommend high level footings unless the sill is replaced as engineered fill.

Testing of shrink-swell properties was outside the scope of this investigation, though based on our experience, the subgrade clays are likely to be moderately to highly reactive (Class H1) with changes in moisture content. If the proposed buildings are sensitive to movement, then unprotected external footings (UPEF) should have a minimum embedment of 1.0m below existing grade. Protected external footings (PEF), where there is at least 1.5m of impermeable paving extending beyond the building should have a minimum embedment of 0.6m below existing grade. Internal footings should have a minimum embedment of 0.4m below existing grade.

All high level footing excavations should be cleaned out of loose debris, inspected by a geotechnical engineer and poured without delay. If delays in pouring are envisaged, then we recommend that a concrete blinding layer be poured to reduce deterioration due to weathering.

4.3.2 Piled Footings

The proposed buildings can be supported on piled footings founded in shale bedrock. Based on the results of the investigation, either conventional bored piles are expected to be appropriate though seepage may affect construction in some cases, particularly if piers extend 7m or more below the surface. Steel screw (helix) piles could be considered for lighter loads bearing upon shale at the first contact where allowable bearing pressures would be limited to 700kPa as we would expect them to encounter difficulties penetrating the weathered bedrock. Similarly bored piles with a nominal socket of 0.3m into extremely weathered shale may be designed for 700 kPa allowable bearing pressure

Conventional bored piles socketed at least 0.3m into very low to low strength or stronger shale bedrock may be designed for a maximum allowable end bearing pressure of 1000kPa. Sockets formed below the minimum 0.3m length requirement may be designed for maximum allowable shaft adhesion values of 100kPa (compression) and 50kPa (tension) on condition that the pile shaft is suitably roughened using a grooving tool fitted to the side of the auger. The provided bearing pressures are based upon a serviceability criteria of deflections at the pile toe of less than 1% of the pile diameter.



Bored pile holes should be cleaned out, inspected and tremie poured on the same day as drilling. The initial stages of bored piling should be inspected by a geotechnical engineer to confirm that a satisfactory bearing stratum has been achieved. Based on the possible groundwater seepage, bored pile holes should be tremie poured immediately after final clean out and inspection. This may warrant having concrete trucks waiting on site. Rock augers and cleaning buckets should be provided for all pile diameters.

If the proposed buildings are supported on piled footings, the on-grade floor slab may be susceptible to edge effects where paved surrounds do not extend to the edge of the building. The edge effects would result in differential movements occurring in the clayey subgrade. Where external pavements are not proposed, the differential movements could be controlled by the construction of a concrete apron slab adjacent to the external walls of the building. The apron slab should be at least 1.5m wide and should be graded away from the building. Alternatively, consideration could be given to the construction of deep edge beams over the pile heads to control the edge effects. The deep edge beams would provide a moisture cut-off and would need to be constructed to at least 1m below final grade.

Higher allowable bearing pressures would be feasible on the medium to high strength shale at greater depths. At BH2 and BH4 which were core drilled the better quality rock was present at about 10m depth and in BH3 which was only auger drilled there was indication that similar rock was present at about 9m depth. Allowable bearing pressures of 3500kPa could be adopted for this material subject to some additional boreholes being completed to confirm the depth and quality of the rock. Higher pressures of say 6000kPa are likely to be feasible but would require substantially more investigation to confirm the rock quality.

4.4 Ground Floor Slabs

Slab-on-grade construction for the proposed buildings are considered feasible provided the subgrade is prepared as discussed in Section 4.2. The slabs-on-grade should be constructed independent of the building footings and walls (ie. designed as “floating” slabs) to permit relative movement.



Based on the laboratory test results and our experience with similar clayey soils, we recommend that the design of pavements and concrete slabs be based on a CBR of 2% or an estimated equivalent Modulus of Subgrade Reaction (k) of 20kPa/mm (750mm diameter plate) for the compacted clay subgrade.

Building slabs-on-grade and light duty concrete pavements should be supported on at least a 100mm thick sub-base of good quality fine crushed rock such as RTA Specification 3051 unbound base (eg. DGB20) or similar quality, and compacted to a minimum density of 100% of SMDD. The sub-base material will provide a more uniform slab support and would reduce “pumping” of subgrade “fines” at joints. Slab joints should be designed to resist shear forces but not bending moments by providing dowelled or keyed joints.

Subsoil drains should be provided along the upslope perimeter of all proposed new external pavement areas, with invert levels of at least 200mm below subgrade level. The drainage trench should be excavated with a uniform longitudinal fall to appropriate discharge points so as to reduce the risk of water ponding. The subgrade should be graded to promote water flow towards the subsoil drains. Discharge from the subsoil drains should be piped to the stormwater system.

4.5 Basement Slabs

If basement excavations are proposed then we recommend that the slabs be underlain by a drainage blanket comprising 100mm of free draining gravel such as 20mm blue metal. Alternatively a sub-base layer of 100mm of DGB20 may be used and a grid of subsoil drains installed at centres not exceeding about 7m.

5 SALINITY

The site is located in an area where soil and groundwater salinity may occur. Salinity can affect the longevity and appearance of structures as well as causing adverse horticultural and hydrogeological effects. The local council may have guidelines relating to salinity issues which should be checked for relevance to this project.

6 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 may be 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.

TABLE A
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Alterations to Existing School
Location: Penshurst Public School,
Corner Forest Way and Arcadia Street,
Penshurst, NSW

Ref No: 30104S
Report: A
Report Date: 30/01/2017
Page 1 of 1

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH
		MPa	(MPa)
2	9.95-9.98	0.9	18
	10.12-10.14	0.5	10
	10.83-10.85	3.1	62
	11.11-11.13	2.3	46
	11.83-11.86	2.0	40
	12.23-12.25	2.1	42
4	8.92-8.94	0.9	18
	9.14-9.17	0.6	12
	10.00-10.03	1.4	28
	10.83-10.87	1.6	32
	11.32-11.34	1.9	38
	11.89-11.92	1.8	36

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 $I_{S(50)}$



CERTIFICATE OF ANALYSIS

160896

Client:

JK Geotechnics
PO Box 976
North Ryde BC
NSW 1670

Attention: K Singh

Sample log in details:

Your Reference:	<u>30104S, Penshurst Public School</u>
No. of samples:	2 soils
Date samples received / completed instructions received	27/01/17 / 27/01/17

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: 3/02/17 / 2/02/17
Date of Preliminary Report: Not Issued

NATA accreditation number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025 - Testing **Tests not covered by NATA are denoted with *.**

Results Approved By:

David Springer
General Manager

Misc Inorg - Soil			
Our Reference:	UNITS	160896-1	160896-2
Your Reference	-----	BH2	BH3
	-		
Depth	-----	0.5-0.95	0.5-0.95
Date Sampled		24/01/2017	24/01/2017
Type of sample		Soil	Soil
Date prepared	-	30/01/2017	30/01/2017
Date analysed	-	30/01/2017	30/01/2017
pH 1:5 soil:water	pH Units	4.8	4.8
Chloride, Cl 1:5 soil:water	mg/kg	44	100
Sulphate, SO4 1:5 soil:water	mg/kg	48	160
Resistivity in soil*	ohmm	110	51

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 Analyser.
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.

Client Reference: 30104S, Penshurst Public School

QUALITYCONTROL	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results	Spike Sm#	Spike % Recovery
Misc Inorg - Soil						Base II Duplicate II %RPD		
Date prepared	-			30/01/2017	[NT]	[NT]	LCS-1	30/01/2017
Date analysed	-			30/01/2017	[NT]	[NT]	LCS-1	30/01/2017
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	LCS-1	102%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-1	103%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	LCS-1	120%
Resistivity in soil*	ohmm	1	Inorg-002	<1.0	[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.



Borehole No.
1
 1 / 1

BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Method:** SPIRAL AUGER **R.L. Surface:** ~51.2 m
Date: 24/1/16 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** K.S./P.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
DRY ON COMPLETION					N = 22 8,8,14	51			-	ASPHALTIC CONCRETE: 50mm.t	D			ROADBASE
							1		CH	FILL: Gravelly sand, fine to coarse grained, dark brown, fine to coarse grained igneous gravel, and trace of brick, tile and asphaltic concrete fragments. FILL: Clayey sand, fine to coarse grained, brown mottled light grey.	MC<PL	H	460 520 480	
					N=SPT 10/ 50mm REFUSAL	50				SILTY CLAY: high plasticity, light grey, with fine to coarse grained ironstone gravel. SHALE: grey.	XW	EL		
						2					DW	VL		VERY LOW 'TC' BIT RESISTANCE
					49									
						48								
						47						L		LOW RESISTANCE
										END OF BOREHOLE AT 4.50 m				
						46								
						45								

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Borehole No.
2
 1 / 3

BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Method:** SPIRAL AUGER **R.L. Surface:** ~52.9 m
Date: 24/1/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** K.S./P.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks	
	ES	U50	DB	DS											
DRY ON COMPLETION OF AUGERING 										ASPHALTIC CONCRETE: 50mm.t	MC<PL				
					N = 21 5,6,15	52	1	CL-CH		FILL: Silty clay, medium plasticity, dark brown, with fine to medium grained igneous gravel, and trace of asphaltic concrete fragments. SILTY CLAY: medium to high plasticity, grey mottled orange brown.	MC<PL	VSt	240 330 360		
					N > 44 10,19,25/ 100mm REFUSAL	51	2			SHALE: grey, with iron indurated bands and clay seams.	XW	EL		VERY LOW 'TC' BIT RESISTANCE BANDED	
						50	3								
						49	4					DW	VL - L		LOW RESISTANCE BANDED
						48	5						L - M		
					47	6									
					46										

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Borehole No.
2
 2 / 3

BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW														
Job No.: 30104S Date: 24/1/17 Plant Type: JK305			Method: SPIRAL AUGER Logged/Checked By: K.S./P.S.				R.L. Surface: ~52.9 m Datum: AHD							
Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
						45	8			SHALE: grey.	DW	L - M		LOW RESISTANCE BANDED
						44	9					M		MODERATE RESISTANCE
						43	10			REFER TO CORED BOREHOLE LOG				
						42	11							
						41	12							
						40	13							
						39								

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Borehole No.
2
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CORED BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Core Size:** NMLC **R.L. Surface:** ~52.9 m
Date: 24/1/17 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK305 **Bearing:** N/A **Logged/Checked By:** K.S./P.S.

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 $I_p(50)$	DEFECT DETAILS		
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.	
								EL-0.03 VL-0.1 L-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General	
					START CORING AT 9.87m						
		43	10		SHALE: dark grey, with light grey laminae at 0-10°.	DW	M			(9.96m) XWS, 0°, 4 mm.t (10.06m) FRAGMENTED ZONE, 0°, 30 mm.t (10.21m) J, 60°, P, S	
			42	11			H			(11.19m) Be, 0°, P, S	
			41	12						(11.68m) Be, 0°, P, S (11.69m) Be, 0°, P, S (11.78m) Be, 0°, P, S (11.95m) J, 60°, P, S	
		40	13		END OF BOREHOLE AT 12.76 m						
			39	14							
			38	15							
			37								

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Borehole No.
3
 1 / 2

BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Method:** SPIRAL AUGER **R.L. Surface:** ~49.2 m
Date: 24/1/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** K.S./P.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
DRY ON COMPLETION					N = 12 5,6,6	49	0			FILL: Silty sand, fine to medium grained, dark brown, with fine to coarse grained shale gravel. FILL: Silty clay, low to medium plasticity, brown mottled dark grey and orange brown.	MC<PL			GRASS COVER APPEARS MODERATELY TO WELL COMPACTED
					N = 15 5,7,8	48	1		CL-CH	SILTY CLAY: medium to high plasticity, light grey mottled red brown, with fine to coarse grained ironstone gravel.	MC<PL	H	410 490 440	
					N = 25 8,10,15	46	3			INTERBEDDED CLAY AND SHALE: high plasticity, light grey, with iron indurated bands.	MC<PL DW	H/ VL	590 480 520	VERY LOW 'TC' BIT RESISTANCE BANDED
						45	4			SHALE: grey and brown.	DW	VL - L		VERY LOW TO LOW RESISTANCE
						44	5							
						43	6							

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Borehole No.
3
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BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Method:** SPIRAL AUGER **R.L. Surface:** ~49.2 m
Date: 24/1/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** K.S./P.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
AFTER 2 HRS						42			SHALE: grey.	DW	VL - L		VERY LOW TO LOW RESISTANCE	
					41	L - M					LOW TO MODERATE RESISTANCE			
					40	M					MODERATE RESISTANCE			
					40	M - H					MODERATE TO HIGH RESISTANCE			
						40			END OF BOREHOLE AT 9.20 m				'TC' BIT REFUSAL	
						39								
						38								
						37								
						36								

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Borehole No.
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 1 / 3

BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Method:** SPIRAL AUGER **R.L. Surface:** ~50.2 m
Date: 23/1/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** K.S./P.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
DRY ON COMPLETION OF AUGERING					N = 14 7,7,7	50				FILL: Silty sand, fine to medium grained, dark brown, with roots.	MC<PL			GRASS COVER APPEARS MODERATELY TO WELL COMPACTED
						49			FILL: Silty clay, low to medium plasticity, dark brown mottled grey, with fine to medium grained ironstone and shale gravel.					
					N = 15 4,5,10	48				SILTY CLAY: medium to high plasticity, grey mottled red brown.	MC~PL	VSt	340 360 370	
					N = 30 7,11,19	47				SHALE: grey.	XW	EL		
						46				INTERBEDDED SHALE AND CLAY: grey mottled red brown, with iron indurated bands.	XW - DW	EL - VL		VERY LOW 'TC' BIT RESISTANCE
						45				SHALE: grey.	DW	VL - L		VERY LOW RESISTANCE WITH LOW BANDS
					44									

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Borehole No.
4
 2 / 3

BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Method:** SPIRAL AUGER **R.L. Surface:** ~50.2 m
Date: 23/1/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** K.S./P.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
						43				SHALE: grey. (continued)	DW	L - M		LOW TO MODERATE RESISTANCE
						42	8							
						41	9			REFER TO CORED BOREHOLE LOG				
						40	10							
						39	11							
						38	12							
						37	13							

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Borehole No.
4
 3 / 3

CORED BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Core Size:** NMLC **R.L. Surface:** ~50.2 m
Date: 23/1/17 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK305 **Bearing:** N/A **Logged/Checked By:** K.S./P.S.

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)	DEFECT DETAILS	
									DEFECT SPACING (mm)	DESCRIPTION Type, inclination, thickness, planarity, roughness, coating.
								EL-0.03 VL-0.1 L-0.3 M-1 H-3 VH-10 EH	500 300 100 50 30 10	Specific General
		42			START CORING AT 8.87m					
		41	9		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	DW	M			(8.96m) Be, 0°, P, S (8.97m) Be, 0°, P, S (9.07m) XWS, 0°, 5 mm.t (9.20m) XWS, 0°, 0 mm.t (9.23m) XWS, 0°, 3 mm.t (9.26m) XWS, 0°, 2 mm.t (9.28m) XWS, 0°, 6 mm.t (9.33m) XWS, 0°, 8 mm.t (9.37m) XWS, 0°, 5 mm.t (9.40m) XWS, 0°, 20 mm.t (9.47m - 9.5m) FRAGMENTED ZONE, 0° (9.59m - 9.65m) FRAGMENTED ZONE, 0°
		40	10		as above, but bedded at 10-15°.	XW	EL			(10.06m - 10.08m) FRAGMENTED ZONE, 0° (10.10m) J, 60°, 60 mm.t (10.14m) XWS, 10°, 11 mm.t (10.18m) J, 50°, P, R (10.22m) XWS, 0°, 6 mm.t (10.26m) XWS, 0°, 15 mm.t (10.36m - 10.39m) FRAGMENTED ZONE (10.52m) J, 50°, P, S (10.65m) Be, 10°, P, S
		39	11			DW	H			(11.60m - 11.75m) FRAGMENTED ZONE, 0°
		38	12		END OF BOREHOLE AT 11.94 m					
		37	13							
		36	14							

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Borehole No.
5
 1 / 2

BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Method:** SPIRAL AUGER **R.L. Surface:** ~48.3 m
Date: 23/1/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** K.S./P.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
						48				FILL: Silty sand, fine to medium grained, dark brown, with roots.	D			GRASS COVER APPEARS MODERATELY TO WELL COMPACTED
				N = 14 7,7,7		1			FILL: Silty clay, low to medium plasticity, brown mottled grey, with fine to medium grained igneous and ironstone gravel.	MC<PL				
						47			CH	SILTY CLAY: high plasticity, grey mottled red brown, with fine to coarse grained ironstone gravel.	MC<PL	H	560 540 >600	
				N = 14 7,6,8		2								
						46								
						45							>600 >600 >600	
				N = 25 8,10,15		45								
						44				SHALE: grey, with iron indurated bands and clay seams.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
						44					DW	VL		VERY LOW TO LOW RESISTANCE
						43						L		LOW RESISTANCE
						42								

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Borehole No.
5
 2 / 2

BOREHOLE LOG

Client: PERUMAL PEDAVOLI PTY LTD
Project: PROPOSED ALTERATIONS TO EXISTING SCHOOL
Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW

Job No.: 30104S **Method:** SPIRAL AUGER **R.L. Surface:** ~48.3 m
Date: 23/1/17 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** K.S./P.S.

Groundwater Record	SAMPLES				Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
	ES	U50	DB	DS										
AFTER 2 HRS						41			SHALE: grey.	DW	L		LOW RESISTANCE	
					40	L - M					LOW TO MODERATE RESISTANCE			
					39	M					MODERATE RESISTANCE			
					38									
						37			END OF BOREHOLE AT 10.50 m					
						36								
						35								

JK_LIB_CURRENT - V8.00.GLB Log J & K AUGERHOLE - MASTER 30104S PENSHURST.GPJ <-DrawingFiles> 08/02/2017 16:07 Produced by gINT Professional. Developed by Datgel

JK Geotechnics



301045 BH2 START CORING AT 9.87m

9 |

10

11

12

END OF BH2 AT 12.76m

PLE

JK Geotechnics



301045 BH4 START CORING AT 887m

8

9

10

11

END OF BH4 AT 11.94m

PLE



Borehole No.

1
1/1

BOREHOLE LOG

Client: LOW AND HOOKE (AUST) PTY LTD
Project: PROPOSED ADMINISTRATION AND HALL BUILDINGS
Location: PENSHURST PUBLIC SCHOOL, CNR. FOREST RD. & ARCADIA ST. PENSHURST

Job No. 11772SV **Method:** SPIRAL AUGER MD 300 **R.L. Surface:** N.A.
Date: 12-4-96 **Datum:**

Logged/Checked by: A.J. / *[Signature]*

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	U30	DB	DS									
DRY ON COMPLETION						0	[Cross-hatched pattern]	-	ASPHALTIC CONCRETE: 50mm.t	MC>PL	-	-	-
						0.5	[Diagonal lines pattern]	CH	FILL: Gravelly clay, low plasticity, brown, with crushed igneous gravel.	MC-II-PL	H	-	-
					N > 33 14,20, 8/50mm R	1	[Diagonal lines pattern]	CH	SILTY CLAY: high plasticity, grey mottled orange, with a trace of fine root fibres.	MC<PL			TOO FRIABLE FOR H.P.
						1.5	[Diagonal lines pattern]	-	SHALY CLAY: high plasticity, grey mottled orange.	XW-DW	EL-VL	-	VERY LOW 'TC' BIT RESISTANCE WITH SOME LOW BANDS
					2	[Diagonal lines pattern]			INTERBEDDED SHALE: grey with some orange iron indurated medium bands and CLAY: high plasticity, grey mottled orange.				
					3	[Diagonal lines pattern]						380 390	
				N = 34 15,13,21	4	[Diagonal lines pattern]			SHALE: grey, with some clay bands and medium strength bands.	XW-DW	EL-VL	-	VERY LOW TO LOW RESISTANCE
CAVE-IN					5	[Diagonal lines pattern]			END OF BOREHOLE AT 5.0m				
					6								
					7								

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Borehole No.

2
1/1

BOREHOLE LOG

Client: LOW AND HOOKE (AUST) PTY LTD
Project: PROPOSED ADMINISTRATION AND HALL BUILDINGS
Location: PENSHURST PUBLIC SCHOOL, CNR. FOREST RD. & ARCADIA ST. PENSHURST

Job No. 11772SV **Method:** SPIRAL AUGER MD 300 **R.L. Surface:** N.A.
Date: 12-4-96 **Datum:**
Logged/Checked by: A.J. / *[Signature]*

Groundwater Record	SAMPLES			Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/Weathering	Strength/Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	USO	DB									
					0			ASPHALTIC CONCERTE: 50mm.f.	MC>PL	-	-	
							CH	FILL: Gravelly clay, low plasticity, grey and brown, with crushed igneous gravel.	MC=PL	H	-	
				N > 19 14,19/ 130mm R			CH	SILTY CLAY: high plasticity, grey mottled orange, with some iron indurated shale gravel bands.	MC<PL		-	TOO FRIABLE FOR H.P.
					1			SHALY CLAY: high plasticity, grey mottled orange.				VERY LOW 'TC' BIT RESISTANCE
					2			SHALE: grey with some orange iron indurated medium strength bands, with some clay bands.				MODERATE BAND 150mm.f
					3		CH	SILTY CLAY: high plasticity, grey mottled orange and red, with some iron indurated shale gravel bands.	MC<PL	H	-	
				N > 10 16,10/ 90mm R				INTERBEDDED SHALE: grey, with some orange iron indurated medium strength bands and CLAY: high plasticity, grey mottled orange and red.	XW-DW	EL-VL	-	SEEPAGE ON OUTSIDE OF SPT SAMPLER
AFTER 5.5 HRS					4							VERY LOW 'TC' BIT RESISTANCE
CAVE-IN					5							WATER ADDED
				N > 10 10/90mm R				SHALE: dark brown with some iron indurated medium and high strength bands, with some clay bands.	DW	VL	-	LOW RESISTANCE
					6			END OF BOREHOLE AT 5.8m				
					7							



Borehole No.

3 1/1

BOREHOLE LOG

Client: LOW AND HOOKE (AUST) PTY LTD
Project: PROPOSED ADMINISTRATION AND HALL BUILDINGS
Location: PENSHURST PUBLIC SCHOOL, CNR. FOREST RD. & ARCADIA ST. PENSHURST

Job No. 11772SV **Method:** SPIRAL AUGER MD 300 **R.L. Surface:** N.A.
Date: 12-4-96 **Datum:**

Logged/Checked by: A.J. / *[Signature]*

Groundwater Record	SAMPLES			Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/Weathering	Strength/Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	USO	DB									
DRY ON COMPLETION					0	[Cross-hatched pattern]	-	ASPHALTIC CONCRETE: 50mm.t FILL: Gravelly sand, fine to coarse grained, brown.	M	-	-	APPEARS MODERATELY COMPACTED
					1	[Cross-hatched pattern]	-	FILL: Crushed igneous gravel, fine to coarse gravel, dark grey. FILL: Silty clay, medium to high plasticity, dark brown, with a trace of fine root fibres.	MC<PL			
				N = 14 5,6,8	1	[Cross-hatched pattern]	-	FILL: Silty clay, high plasticity, grey and red brown, with a trace of fine root fibres.	MC<PL	(H)	-	-
					2	[Diagonal lines pattern]	CH	SILTY CLAY: high plasticity, grey mottled orange and red, with some iron indurated shale gravel bands.	XW-DW	EL-VL		VERY LOW TO LOW 'TC' BIT RESISTANCE
				N > 5 5/50mm R	2	[Diagonal lines pattern]	-	SHALE: grey with some clay bands and low to medium strength bands.	DW	L-M		
					3	[Diagonal lines pattern]	-	SHALE: grey, with some clay bands, with some high bands.				
					4	[Diagonal lines pattern]	-	INTERBEDDED SHALE: as above and CLAY: high plasticity, grey mottled orange and red (clay with shale bands)		VL		WATER ADDED
					5	[Diagonal lines pattern]	-	SHALE: grey with some orange iron indurated bands, with some clay bands.				
				N > 41 13,21, 20/ 100mm R	5	[Diagonal lines pattern]	-					
					6			END OF BOREHOLE AT 5.8m				
					7							

▼
AFTER 4.5 HRS
CAVE-IN AT 4.1m



Borehole No.

4 1/1

BOREHOLE LOG

Client: LOW AND HOOKE (AUST) PTY LTD
 Project: PROPOSED ADMINISTRATION AND HALL BUILDINGS
 Location: PENSHURST PUBLIC SCHOOL, CNR. FOREST RD. & ARCADIA ST. PENSHURST

Job No. 11772SV Method: SPIRAL AUGER R.L. Surface: N.A.
 Date: 12-4-96 MD 300 Datum:

Logged/Checked by: A.J. / *ML*

Groundwater Record	SAMPLES			Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/Weathering	Strength/Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	FS	USO	DB									
DRY ON COMPLETION					0			ASPHALTIC CONCERTE: 50mm.t.	MC>PL	-	-	-
					0.5		CH	FILL: Gravelly clay, low plasticity, dark grey, with crushed igneous gravel.	MC>PL	VSt	-	-
				N = 7 2,3,4	1			SILTY CLAY: high plasticity, red brown mottled grey.	MC<PL		220 280 240	
					1.5			as above, but grey mottled orange and red, with a trace of fine root fibres and iron indurated shale gravel.	XW-DW	EL-VL		VERY LOW 'TC' BIT RESISTANCE
					2			SHALE: grey with some iron indurated low and medium strength bands, with some clay bands.				
					3							
					3.5			INTERBEDDED SHALE: as above, and CLAY: high plasticity, grey mottled orange and red.				MODERATE BAND 100mm.t
					4							WATER ADDED
				N > 25 17,25 R	5							MODERATE BAND 100mm.t
					6			END OF BOREHOLE AT 5.8m				
					7							

▼
AFTER 3.5 HRS CAVE IN

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Borehole No.

5
1/1

BOREHOLE LOG

Client: LOW AND HOOKE (AUST) PTY LTD
Project: PROPOSED ADMINISTRATION AND HALL BUILDINGS
Location: PENSHURST PUBLIC SCHOOL, CNR. FOREST RD. & ARCADIA ST. PENSHURST

Job No. 11772SV **Method:** SPIRAL AUGER MD 300 **R.L. Surface:** N.A.
Date: 12-4-96 **Datum:**

Logged/Checked by: A.J. / *[Signature]*

Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/Weathering	Strength/Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES	USO	DB	DS									
DRY ON COMPLETION						0		-	ASPHALTIC CONCERTE: 50mm.t. FILL: Crushed igneous gravel.	-	-	-	-
					N = 10 3,5,5	1		CH	FILL: Silty clay, high plasticity, dark brown, with a trace of crushed igneous gravel and ash. SILTY CLAY: high plasticity, red brown mottled grey, with a trace of fine root fibres.	MC<PL	H	420 430 400	-
						2		-	as above, but grey mottled orange and red, with no root fibres. SHALE: grey with some low and medium strength bands, with some clay bands.	XW-DW	EL-VL	-	VERY LOW 'TC' BIT RESISTANCE
					N > 20 17,20 R	3		-	INTERBEDDED SHALE: as above, and CLAY: high plasticity, grey mottled orange.				
					N > 20 20 R	4		-	SHALE: grey, with some iron indurated low and medium strength bands, with some clay bands.				
					5		-	SHALE: grey, with some iron indurated low and medium strength bands, with some clay bands.					
					6			END OF BOREHOLE AT 5.8m					
					7								

▼
AFTER
3 HRS
CAVE IN



Borehole No.

7
1/1

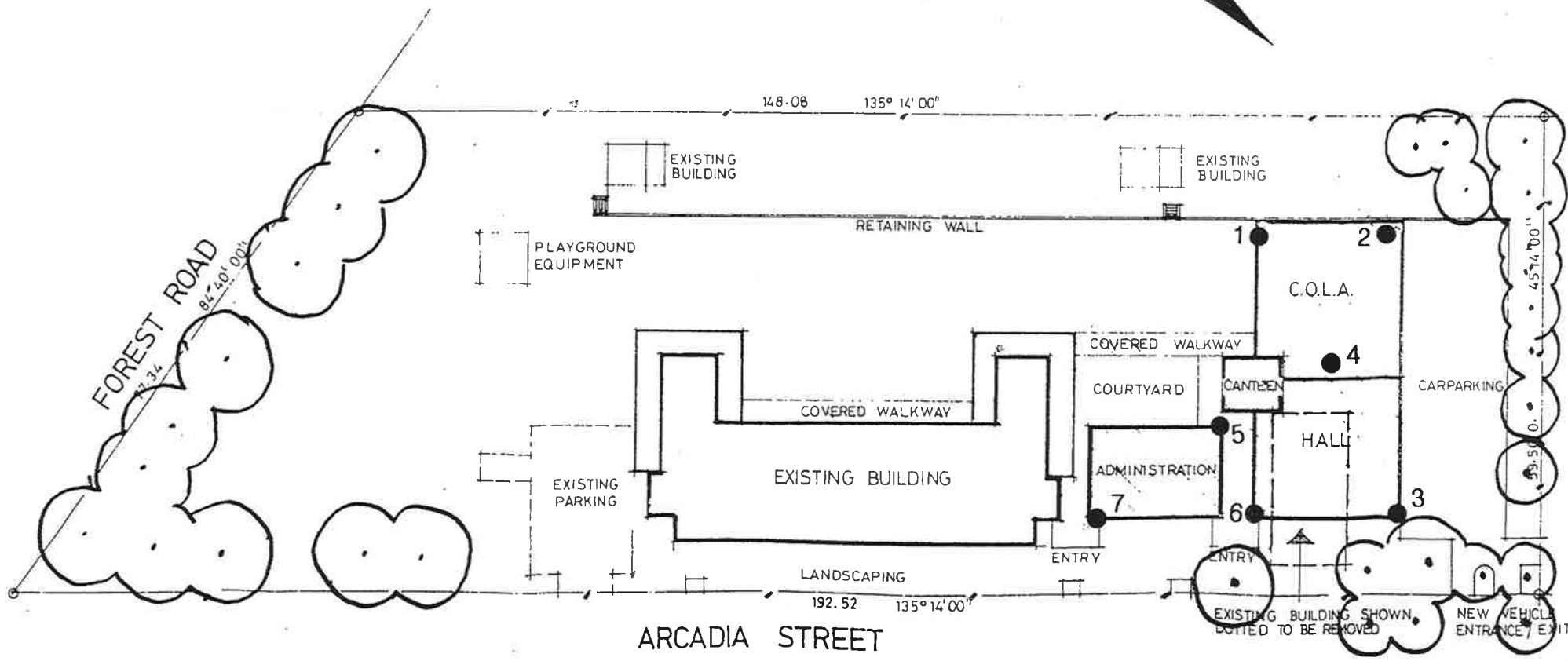
BOREHOLE LOG

Client: LOW AND HOOKE (AUST) PTY LTD
Project: PROPOSED ADMINISTRATION AND HALL BUILDINGS
Location: PENSHURST PUBLIC SCHOOL, CNR. FOREST RD. & ARCADIA ST. PENSHURST

Job No. 11772SV **Method:** SPIRAL AUGER MD 300 **R.L. Surface:** N.A.
Date: 12-4-96 **Datum:**

Logged/Checked by: A.J. / *[Signature]*


Groundwater Record	SAMPLES				Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/Weathering	Strength/Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	FS	USO	DB	DS									
DRY ON COMPLETION						0		-	ASPHALTIC CONCRETE: 50mm.t. FILL: Crushed igneous gravel.	-	-	-	-
					N = 7 3,3,4	0.5		CH	FILL: Silty clay, high plasticity, dark brown, with a trace of ash, fine root fibres and shale gravel. SILTY CLAY: high plasticity, grey and orange, with a trace of shale gravel and fine root fibres.	MC<PL MC=PL	VSI	370 360 310	-
					N = 17 6,7,10	1.5			as above, but grey mottled orange and pale brown, with no root fibres.	MC=PL			
					N = 29 9,11,18	2.5			as above, but grey mottled orange and red, with some iron indurated shale gravel bands, with a trace of fine root fibres.	MC<PL	VSt-H	480 520 380	
					N = 14 14/ 110mm	4.5						370 >600 >600	
					5		-	SHALE: grey with some iron indurated bands, with some clay bands.	XW-DW	EL-VL	-		VERY LOW 'C' BIT RESISTANCE WITH SOME LOW BANDS
					7			END OF BOREHOLE AT 7.0m					



ARCADIA STREET

BOREHOLE LOCATION PLAN

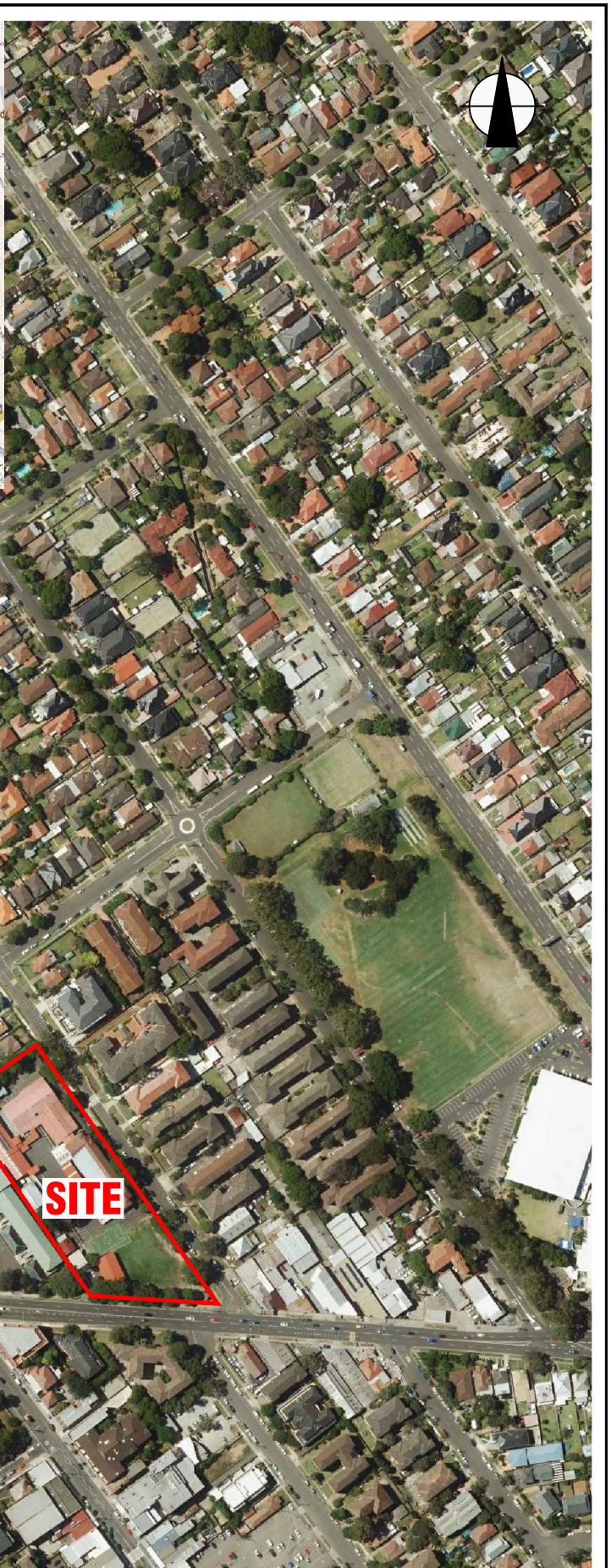
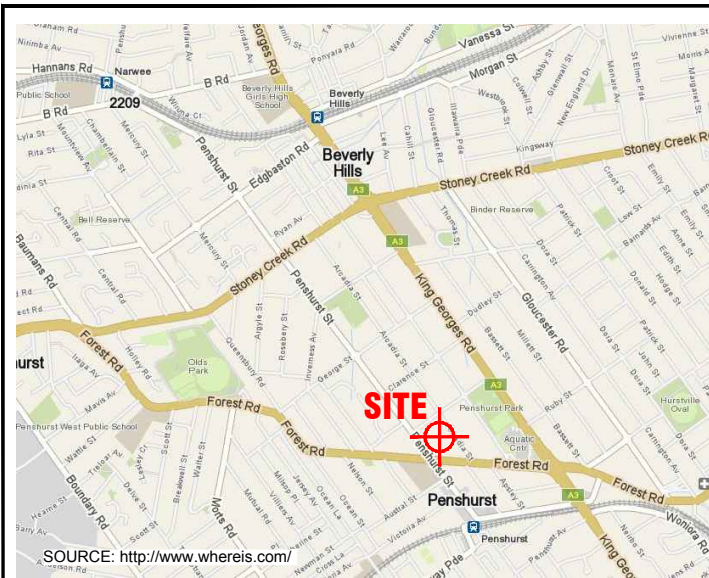


Jeffery and Katauskas Pty Ltd 
CONSULTING GEOTECHNICAL ENGINEERS

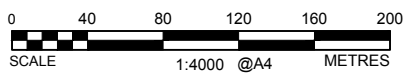
39 BUFFALO ROAD
GLADESVILLE
NSW 2111

Tel: 02-809 7322
Fax: 02-809 7628

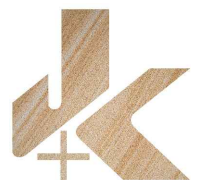
Report No. 1.1772SV. Figure No. 1



AERIAL IMAGE SOURCE: GOOGLE EARTH PRO 7.1.5.1557
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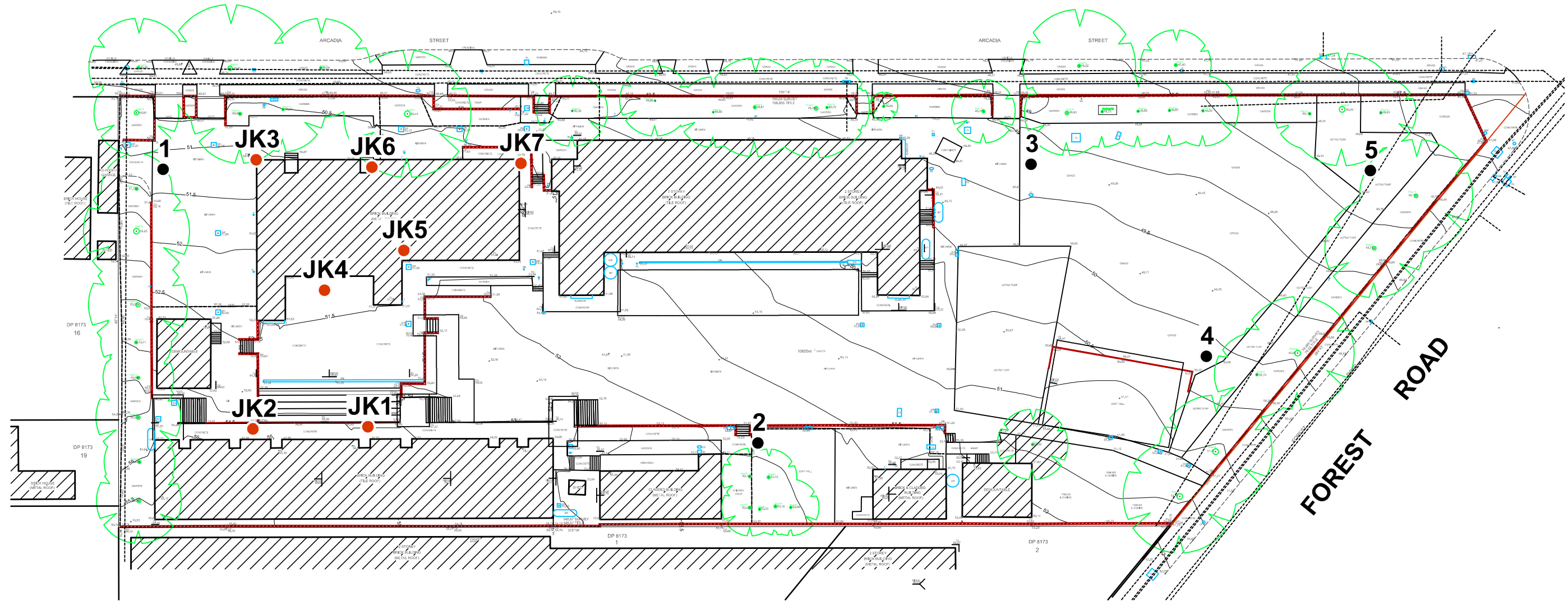


Title: SITE LOCATION PLAN	
Location: PENSURST PUBLIC SCHOOL , ARCADIA STREET PENSURST, NSW	
Report No: 30104S	Figure No: 1
JK Geotechnics	



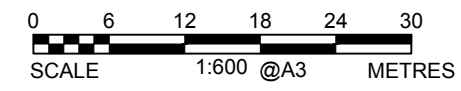


ARCADIA STREET



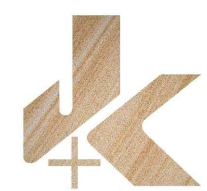
LEGEND

- APPROXIMATE CURRENT BOREHOLE LOCATION
- JK APPROXIMATE PREVIOUS JK GEOTECHNICS BOREHOLE LOCATION



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

Title: BOREHOLE LOCATION PLAN	
Location: PENSURST PUBLIC SCHOOL , ARCADIA STREET PENSURST, NSW	
Report No: 30104S	Figure No: 2
JK Geotechnics	



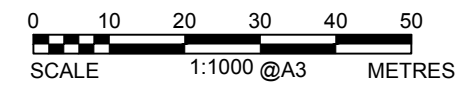
PLOT DATE: 9/02/2017 11:30:12 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL_JOBS\30000\30104S PENSURST\CAD\30104S.DWG



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

LEGEND

- APPROXIMATE CURRENT BOREHOLE LOCATION
- JK APPROXIMATE PREVIOUS JK GEOTECHNICS BOREHOLE LOCATION

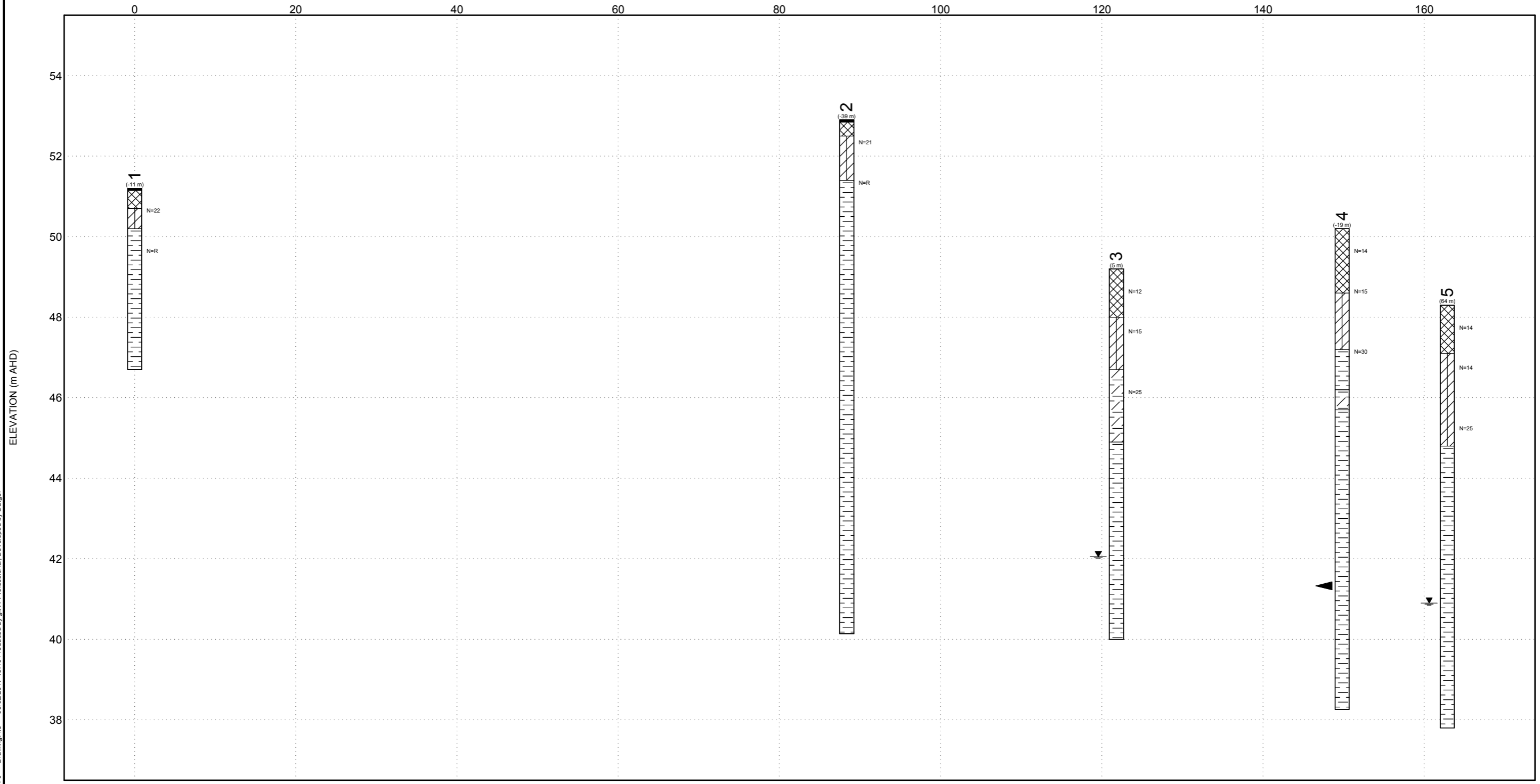


This plan should be read in conjunction with the JK Geotechnics report.

Title: BOREHOLE LOCATION PLAN	
Location: PENSURST PUBLIC SCHOOL , ARCADIA STREET PENSURST, NSW	
Report No: 30104S	Figure No: 2
JK Geotechnics	



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- ASPHALTIC CONCRETE
- CLAY
- SILTY CLAY
- FILL
- SHALE

Scales(A3)	Title: GRAPHICAL BOREHOLE		
	Location: CNR. FOREST WAY AND ARCADIA STREET, PENSHURST, NSW		
H 1:500	Report No: 30104S	Figure No: 3	
V 1:100	JK Geotechnics		



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

The 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 or where only a limited investigation has been completed or 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

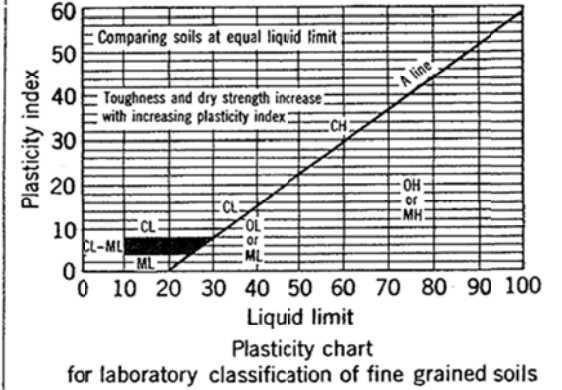
SOIL		ROCK		DEFECTS AND INCLUSIONS	
	FILL		CONGLOMERATE		CLAY SEAM
	TOPSOIL		SANDSTONE		SHEARED OR CRUSHED SEAM
	CLAY (CL, CH)		SHALE		BRECCIATED OR SHATTERED SEAM/ZONE
	SILT (ML, MH)		SILTSTONE, MUDSTONE, CLAYSTONE		IRONSTONE GRAVEL
	SAND (SP, SW)		LIMESTONE		ORGANIC MATERIAL
	GRAVEL (GP, GW)		PHYLLITE, SCHIST		
	SANDY CLAY (CL, CH)		TUFF		CONCRETE
	SILTY CLAY (CL, CH)		GRANITE, GABBRO		BITUMINOUS CONCRETE, COAL
	CLAYEY SAND (SC)		DOLERITE, DIORITE		COLLUVIUM
	SILTY SAND (SM)		BASALT, ANDESITE		
	GRAVELLY CLAY (CL, CH)		QUARTZITE		
	CLAYEY GRAVEL (GC)				
	SANDY SILT (ML)				
	PEAT AND ORGANIC SOILS				



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: <i>Silty sand, gravelly</i> ; 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; (<i>SM</i>)	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for <i>GW</i> Atterberg limits below "A" line, or <i>PI</i> less than 4 Atterberg limits above "A" line, with <i>PI</i> greater than 7 $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3 Not meeting all gradation requirements for <i>SW</i> Atterberg limits below "A" line or <i>PI</i> less than 5 Atterberg limits below "A" line with <i>PI</i> greater than 7							
			Gravels with fines (appreciable amount of fines)	Predominantly one size or a range of sizes with some intermediate sizes missing	GP			Poorly graded gravels, gravel-sand mixtures, little or no fines						
		Plastic fines (for identification procedures, see <i>CL</i> below)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures										
	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									
			Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines									
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see <i>ML</i> below)	SM	Silty sands, poorly graded sand-silt mixtures									
Plastic fines (for identification procedures, see <i>CL</i> below)	SC	Clayey sands, poorly graded sand-clay mixtures												
Fine-grained soils More than half of material is smaller than 75 μm sieve size (The 75 μm sieve size is about the smallest particle visible to naked eye)	Identification Procedures on Fraction Smaller than 380 μm Sieve Size													
	Silt and clays liquid limit less than 50	Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbol	Typical Name	Information	Classification						
									None to slight	Quick to slow	None	<i>ML</i>	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: <i>Clayey silt, brown</i> ; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (<i>ML</i>)
									Medium to high	None to very slow	Medium	<i>CL</i>	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	<i>OL</i>	Organic silts and organic silt-clays of low plasticity								
		Silt and clays liquid limit greater than 50	High to very high	None	High	Slight to medium	<i>MH</i>	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts						
									Medium to high	None to very slow	Slight to medium	<i>OH</i>	Organic clays of medium to high plasticity	
	High to very high								None	High	<i>CH</i>	Inorganic clays of high plasticity, fat clays		
	Highly Organic Soils	Readily identified by colour, odour, spongy feel and frequently by fibrous texture	None	None	Slight to medium	<i>Pt</i>	Peat and other highly organic soils							

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

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 5% to 12% *GM, GC, SM, SC*
Borderline cases requiring use of dual symbols



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.		
		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.		
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	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.	
		7		
		3R		
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) (Cohesionless 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.		
	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 (%)		
		VL	Very Loose <15	SPT 'N' Value Range (Blows/300mm)
		L	Loose 15-35	0-4
		MD	Medium Dense 35-65	4-10
		D	Dense 65-85	10-30
		VD	Very Dense >85	30-50
()	Bracketed symbol indicates estimated density based on ease of drilling or other tests.	>50		
Hand Penetrometer Readings	300	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.		
	250			
Remarks	'V' bit	Hardened steel 'V' shaped bit.		
	'TC' bit 	Tungsten carbide wing bit. 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	0.03	Easily remoulded by hand to a material with soil properties.
Very Low: -----	VL	0.1	May be crumbled in the hand. Sandstone is "sugary" and friable.
Low: -----	L	0.3	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.
Medium Strength: -----	M	1	A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
High: -----	H	3	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.
Very High: -----	VH	10	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.
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	