Appendix D

Geotechnical Report

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
A.B.N. 17 003 550 801 A.C.N. 003 550 801

Principals
B F WALKER BE DIC MSc
P STUBBS BSc MICE FGS
D TREWEEK Dip Tech
E H FLETCHER BSc (Eng)

Senior Associates
F A VEGA BSc(Eng) GDE
A ZENON BSc(Eng) GDE
P C WRIGHT BE(Hons) MEngSc
L J SPEECHLEY BE(Hons) MEngSc

Associates
A B WALKER BE(Hons) MEngSc

Consultant
R P JEFFERY BE DIC MSc

39 BUFFALO ROAD
GLADESVILLE
NSW 2111
Tel: 02-9809 7322
02-9807 0200
Fax: 02-9809 7626

REPORT

TO

COASTAL HAMLETS PTY LTD
C./- ROSECORP PTY LTD

ON

PRELIMINARY GEOTECHNICAL INVESTIGATION

FOR

PROPOSED RESIDENTIAL SUBDIVISION

AT

MOONEE COLLIERY, MONTEFIORE STREET,
CATHERINE HILL BAY/ MOONEE, NSW

15 December 2004 **Ref: 19029Vrpt**

TABLE OF CONTENTS

1 INTRODUCTION

This report presents the results of a preliminary geotechnical investigation for a proposed residential subdivision at Moonee Colliery, Montefiore Street, Catherine Hill Bay/Moonee, NSW. The investigation was commissioned by Mr Stuart Rose of Rosecorp Pty Ltd, on behalf of Coastal Hamlets Pty Ltd, by returned Acceptance of Proposal, Ref: P10878V.

At the time of the investigation, the proposed subdivision was at a concept stage. Details, including lot arrangements and earthwork levels, were unknown; however, a preliminary access road layout was provided and this forms the basis for our borehole location plan, Figure 1. We understand that it is proposed to develop a residential subdivision at the Moonee section of the Colliery, essentially comprising several internal roads and probably up to 1000 dwellings. Structural loads had not been worked out at this concept stage but we assume that light loads may apply for this type of subdivision.

In view of the size and varied nature of the site topography, we expect that large scale earthworks will be planned. Based on information provided to us by Mr David Gaskell (Hyder Consulting Pty Ltd), it is anticipated that some rehabilitation works will occur generally at existing dam areas within the site. For further details of proposed mine rehabilitation works, reference should be made to "Figure 18 of Mine Rehabilitation & Closure Plan" (Drg No. Figure 7, Issue 01, dated; 29 June 2004), prepared by Hyder Consulting Pty Ltd. Fill earthworks will also be required in order to bring the current existing ground levels to meet the design finished subgrade levels. These finished subgrade levels were unknown to us at the time of this report; however, we have been informed that some filling of up to 3 meters will be carried out to level off the site.

At this concept stage, the scope of the investigation was limited to obtaining geotechnical information on subsurface conditions in a very broad grid of boreholes spread as best as practically possible across the site taking into consideration access constraints imposed by the existing vegetation, mine structures, coal storage areas, dams, etc.. Based upon the information obtained, we have prepared general comments and recommendations on relevant geotechnical aspects associated with a typical residential subdivision. We emphasise that the recommendations are provided in general terms only, and will require revision and further detailed investigation work once exact development details, such as lot, pavement and building layouts, earthwork levels, floor levels, structural loads, etc. have been determined.

2 INVESTIGATION PROCEDURE

Twenty-one boreholes were drilled at the proposed subdivision site, in areas accessible to our truck mounted rig. The boreholes (BHs) were auger drilled using our JK350 drill rig to depths between 4.5m and 13.95m below the existing ground surface. The borehole locations, as shown on Figure 1, were set out initially by measurements from existing surface features shown on supplied preliminary base plan using a 'trundle wheel' and marked out on site with wooden pegs. On completion of the fieldwork, selected existing surface features as well as each borehole peg had its coordinates referenced using our GPS tracking equipment. The GPS coordinates recorded were then used to plot the borehole locations as shown on Figure 1. Notwithstanding, we estimate that the actual locations may have a variation in the order of about 5m-10m from the locations shown on Figure 1.

The approximate surface levels, as shown on the borehole logs, were estimated by interpolation between contours shown on the supplied preliminary base plan (Hyder Consulting Pty Ltd, Project Code No.NS02121, Drawing No.SK051, Issue P1), which also formed the basis of Figure 1. The datum of the levels is Australian Height Datum (AHD).

The relative compaction of the fill, the relative density and strength of the subsurface soils were assessed from Standard Penetration Test (SPT) 'N' values, augmented by hand penetrometer readings on cohesive samples recovered in the SPT split tube sampler. The strength of the underlying shale, sandstone and conglomerate was assessed by observation of the drilling resistance of a tungsten carbide (TC) bit attached to the augers, together with examination of the recovered rock chips and subsequent correlation with laboratory moisture content tests.

Groundwater observations were made both during drilling and up to 22.75 hours after completion of the boreholes.

Our geotechnical engineer, Mr M Sheard, set out the borehole locations, took GPS readings of selected surface features and borehole locations, nominated the 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 this report together with a set of explanatory notes, which describe the investigation techniques and their limitations and define the logging terms and symbols used.

Soil Test Services Pty Ltd (STS), a NATA registered laboratory, tested selected samples for moisture content and soil classification. The results of the laboratory testing are summarised in Table A. Standard Compaction and soaked CBR tests on pavement subgrade and contamination testing of the site soils was outside the agreed, limited scope of this preliminary investigation.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located at the Moonee Headland peninsula, bounded to the east by the Pacific Ocean. Located in a hilly, undulating coastal region, the site is located towards the crest of a slightly to moderately sloping hill that generally fall towards the south-east from RL50.0m AHD (at north-western corner of site) to RL2.5m AHD (at south-eastern corner of site). Refer to Figure 1 for further details of the site topography including ground contours, other features, borehole locations and proposed road layout.

The site consists of the Moonee section of the Colliery, which is located at the far south-eastern end of Montefiore Street (approximately 8 kilometres east of the Pacific Highway). Monitefiore Street forms the border between the suburbs of Catherine Hill Bay and Moonee and approximately forms the northern boundary of the site.

The western half of the site contains an existing open shallow pit, currently used as a coal storage area. At the time of surveying, the pit had base levels generally between RL42.0m AHD and RL45.0m AHD. The majority of the pit's base revealed coal at the surface with occasional coal stockpiles. The eastern half of the site typically contained the existing and non-operational colliery infrastructure. This infrastructure consisted of asphaltic and concrete paved roadways and paths, several brick offices and concrete slabs. The buildings on site were of good structural, but dilapidated, condition and appeared to have been vacant for some time.

There are several dams located generally around the out skirts of the site. The larger dams were clustered towards the eastern end of the site. At the time of observation, the majority of the site dams were less than a quarter full of water. Remaining areas of the site contained bushland with various bush-dirt tracks.

The site is mostly surrounded by National Park bushland. Neighbouring the north-eastern end of the site is the continuation of the colliery into Catherine Hill Bay. This neighbouring section of the colliery was outside the scope of works for this preliminary investigation.

3.2 <u>Subsurface Conditions</u>

In summary, the boreholes encountered a highly variable profile of deep fill (up to 11.5m) covering clayey sands, silty sands, gravely silty clays, and/or silty clays. Shale and sandstone bedrock and conglomerate was only encountered in BH 6 and 16 at depths of 0.5m and 2.0m, respectively. Reference to the 1 in 100,000 Newcastle Coalfield Regional Geology sheet (No. 9231) indicates the site is at an intersection of the Clifton and Moon Island Beach subgroups of conglomerate, sandstone, siltstone, tuff and coal. The geological sheet also indicates the presence of overlying alluvial and/or estuarine-shallow marine and/or dune beach sand deposits. Further comments on the highly variable subsurface conditions encountered are provided below. Graphical summaries of borehole information are provided in Figures 2a to 2c. Reference should be made to the borehole logs for detailed descriptions of the subsurface conditions.

Fill

Fill was encountered in most boreholes. The depth, composition, and apparent compaction of the fill were significantly variable. The deepest fill, varying in depth from 2m to 11.5m, was encountered in the boreholes drilled in the eastern portion of the site (BHs 9, 13 to 19 and 21), with fill extending to depths of 11m and 11.5m in BHs 14 and 15, respectively. It is suspected that this very deep fill area, which is currently surrounded by some of the larger existing dams, may comprise a backfilled previous mine workings/pit area. Outside this eastern area, there were some isolated areas of moderately deep (1.6m-3.1m) such as around BHs 5, 7, 8 and 20. The fill varied in composition, but predominantly comprising gravely silty clay and silty sand mixtures with varying proportions of coal gravel and slag up to cobble size.

Based on the SPT test results and our observations during drilling, the fill was assessed to generally vary from poorly to moderately compacted, with some well compacted layers.

Silty Clays and Gravely Silty Clays

Silty clays and gravely silty clays were predominantly encountered in BHs 1, 2, 4, 5, 10 14, 15, 17 and 21. In general, these clays were assessed as being very stiff to hard in strength and of high plasticity.

Silty Sands and Clayey Sands

These sands were predominantly encountered in the remainder of the boreholes. The sands contained varying quantity of gravel and some of the sands were in various stages of cementation. In general, most of the sand profile was of medium dense, dense, or very dense relative density, with some occasional layers of very loose or loose sands (e.g. BHs 2, 3 and 7).

Shale, Sandstone and Conglomerate

In BH6, extremely to distinctly weathered shale of extremely low to very low strength was encountered at a depth of 0.5m. The shale was underlain by distinctly weathered sandstone of low strength at a depth of 2.4m. In BH16, distinctly to slightly weathered sandstone of low to medium strength was encountered at a depth of 2.5m. The sandstone was underlain at a depth of 3m by conglomerate of high strength.

Groundwater

Groundwater was not encountered in most of the boreholes, with the exception of BHs 8, 14, 17 and 19. Seepage was encountered during drilling of the deep fill boreholes 14, 17 and 19 at depths of 10.5m, 7.5m, and 3.6m, respectively. Groundwater levels were measured several hours after completion of drilling the latter boreholes at depths varying between 2.5m and 8.3m. Although no seepage was encountered during drilling of BH8, a groundwater level was recorded within the fill at a depth of 0.5m after 17.75 hours of completion; we suspect that this level is possibly a 'perched' level associated with the adjoining coal storage areas.

3.2.1 Laboratory Test Results

The results of the moisture content and soil classification tests on selected rock chip and soil samples correlated reasonably well with our field assessment of both rock strength and cohesive soil plasticity. The Atterberg limits and linear shrinkage results indicate that the silty clays at the site have a high potential for shrink/swell movements with changes in moisture content.

4 COMMENTS AND RECOMMENDATIONS

4.1 Summary of Geotechnical Design Issues and Further Investigation

The principal geotechnical issues to be considered in the design and construction of the proposed development are listed below. Further comments on these issues and general recommendations for future residential development are provided in the subsequent sections of this report.

1. The uneven compressibility potential of the existing fill, which was assessed as being in a variable state of compaction, although it is generally in a poor to moderately compacted condition. We are unaware of records that document the manner of placement, compaction specification, and control of the fill. Accordingly, this existing material must be considered 'uncontrolled' fill.
2. It is also important to note that the existing fill is a potentially variable material from unknown origins and may contain large inclusions and obstacles which

could affect future construction. Such inclusions may not have been encountered within our boreholes of relatively small diameter (about 100mm). Such inclusions can produce construction difficulties and delays. Variations in fill quality/nature must be anticipated.

3. The site is located in an area of subject to mine subsidence and hence, this will be factor in the design of the proposed buildings. Mine subsidence potential together with the presence of uncontrolled fill results in a site classification of Class 'P' in accordance with AS2870.
4. We note that the fill is very deep (11m-11.5m) at some borehole locations in the eastern portion of the site and hence, we expect that piled footings would be necessary to found on natural, competent stratum below the fill.
5. High shrink-swell reactivity potential of the silty clays; the design of buildings on lots underlain by the silty clays, would have to take into consideration the reactivity potential of the clays. This design factor would only be applicable around BH4, which is the only borehole that disclosed silty clays over the upper profile (in other boreholes the silty clays were covered by significant thicknesses of clayey or silty sand or fill).
6. There are a number of dams and water features at the site that will require special drainage and subgrade preparation measures, as well as significant earthworks, for backfilling to allow the construction in these areas.
7. Although no CBR tests were commissioned, based on the Atterberg limits test and the borehole results, we expect that there will be markedly different CBR values for the three major soil subgrades at the site, namely the fill, the clayey sands and the silty clays. We expect that the silty clay subgrade, which is of medium to high plasticity and reactive, would have the lowest CBR values, probably in the order of 3%.
8. In the areas of shallow or absent or replaced fill, buildings may be founded on footings (probably stiffened raft slabs) bearing on clayey sands or silty clays of medium dense or very stiff strength, or, on engineered, controlled fill, where the existing uncontrolled fill has been replaced. Such footings would have to be

designed for mine subsidence effects, and in silty clay areas, for the effects of shrink/swell reactive movements.

9. Another possible option for using high level footings would be to improve the compaction of the existing fill by excavation and replacement or alternatively, attempt to improve the fill compaction by rolling the surface with a heavy impact roller. Such excavation and replacement or impact compaction treatments would only be feasible in areas of moderately deep fill say 3m or less. In the deeper fill areas, we expect that only feasible solution would be to suspend the buildings, including the floor slabs, on piles taken down to competent, natural strata below the uncontrolled fill.

The number of boreholes employed in this investigation provides only a very broad general coverage of the site. For the purposes of the final design, additional boreholes and tests will be required together with revision and amplification of the general recommendations provided herein, once exact development details, such road and lot layout, earthwork levels, building locations, floor levels, structural loads, etc., are finalised.

The further investigations should include boreholes and possibly a closely spaced grid of Electronic Friction Cone Penetration (EFCP) Tests, if it is desired to leave the fill in place and use it as a bearing stratum. We emphasise that the subsurface conditions may be different in the other parts of the site not covered by the current boreholes. The additional and detailed borehole drilling and testing should be carried out once demolition has been completed, vegetation areas cleared and access is made possible for a truck mounted rig over the entire site.

We believe that a meeting of the design team would be fruitful, once the concept design is further advanced, in order to discuss geotechnical problems and solutions in more detail.

4.2 Earthworks

The following are some preliminary guidelines and recommendations for site earthworks, which should be complemented by reference to AS3798. The main issues for the earthworks would be:

- Site drainage
- Treatment of the existing uncontrolled fill subgrade
- Fill quality and compaction criteria for raising existing site levels by up to 3m at some locations
- Engineered fill specification
- Batter slopes and/or retention systems

4.2.1 Site Drainage

Good drainage must be provided both during construction and for the long-term maintenance of the site; this is particularly important in silty clay subgrade areas. The principal aim of the drainage should be to promote run-off and reduce ponding, as silty clay subgrade may become untrafficable when wet. The earthworks should be carefully planned and scheduled to maintain cross-falls during construction. We recommend that reference be made to AS2870 for drainage and vegetation precautions.

4.2.2 Fill Replacement and Subgrade Preparation

As discussed in Section 4.1, with the limited information currently available, the existing site fill is taken to be 'uncontrolled' fill and hence, cannot be relied upon as a suitable bearing stratum under floor slabs and footings.

If the slab is to be fully suspended on piled footings, which is likely to be the only feasible option in very deep fill areas in the eastern portion of the site, then it would be unnecessary to complete any particular subgrade preparation other than stripping of root affected soil.

Alternatively, in the area of proposed buildings, the 'uncontrolled' fill may be excavated and replaced with controlled, engineered fill. We anticipate that such replacement earthworks would only be feasible where the fill is less than about 3m depth, even so, significant earthworks would still be required. In addition, the replacement should extend to at least 2m beyond the boundaries of the floor area. Such large excavations would have to be completed with battered sides of no steeper than 1 Vertical to 1.5 Horizontal and with appropriate groundwater seepage control measures, where necessary. With this fill replacement option, we emphasise that difficult and expensive earthworks must be expected at some site locations.

If it can be proven that the existing fill is in fact 'controlled' fill (by obtaining compaction records and/or by further geotechnical testing as discussed in Section 4.1), then a reduced scope of replacement and recompaction, may be adopted. However, given the generally poorly to moderately compacted condition of the fill it is highly unlikely that the need for fill treatment would be eliminated.

In the area of proposed pavements, the fill subgrade may be left in place provided it performs satisfactorily under proof rolling treatment as detailed below. However, all topsoil and root affected upper layers of the fill or any deleterious materials must be fully stripped. This root affected upper layer is irregular in depth and occurrence but for budgeting purposes allow for an average stripping depth of about 0.2m, but deeper as deemed necessary after inspection by a geotechnician or geotechnical engineer.

After the aforementioned excavation/stripping and prior to any filling/backfilling taking place, the exposed subgrade should be proof rolled with at least seven passes of a heavy vibratory roller (e.g. minimum 8 tonne dead weight) to improve the surface compaction. The final pass should be undertaken without vibration and within the presence of a geotechnician or geotechnical engineer, to detect any unstable or soft subgrade areas.

During proof rolling, care should be taken to avoid damage to any future neighbouring improvements from vibrations transmitted by the roller. If necessary, the vibrations should be reduced or ceased.

Subgrade heaving may occur during proof rolling in areas where the existing fill is not well compacted or where the sand subgrade is very loose or where the fill and/or silty clay is allowed to become wet due to poor site drainage or prolonged exposure to periods of wet weather. Heaving areas should be locally removed to a stiff base and replaced with engineered fill as defined below. Allowance should be made for either tyning, aerating and drying the subgrade, or removal and replacement with a select imported fill. We expect that further geotechnical advice and inspections will be required to assess the most suitable method of subgrade improvement.

Another option is to improve the state of compaction of the existing fill by rolling the ground surface with an impact roller. This option would involve further investigation and trial strips or areas. In addition, verification of compaction improvement would have to be carried out by in-situ density testing as well as testing at depth with a penetrometer. We expect that this option would only be feasible where the fill is less than about 2m to 3m depth. Further advice should be sought if this option is to be seriously considered.

There are a number of dams and water features at the site that will require special drainage and subgrade preparation measures, as well as significant earthworks, for backfilling to allow the construction in these areas.

4.2.3 Engineered Fill and Compaction Control

Materials recommended for use as imported engineered fill, are well-graded, granular materials, of low plasticity, non-dispersive characteristics and no or very slight reactivity potential, free of deleterious substances, chemical contaminants and having a maximum particle size of 75mm. Such fill should be compacted in layers not greater than 200mm loose thickness, to a minimum density of 98% of Standard Maximum Dry Density (SMDD).

For any cut/fill earthworks, the existing fill and natural soils may be reused as engineered fill provided they are free of deleterious materials and particles greater than 75mm in size. The silty clays may also be used but use of clay materials for engineered fill will entail more rigorous earthwork supervision and compaction control, time for drying out the soils and hence, possibly a greater eventual cost for earthworks. All clayey fill should be compacted in maximum 200mm loose thickness layers to a density strictly between 98% and 102% of SMDD and at a moisture content within 2% of Standard Optimum Moisture Content (SOMC).

Soils comprising clays of very high plasticity and/or significant dispersive potential should not be used as fill and a geotechnical engineer should approve any clay prior to use.

Density tests should be carried out on the fill to confirm the above specifications are achieved. The frequency of density testing should be at least one test per layer per 500m^2, or three tests per visit, whichever requires the most tests. We recommend that Level 1 control of fill compaction be adhered to within the building pad areas and at least Level 2 within the remainder of the site. We can complete the abovementioned testing and supervision if required. Preferably, the geotechnical testing authority should be engaged directly on behalf of the client and not by the earthworks subcontractor.

4.2.4 Batters and Retaining Walls

Batter slopes for excavation (cut) sides of maximum 1 Vertical (V) in 1.5 Horizontal (H) in existing fill and natural sands and 1V:1H in natural silty clays of at least very stiff strength should be assumed as temporary, stable batters, as long as surcharge loads are kept well away from the perimeter of the excavation. Flatter batters and additional shoring would be required where groundwater is encountered.

Permanent batter slopes of no steeper than 1V:2H may be used in engineered fill embankments or in natural sand and clay cuts. Provision should be made to reduce infiltration of rain water and to divert surface water run-off away from the slopes. Permanent slopes should also be protected from erosion by provision of a suitable dense vegetation cover or appropriate lining.

Any cantilevered or gravity type retaining walls required at the site, which are capable of some movement, may be designed for a coefficient of 'active' earth pressure, K_a, of at least 0.33 (assuming a horizontal backfill surface) and a bulk unit weight of 20kN/m^3. The retaining walls should be designed to withstand hydrostatic pressure unless measures are taken to introduce complete and permanent drainage of the ground behind the wall. All surcharge loads should also be considered in the design of retaining walls. Propped walls, such as those supported by floor slabs, should be designed using a coefficient of earth pressure 'at rest', K_0, of at least 0.6 (assuming a horizontal backfill surface).

Caution will be required not to overcompact and cause excessive lateral pressures on the retaining walls. Only small rollers should be used for fill adjacent to any retaining wall. The aforementioned earth pressure parameters apply to a horizontal backfill surface and, if inclined backfill surfaces are to be designed, then the above factors would have to be increased or the inclined section of backfill should be taken as a surcharge load in the design.

4.3 Footings

Design of footings for residential buildings on this site would have to incorporate the following principal factors:

- Class P site classification in terms of AS2870
- Mine subsidence potential
- Reactivity potential of the silty clay areas (Class H)
- Any remaining uncontrolled fill (e.g. very deep fill areas in the eastern portion of the site), which are not feasible to treat and improve by implementing the guidelines provided in Section 4.2.

The site classifies as Class P and design of all residential buildings would have to be carried out by engineering principles in accordance to AS2870 and to the requirements of the Mine Subsidence Board, who should be approached to provide details of their requirements for this site and possibly formal approval for the proposed development.

Mine subsidence is simply the movement of the ground surface because of underground mining of coal or other materials. We do not know the extent of such mining beneath the site; however, the site is located in the Swansea North Entrance Mine Subsidence District. Parameters associated with these movements are subsidence, tilt, curvature, horizontal displacement, and horizontal ground strain. Of these five subsidence parameters, the horizontal ground strains and ground curvatures will generally cause damage to buildings. For the case of low rise buildings, the most important aspect of design has been shown to be the isolation of the superstructure from the horizontal ground strains. For small structures, such as houses, the Board should recommend acceptable footing and superstructure details (most likely AS2870 designs such as a stiffened raft slab) to assist the owner to gain approval for the proposed development. For larger, more complicated structures (if any are proposed), the Board should supply the necessary design subsidence parameters to allow designers of the proposed development to accommodate surface movements caused by mine subsidence and thereby, gain Board approval. During the detailed investigation stage, we can provide services, if commissioned, to investigate further with the Board for specific requirements for foundation design against mine subsidence on this site.

Two foundation options are discussed below for typical residential dwellings. Due to the potential for differential foundation movements, we recommend that an entire building unit be uniformly supported on similar foundations.

In lots with no or only shallow fill, or if all uncontrolled fill is excavated and replaced with controlled, engineered fill, buildings may be founded on shallow footing systems such as stiffened raft slabs. Such footings should be designed for mine subsidence and in silty clay areas, for shrink/swell reactivity. The latter design factor would only be applicable around BH4 area, which is the only borehole that disclosed silty clays in the upper profile (in other boreholes the silty clays were covered by significant thicknesses of clayey or silty sand or fill). However, during the detailed investigation stage, further silty clay strata in the upper profile may be revealed in areas of the site not covered by the current boreholes. Preliminary allowable bearing pressures of 200kPa within the very stiff to hard silty clays or medium dense to dense clayey or silty sands, or, 100kPa on loose clayey sands and controlled, engineered fill may be used. Where the bedrock occurs at shallow depths, which was only disclosed around BHs 6 and 16, the foundation conditions may comprise shale or sandstone or conglomerate and may be designed on a preliminary basis for an allowable bearing pressure of 700kPa. Reference should also be made to AS2870 for design, construction, performance criteria, and maintenance precautions.

In the very deep fill areas around BHs 14, 15, 17, 18 and 19, where it is likely to be unfeasible to treat the existing uncontrolled fill by replacement or impact compaction, piled footings are likely to be employed to reach the underlying natural soil foundation. At this stage, the geotechnical test data we have on the natural soils underlying the deep fill is very limited and indicates to highly variable conditions. In these deep fill areas where piles are likely to be necessary, further testing using an electric friction cone penetrometer is recommended for the final, detailed investigation stage. Notwithstanding, with the current borehole data it deduced that predominantly silty clays of very stiff strength occur at BHs 15, 14 and 17 and for preliminary analysis, an allowable end bearing pressure of 300kPa may be employed. In BHs 18 and 19, where medium dense or dense clayey sands were found, a higher allowable end bearing pressure of 600kPa may be used for preliminary design.

Based on the borehole results, auger, grout injected piles or displacement type piles are considered suitable. Drilling contractors should be warned of possible difficult drilling conditions requiring penetrating very deep fill profile with cobble size inclusions. Heavy drilling rigs with rock cutting augers may be required.

We note that the use of driven piles may be possible on this site, although potential damage to any future improvements and buried services due to pile driving vibrations or noise resulting from pile driving operations, should further be considered. The advice from a specialist piling contractor should be sought and vibrations monitored if necessary. The allowable driven pile load capacity may be taken to be the lesser of:

1. The allowable structural capacity of the pile shaft.
2. The allowable load capacity as assessed from a recognised dynamic pile driving equation using an appropriate Factor of Safety. For example, a Factor of Safety

of 4 is usually adopted using the Hiley formula unless pile load tests are carried out to provide better correlation.

All footings should be excavated, cleaned, inspected and poured with minimal delay. If delays in pouring high level footings are anticipated, we recommend that the footing base be covered with a protective layer of concrete. For piles socketed into the bedrock or conglomerate, we recommend that large capacity drilling rigs with rock augers and rock coring buckets be used to drill the piles.
As a minimum, the initial stages of footing construction should be inspected by a geotechnical engineer to ascertain that the recommended foundation has been reached and to check initial assumptions about foundation conditions and possible variations that may occur between borehole locations. The need for further inspections can be assessed following the initial visit. We can assist with the future geotechnical inspections if you wish to commission us at the appropriate time.

4.4 Pavements

Although no CBR tests were commissioned, based on the Atterberg limits test and the borehole results, we expect that there will be markedly different CBR values for the three major soil subgrades at the site, namely the fill, the clayey or silty sands, and the silty clays. We expect that the silty clay subgrade, which is of medium to high plasticity and reactive, would have the lowest CBR values probably in the order of 3%.

Preliminary design of pavements may be based on assumed soaked CBR values in the order of 5% for the clayey or silty sand or sandy fill and 3% for the silty clay.

The pavement sections where imported fill is used to raise site levels, or replace unsuitable (heaving) subgrade by a depth of at least 0.5m, may be designed on the basis of the four-day soaked CBR value of the imported fill material.

For final design purposes, the design CBR values should be analysed from the results of a series of four day soaked CBR tests, which should be completed on representative subgrade samples obtained from the proposed road alignments and other pavement areas. Careful attention to subsurface and surface drainage is required.

Concrete pavements should have a sub-base layer of at least 100mm thickness of crushed rock to RTA QA specification 3051 (1994) unbound base material (or equivalent good quality and durable fine crushed rock), which should be compacted to at least 100% SMDD. Concrete pavements should be designed with an effective shear transmission of all joints by way of either doweled or keyed joints.

5 GENERAL COMMENTS

The number of boreholes employed in this investigation provides only a very broad general coverage of the site. We, therefore, recommend that further, detailed investigations be carried out at later stages to drill further boreholes at a closer grid spacing and within defined lot layouts and along final road alignments.

The subsurface soil and rock conditions between the completed boreholes and away from them, 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.

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 Jeffery and Katauskas Pty Ltd accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long-term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgement from an experienced engineer. Such judgement 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.

This report provides preliminary advice on geotechnical aspects for the proposed civil and structural design.

The offsite disposal of soil may require classification in accordance with the EPA guidelines as inert, solid, industrial or hazardous waste. We can complete the necessary classification and testing if you wish to commission us. As testing requires about seven days to complete, allowance should be made for such testing in the construction program unless testing is completed prior to construction. If contamination is found to be present then substantial further testing and delays should be expected.

If there is any change in the proposed development described in this report then all recommendations should be reviewed.

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. Copyright in this report is the property of Jeffery and Katauskas Pty Ltd. 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.

Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD

F Vega
Senior Associate

D J Bliss
Senior Geotechnical Engineer

Unit 3, 39 Buffalo Road
Gladesville, NSW 2111
Telephone: 02 9809 7322
Facsimile: 02 9809 7626
Email: dtreweek@jkgroup.net.au

STS
SOIL TEST SERVICES
ABN 43 002 145 173

Ref No:19029V

TABLE A
SUMMARY OF LABORATORY TEST RESULTS

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	**DEPTH m**	**MOISTURE CONTENT %**	**LIQUID LIMIT %**	**PLASTIC LIMIT %**	**PLASTICITY INDEX %**	**LINEAR SHRINKAGE %**
2	3.00-3.45	28.6	54	18	36	15.0
4	0.50-0.95	23.8	63	22	41	15.0
6	0.50-0.75	10.0				
6	1.50-1.65	10.2				
6	2.40-3.00	5.9				
6	3.50-4.50	11.3				
10	3.00-3.45	18.9	58	16	42	16.0
16	2.50-3.00	6.3				
16	3.50-4.50	1.8				
17	7.50-7.95	13.9	20	12	8	4.0

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **1**

1/1

Client: COASTAL HAMLETS PTY LTD

Project: PROPOSED RESIDENTIAL SUBDIVISION

Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V

Date: 15-11-04

Method: SPIRAL AUGER JK350

Logged/Checked by: M.S./

R.L. Surface: ≅ 46.5m

Datum: AHD

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Gravelly silty sand, fine to medium grained, black, with fine to coarse grained coal gravel.	D			
					SC	CLAYEY SAND: fine to medium grained, orange brown.	M	MD	-	
		N = 11 2,4,7								
			1			CLAYEY SAND: fine to medium grained, orange brown mottled light brown and red brown, with a trace of fine to medium grained quartz gravel.				
		N = 35 9,20,15						D		
			2		CH	GRAVELLY SILTY CLAY: high plasticity, light grey, with fine to medium grained quartz and ironstained basalt gravel, with a trace of fine to medium grained iron indurated gravel.	MC≅PL	H	>600	
		N = 31 7,11,20	3						>600 >600 >600	
			4		CH	SILTY CLAY: high plasticity, light grey, with iron indurated bands.				
		N = 28 12,13,15							>600 >600 520	
			5							
		N = 56 7,18,27	6						>600 >600 >600	
						END OF BOREHOLE AT 6.45m				
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
2
1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 32.5m
Date: 15-11-04 **Datum:** AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 2.25 HRS			0		SC	CLAYEY SAND: fine to medium grained, orange brown.	M	L		
	DS	N = 5 1,3,2								
			1							
	DS	N = 5 1,3,2								
			2							
					CH	SILTY CLAY: high plasticity, light grey, with iron indurated bands and fine to medium grained sand.	MC>PL	VSt -H		
	DS	N = 17 8,7,10	3						210 250 440	
			4		CH	GRAVELLY SILTY CLAY: high plasticity, dark grey and orange brown, with fine to medium grained sand and fine to medium grained quartz and ironstained basalt gravel.				
	DS	N = 34 10,25,9							300 400 210	
			5							
						as above, but light grey, mottled orange brown.				
	DS	N = 15 7,6,9	6						380 400 410	
						END OF BOREHOLE AT 6.45m				
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **3**
1/1

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 15-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 30.0m
Datum: AHD
Logged/Checked by: M.S./JM

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0		SM	SILTY SAND: fine to medium grained, light and dark grey.	M	L		
					SC	CLAYEY SAND: fine to medium grained, orange brown.				
		N = 6 2,2,4								
			1							
		N = 13 6,6,7						MD		
			2							
			3			CLAYEY SAND: fine to medium grained, light grey and orange brown, with cemented bands.		D		
		N = 31 18,17,14								
			4							
		N = 41 10,19,22								
			5							
						as above, but light grey and cemented.				
		SPT 30/150mm REFUSAL	6					VD		
						END OF BOREHOLE AT 6.15m				SPT REFUSAL ON INFERRED VERY DENSE CEMENTED CLAYEY SAND
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
4
1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 15-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 27.0m
Datum: AHD
Logged/Checked by: M.S./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0		CH	SILTY CLAY: high plasticity, light grey, mottled orange brown, with fine to medium grained sand, and fine to medium grained quartz and iron stained basalt gravel.	MC<PL	VSt -H		
	DS	N = 13 3,8,5					MC≅PL		360 420 470	
			1							
	DS	N = 13 7,7,6						VSt	200 300 320	
			2		CH	SILTY SANDY CLAY: high plasticity, light grey and orange brown, with fine to medium grained quartz iron stained basalt and iron indurated gravel.				
	DS	N = 18 7,7,11	3				MC>PL		250 300 300	
					CH	GRAVELLY SANDY CLAY: high plasticity, light grey and orange brown, with silt and fine to coarse grained quartz, ironstained basalt and iron indurated gravel.				
			4							
	DS	N = 20 6,9,11							250	
			5							
						as above, but light grey mottled light brown, with fine to coarse grained ironstained basalt gravel.				
	DS	N = 30 11,18,12	6						250	
						END OF BORHOLE AT 6.45m				
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **5**
1/1

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 16-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 45.0m
Datum: AHD
Logged/Checked by: M.S./

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 22.75 HRS			0			FILL: Gravelly silty sand, fine to medium grained, black, with fine to coarse grained coal gravel and slag cobbles.	D			
		N = 11 6,6,5	1			as above, but without slag cobbles.				APPEARS POORLY COMPACTED
		N = 6 1,3,3	2			FILL: Silty clay, medium plasticity, light grey, light brown, dark brown and orange brown, with fine to medium grained sand, black coal seams and fine to medium grained ironstained basalt gravel, with a trace of fine to coarse grained quartz gravel.	MC>PL		110 120	
		N = 12 4,6,6	3		CH	SILTY SANDY CLAY: high plasticity, orange brown mottled brown, with rootlet fibres and fine to coarse grained basalt and quartz gravel.	MC>PL	Vst	330 290	
		N = 44 16,17,27	4		CH	SILTY CLAY: high plasticity, light grey mottled orange brown, with iron indurated bands.	MC<PL	H	>600 >600 >600	
		N > 20 14,20/ 150mm REFUSAL	5 6		CL-CH	SILTY SANDY CLAY: medium to high plasticity, light grey with red brown seams and with cemented clayey sand bands, with a trace of fine to medium grained quartz gravel.			>600	
			7			END OF BOREHOLE AT 6.3m				SPT REFUSAL ON INFERRED CEMENTED CLAYEY SAND BAND

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 6

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD

Project: PROPOSED RESIDENTIAL SUBDIVISION

Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V

Date: 16-11-04

Method: SPIRAL AUGER JK350

R.L. Surface: ≅ 45.0m

Datum: AHD

Logged/Checked by: M.S./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 22 HRS			0			SILTY CLAYEY SAND: fine to medium grained, dark orange brown, with fine to coarse grained ironstained basalt gravel and fine grained shale gravel.	D	(D)		
		N > 20 19,20/ 100mm REFUSAL			-	SHALE: light and dark grey, with clay bands and with a trace of ironstained seams.	XW-DW	EL-VL	>600 >600	VERY LOW 'TC' BIT RESISTANCE
		SPT 20/150mm REFUSAL	1							
			2							
					-	SANDSTONE: fine to medium grained, orange brown, with medium strength iron indurated seams.	DW	L	-	LOW 'TC' BIT RESISTANCE
			3							
						SANDSTONE: fine to medium grained, light grey, light brown and orange brown, with medium to coarse grained quartz gravel.				LOW RESISTANCE WITH MODERATE BANDS
			4							
						END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
7
1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 16-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 43.5m
Datum: AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Silty sand, fine to medium grained, light and dark grey, with fine to coarse grained coal gravel.	M			APPEARS POORLY COMPACTED
		N = 6 1,4,2				FILL: Silty sand, fine to medium grained, orange brown, with a trace of cemented nodules.				
			1			as above, but with dark grey bands and fine to medium grained coal gravel.				
		N = 1 1,1/300mm			SM	SILTY SAND: fine to medium grained, orange brown with clay and fine to medium grained cemented nodules.	M-W	VL	-	APPEARS WATER LOGGED FROM 1.5m TO 2.2m
			2		SC	SILTY CLAYEY SAND: fine to medium grained, orange brown.	M	(MD)		
		N = 27 5,15,12	3					MD		
			4		SM	SILTY SAND: fine to medium grained, orange brown mottled light grey, cemented.		D-VD		
		N > 40 12,20, 20/50mm REFUSAL	5							
		SPT 20/150mm REFUSAL	6			END OF BOREHOLE AT 6.15m				
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **8**

1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD

Project: PROPOSED RESIDENTIAL SUBDIVISION

Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V

Date: 16-11-04

Method: SPIRAL AUGER JK350

R.L. Surface: ≅ 45.0m

Datum: AHD

Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty sandy gravel, black coal up to cobbles size.	W			APPEARS WELL COMPACTED
17.75 HRS AFTER COMPLETION	DS	N = 13 5,7,6				FILL: Silty sand clay/silty clayey sand, medium plasticity, fine to medium grained, dark brown and orange brown, with black timber pieces and root fibres.	MC>PL/ M			
			1							
	DS	N = 13 5,7,6			SC	SILTY CLAYEY SAND: fine to medium grained, orange brown, mottled red brown and light grey, with a trace of fine to medium grained quartz gravel.	M	MD	-	
			2			as above, but without quartz gravel.				
	DS	N = 21 7,6,15	3							
			4		SM	SILTY SAND; fine to medium grained, orange brown mottled red brown and light grey, cemented.		VD		
	DS	SPT 31/150mm REFUSAL								
			5							
	DS	N > 51 17,36, 15/50mm REFUSAL	6							
						END OF BOREHOLE AT 6.35m				
			7							

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 9

1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD

Project: PROPOSED RESIDENTIAL SUBDIVISION

Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 41.0m

Date: 16-11-04 **Datum:** AHD

Logged/Checked by: M.S./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Gravelly silty sand, fine to medium grained, dark grey, with fine to coarse grained igneous and basalt gravel.	D			
	DS	N = 14 1,7,7				FILL: Silty sand, fine to medium grained, yellow brown, with fine to coarse grained sandstone gravel.	MC<PL		450 520	APPEARS WELL COMPACTED
			1			FILL: Silty sandy clay, medium plasticity, dark brown, mottled orange brown with black ashy/coal seams and fine to medium grained quartz gravel.				
	DS	N = 11 7,4,7	2			FILL: Silty clay, medium to high plasticity, light grey, orange brown and dark brown, with fine to medium grained sand, fine to medium grained ironstained basalt gravel and black coal nodules.			430 450 430	
						as above, but with dark grey bands bands.				
	DS	SPT 27/150mm REFUSAL	3		SM	GRAVELLY SILTY SAND: fine to medium grained, orange brown mottled light grey, cemented with clay and fine to coarse grained ironstained basalt gravel.	D	D-VD	-	SPT REFUSAL ON GRAVEL
	DS	SPT 25/50mm REFUSAL	4							SPT REFUSAL ON GRAVEL
			5							
	DS	N > 41 15,41/ 150mm REFUSAL	6							
						END OF BOREHOLE AT 6.3m				SPT REFUSAL ON GRAVEL
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
10
1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 17-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 38.5m
Datum: AHD
Logged/Checked by: M.S./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 22.5 HRS			0			FILL: Clayey sand, fine to medium grained, orange brown, with black ashy/coal seams.	M			APPEARS WELL COMPACTED
					SC	SILTY CLAYEY SAND: fine to medium grained, orange brown, mottled light grey and red brown cemented.	M	D	-	
	DS	N = 33 10,18,15								
			1							
	DS	N = 45 14,20,25								
			2							
			3		CH	SILTY CLAY: high plasticity, light grey with fine to medium grained sand.	MC≅PL	H	450 530 >600	
	DS	N = 30 11,15,15								
			4			SILTY CLAY: high plasticity, light grey with red brown seams, mottled orange brown.	MC<PL			
	DS	N = 28 10,15,13							540 >600 >600	
			5			as above, but with red brown bands.				
			6		CL-CH	SILTY SANDY CLAY: medium to high plasticity, light grey, orange brown and red brown, with fine to medium grained iron indurated basalt gravel.	MC>PL		420 470 >600	
	DS	N = 15 8,6,9								
						END OF BOREHOLE AT 6.45m				
			7							

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **11**

1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD

Project: PROPOSED RESIDENTIAL SUBDIVISION

Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V

Date: 17-11-04

Method: SPIRAL AUGER JK350

R.L. Surface: ≅ 33.5m

Datum: AHD

Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 21.75 HRS			0			ASPHALTIC CONCRETE: 60mm.t	D	-	-	SUBBASE
						FILL: Gravelly silty sand, fine to medium grained, dark orange brown, with fine to coarse grained basalt gravel.	D	MD	-	
	DS	N = 25 9,12,13			SC	SILTY CLAYEY SAND: fine to medium grained, light grey, red brown and orange brown, with a trace of fine to medium grained basalt and quartz gravel.				
			1				M			
	DS	N = 16 5,8,8								
			2		SM	GRAVELLY SILTY SAND: fine to medium grained, light grey mottled orange brown and red brown, with clay and fine to medium grained ironstained basalt gravel.				
	DS	N = 39 26,14,25	3					D		
					SC	SILTY CLAYEY SAND: fine to medium grained, light grey and red brown, mottled orange brown, with silty clay seams.				
			4							
	DS	N = 27 5,13,14								
			5							
	DS	SPT 20/150mm REFUSAL	6			END OF BOREHOLE AT 6.15m				SPT REFUSAL ON INFERRED VERY DENSE SILTY CLAYEY SAND
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
12
1/1

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 30.0m
Date: 17-11-04 **Datum:** AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 20.5 HRS			0			FILL: Silty clayey sand, fine to medium grained, dark orange brown, with fine to medium grained coal gravel and with a trace of rootlets fibres.	M			DENSE GRASS COVER APPEARS POORLY COMPACTED
	DS	N = 4 2,2,2			SC	SILTY CLAYEY SAND: fine to medium grained, orange brown, with a trace of fine to medium grained ironstained basalt gravel.	M	L	-	
			1			CLAYEY SAND: fine to medium grained, orange brown mottled light grey, with silt.		MD		
	DS	N = 12 2,5,7								
			2							
	DS	N = 26 10,11,15	3							
			4							
	DS	N > 50 33,38, 12/50mm REFUSAL			SM	SILTY SAND: fine to medium grained, orange brown mottled light grey and red brown, cemented.		D-VD		
			5							
	DS	N = 42 23,20,22	6							
						END OF BOREHOLE AT 6.45m				
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **13**
1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 17-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 34.5m
Datum: AHD
Logged/Checked by: M.S./ℋ

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 20 HRS			0			FILL: Silty sand, fine to medium grained, black, with fine to medium grained coal gravel.	M			APPEARS POORLY COMPACTED
		N = 5 1,3,2				FILL: Gravelly silty sand, fine to medium grained, brown, with clay and fine to medium grained basalt gravel, with a trace of plastic pieces.				
			1			FILL: Silty clay, medium plasticity, brown, with fine to medium grained sand, fine to medium grained basalt and coal gravel, with a trace of root fibres and black timber pieces.	MC>PL			
		N = 5 2,3,2	2						130 180 200	
					SC	SILTY CLAYEY SAND: fine to medium grained, light grey, red brown and orange brown, with a trace of fine to medium grained basalt gravel, cemented.	M	D	-	
		N = 41 11,17,24	3							
			4							
		N = 52 13,16,36				as above, but with fine to medium grained basalt and quartz gravel and with a trace of silty clay seams.		VD		
			5							
		SPT 25/100mm REFUSAL	6			END OF BOREHOLE AT 6.1m				SPT REFUSAL ON VERY DENSE CEMENTED SAND
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
14
1/2

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 17-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 25.0m
Datum: AHD
Logged/Checked by: M.S./ny

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						0			FILL: Gravelly silty sand, fine to medium grained, black, with coal up to cobble size.	D			
				■	N > 20 14,20/ 50mm REFUSAL								APPEARS POORLY TO MODERATELY COMPACTED
						1							
				■	N = 6 1,3,3								
									as above, but with orange brown, light grey and red brown silty sandy clay bands, with fine to medium grained iron indurated gravel inclusions in bands.			300	
						2							
				■	N = 22 9,9,13	3						320	APPEARS MODERATELY COMPACTED
						4							
				■	N = 12 4,6,6								
						5							
						6			as above, but without clay bands.	M			
						7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **14**

2/2

Client: COASTAL HAMLETS PTY LTD

Project: PROPOSED RESIDENTIAL SUBDIVISION

Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 25.0m

Date: 17-11-04 **Datum:** AHD

Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
19.25 HRS AFTER COMPLETION (at ~8.3m)			8, 9, 10			FILL: Gravelly silty sand, fine to medium grained, black with coal up to cobble size.	M			APPEARS MODERATELY COMPACTED
▶ (at ~10.5m)	DS	N = 1 1/300mm,1				FILL: Clayey silt, low plasticity, dark grey, with fine to medium grained sand.	MC>>PL	F	80 70 80	HIGH HYDROCARBON ODOUR POSSIBLY PEAT
	DS	N = 11 6,6,5	11, 12		CL-CH	SILTY CLAY: medium to high plasticity, light and dark grey.	MC>PL	VSt	- 340 340 330	
			13, 14			END OF BOREHOLE AT 12.45m				

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **15**

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 23.0m
Date: 17-11-04 **Datum:** AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Clayey silt, low plasticity, black, with fine to medium grained sand and fine to medium grained coal gravel and with a trace of fine to medium grained basalt gravel.	MC>PL			APPEARS POORLY TO MODERATELY COMPACTED
	DS	N = 5 3,3,2							180 200 200	
			1							
	DS	N = 6 3,3,3							200 220 200	
			2							
	DS	N = 12 6,6,6	3			FILL: Gravelly silty sand, fine to medium grained, black with coal up to cobble size and with a trace of fine to coarse grained slag gravel.	M			APPEARS MODERATELY TO WELL COMPACTED
			4							
			5							
			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
15
2/2

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 23.0m
Date: 17-11-04 **Datum:** AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	DS	N = 15 9,8,7				FILL: Gravelly silty sand, fine to medium grained, black, with coal up to cobble sizes, and with a trace of fine to coarse grained slag gravel.	M			APPEARS MODERATELY TO WELL COMPACTED
			8			as above, but with slag up to cobble size.				
			9							
			10							
17.75 HRS AFTER COMPLETION			11							
	DS	N = 11 5,6,5	12		SM	SILTY SAND: fine to medium grained, light grey, with orange brown seams and clay.	W	MD	-	
			13		CL-CH	SILTY SANDY CLAY: medium to high plasticity, light grey with orange brown seams and fine to medium grained ironstained basalt gravel.	MC>PL	VSt		
	DS	N = 28 6,11,17							220 230 300	
			14			END OF BOREHOLE AT 13.95m				

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
16
1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 17-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 28.5m
Datum: AHD
Logged/Checked by: M.S./[illegible]

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 17.25 HRS			0			ASPHALTIC CONCRETE: 40mm.t	D	-	-	
						FILL: Silty sand, fine to medium grained, black, with fine to medium grained coal gravel and with a trace of fine to medium grained slag gravel.				APPEARS MODERATELY COMPACTED
		N = 22 4,14,8								
			1			FILL: Silty clay, low to medium plasticity, black mottled orange brown and light grey, with fine to medium grained sand, fine to medium grained iron indurated gravel and gravelly coal bands.	MC<PL		590	
							MC>PL			
		N = 10 7,5,5							330 350 360	
			2		SC	SILTY CLAYEY SAND: fine to medium grained, light grey and orange brown, with fine to medium grained iron indurated gravel.	M	(MD)	-	
					-	SANDSTONE: fine to medium grained, orange brown and light grey, with fine to medium grained iron indurated gravel.	DW-SW	L-M	-	LOW TO MODERATE 'TC' BIT RESISTANCE
			3		-	CONGLOMERATE: fine to medium grained, orange brown and light grey, with medium to coarse grained ironstained basalt gravel.	SW	H		HIGH RESISTANCE
			4							
						END OF BORHOLE AT 4.5m				
			5							
			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
17
1/2

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 26.0m
Date: 18-11-04 **Datum:** AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty sand, fine to medium grained, black, with fine to coarse grained coal and slag gravel.	D			APPEARS MODERATELY TO WELL COMPACTED
	DS	N = 16 6,9,7								
			1			as above, but with light grey and orange brown silty sandy clay /silty clayey sand bands.				
	DS	N = 11 5,6,5							250 280	
			2							
	DS	N = 8 4,3,5	3							
						FILL: Silty sand, fine to medium grained, black, with fine to coarse grained coal gravel and slag up to cobble size and with silty clayey sand bands.	M			
			4							
	DS	N = 45 19,25,20								
			5							
4.25 HRS AFTER COMPLET-ION			6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
17
2/2

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 26.0m
Date: 18-11-04 **Datum:** AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
					CL	SILTY CLAY: medium plasticity, light grey and red brown mottled orange brown, with fine to medium grained sand.	MC≅PL	(VSt)		HP = 300kPa ON DISTURBED AUGER SAMPLE AT 7.2m
▶	DS	N = 10 6,6,4			SC	CLAYEY SAND: fine grained, light grey mottled red brown and orange brown, with fine to medium grained iron indurated gravel.	MC>>PL	MD		
	DS		8		CL	SILTY CLAY: medium plasticity, light and dark grey, mottled red brown.	MC≅PL	(VSt -H)		HP = 370kP ON DISTURBED AUGER SAMPLE AT 8.2m HP = 450kPa ON DISTURBED AUGER SAMPLE AT 8.7m
			9			END OF BOREHOLE AT 9.0m				
			10							
			11							
			12							
			13							
			14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
18
1/2

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 24.5m
Date: 18-11-04 **Datum:** AHD

Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION & AFTER 3.25 HRS			0			FILL: Clayey silt, low plasticity, black, with fine to medium grained sand and fine to coarse grained coal gravel.	MC>PL			
	DS	N = 14 3,7,7							200 230 200	APPEARS MODERATELY TO WELL COMPACTED
			1			FILL: Silty sand, fine to medium grained, dark brown, with orange brown clayey sand seams and fine to medium grained coal gravel.	M			
	DS	N = 14 7,7,7								
			2			FILL: Clayey silt, low plasticity, black, with fine to medium grained sand and with a trace of fine to medium grained coal and claystone gravel.	MC>PL			
	DS	N = 4 2,2,2	3				MC>>PL		50 40 60	APPEARS WATER LOGGED BETWEEN 3.0-3.5m
						as above, but with fine to medium grained slag gravel.	MC>PL			APPEARS MODERATELY TO WELL COMPACTED
			4							
	DS	N = 28 15,14,14				FILL: Gravelly silty sand, fine to medium grained, black mottled light grey and orange brown, with silty clay seams and fine to coarse grained coal and slag gravel.	M			
			5							
						FILL: Silty clay/clayey silt, low to medium plasticity, black mottled light grey, with fine to medium grained sand and with a trace of fine to coarse grained coal and fine to medium grained basalt gravel.	MC>PL			
	DS	N = 12 6,6,6	6						180 320 250	
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
18
2/2

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 24.5m
Date: 18-11-04 **Datum:** AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						FILL: Silty clay/clayey silt, low to medium plasticity, black mottled light grey, with fine to medium grained sand and with a trace of fine to coarse grained coal and fine to medium grained basalt gravel.	MC>PL			
					CL-CH	SANDY CLAY: medium to high plasticity, light grey and orange brown, with red brown silty sand seams.	MC≅PL	H	-	
	DS	N = 23 5,6,17							450 560 >600	
			8		SC	CLAYEY SAND: fine to medium grained, light grey, orange brown and red brown.	M	D		
	DS	N = 31 9,16,15	9							
						END OF BOREHOLE AT 9.45m				
			10							
			11							
			12							
			13							
			14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
19
1/2

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V | **Method:** SPIRAL AUGER JK350 | **R.L. Surface:** ≅ 22.5m
Date: 18-11-04 | **Datum:** AHD

Logged/Checked by: M.S./ [illegible]

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty sand, fine to medium grained, dark brown, with fine to medium grained basalt gravel.	M			GRASS COVER
	DS	N = 16 9,10,6				FILL: Sandy clay, medium plasticity, light grey and orange brown, with black gravelly silty sand bands and with fine to medium grained coal inclusions in bands.	MC<PL		>600 >600	APPEARS POORLY TO MODERATELY COMPACTED
			1							
	DS	N = 6 3,3,3				FILL: Silty sand, fine to medium grained, brown, with orange brown clayey sand seams and fine to medium grained quartz gravel.	M-W			
			2							
2 HRS AFTER COMPLETION										
	DS	N = 15 6,6,9	3			FILL: Gravelly silty sand, fine to medium grained, black, with fine to medium grained coal gravel.				
▶							W			APPEARS POORLY COMPACTED
			4							
		N = 2 1,1,1								
			5							
					SM	GRAVELLY SILTY SAND: fine to medium grained, light grey with clay and fine to medium grained quartz and basalt gravel.	W	MD	-	
	DS	N = 14 6,7,7	6							
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
19
2/2

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 22.5m
Date: 18-11-04
Datum: AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■	SPT 25/150mm REFUSAL				GRAVELLY SILTY SAND: fine to medium grained, light grey with clay and fine to medium grained quartz and basalt gravel.	W	(MD)		
									END OF BOREHOLE AT 7.65m				SPT REFUSAL ON GRAVEL
						8							
						9							
						10							
						11							
						12							
						13							
						14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
20
1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V **Method:** SPIRAL AUGER JK350 **R.L. Surface:** ≅ 18.5m
Date: 18-11-04 **Datum:** AHD
Logged/Checked by: M.S./ [signature]

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Silty sand, fine to medium grained, black, with fine to coarse grained coal gravel.	D			
	DS	N = 20 3,10,10								APPEARS WELL COMPACTED
			1			FILL: Silty sandy clay, medium plasticity, orange brown and dark brown, with fine grained coal gravel.	MC>PL		120	
	DS	N = 16 3,5,11			SC	SILTY CLAYEY SAND: fine to medium grained, orange brown and light grey, mottled red brown, with silty clay bands.	M	MD-D	550	
			2							
	DS	N = 32 10,17,15	3						>600	
			4							
	DS	N = 20 22,10,10							420	
			5							
	DS	N > 50 33,32, 28/100mm	6		SM	SILTY SAND: fine to medium grained, orange brown and light grey, cemented.		VD		
		REFUSAL				END OF BOREHOLE AT 6.4m				SPT REFUSAL ON VERY DENSE CEMENTED SILTY SAND
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

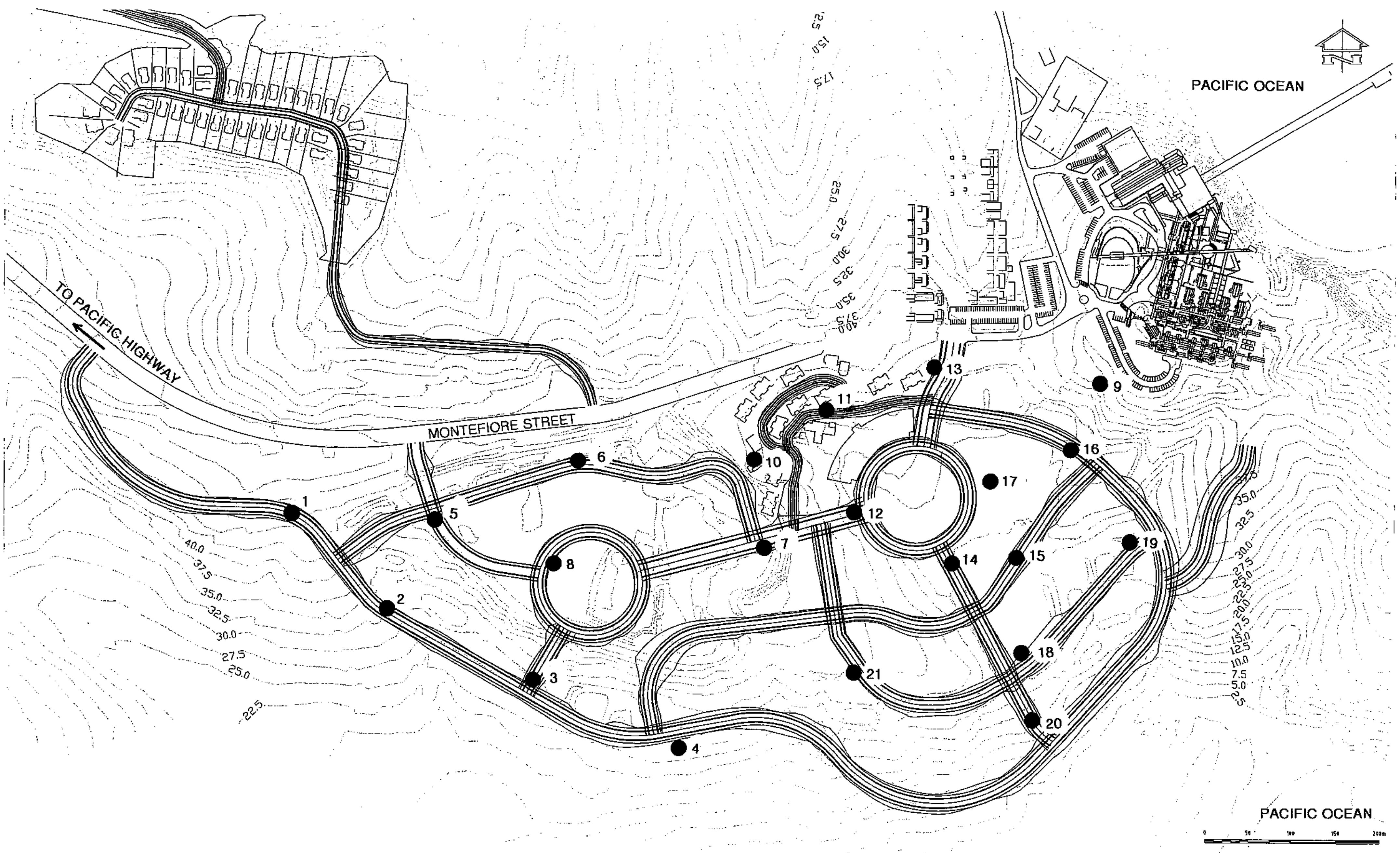
Borehole No.
21
1/1

BOREHOLE LOG

Client: COASTAL HAMLETS PTY LTD
Project: PROPOSED RESIDENTIAL SUBDIVISION
Location: MOONEE COLLIERY, MONTEFIORE STREET, CATHERINE HILL BAY/MOONEE, NSW

Job No. 19029V
Date: 18-11-04
Method: SPIRAL AUGER JK350
R.L. Surface: ≅ 34.5m
Datum: AHD
Logged/Checked by: M.S./

Groundwater Record	SAMPLES ES U50 DB DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION			0			FILL: Silty sand, fine to medium grained, light grey, with a trace of root fibres.	D			DAM EMBANKMENT APPEARS WELL COMPACTED
	DS	N = 17 6,8,9								
			1							
						FILL: Sandstone floater, 500mm.t				LOW TO MODERATE RESISTANCE
	DS		2			FILL: Silty clay, high plasticity, light grey and orange brown, with fine to medium grained sand.	MC≅PL			APPEARS WELL COMPACTED
						FILL: Silty sand, fine to medium grained, light grey and brown, with fine to coarse grained slag gravel.	D			
	DS	N = 26 10,10,16	3							
					CL-CH	GRAVELLY SILTY CLAY: medium to high plasticity, orange brown, light and dark grey, with fine to medium grained sand and fine to medium grained quartz basalt and claystone gravel.	MC≅PL	H	-	APPARENT BASE OF DAM EMBANKMENT
			4							
	DS	N = 25 12,13,12							490 500 590	
			5							
	DS	N = 25 16,12,13	6						410 490 430	
						END OF BOREHOLE AT 6.45m				
			7							

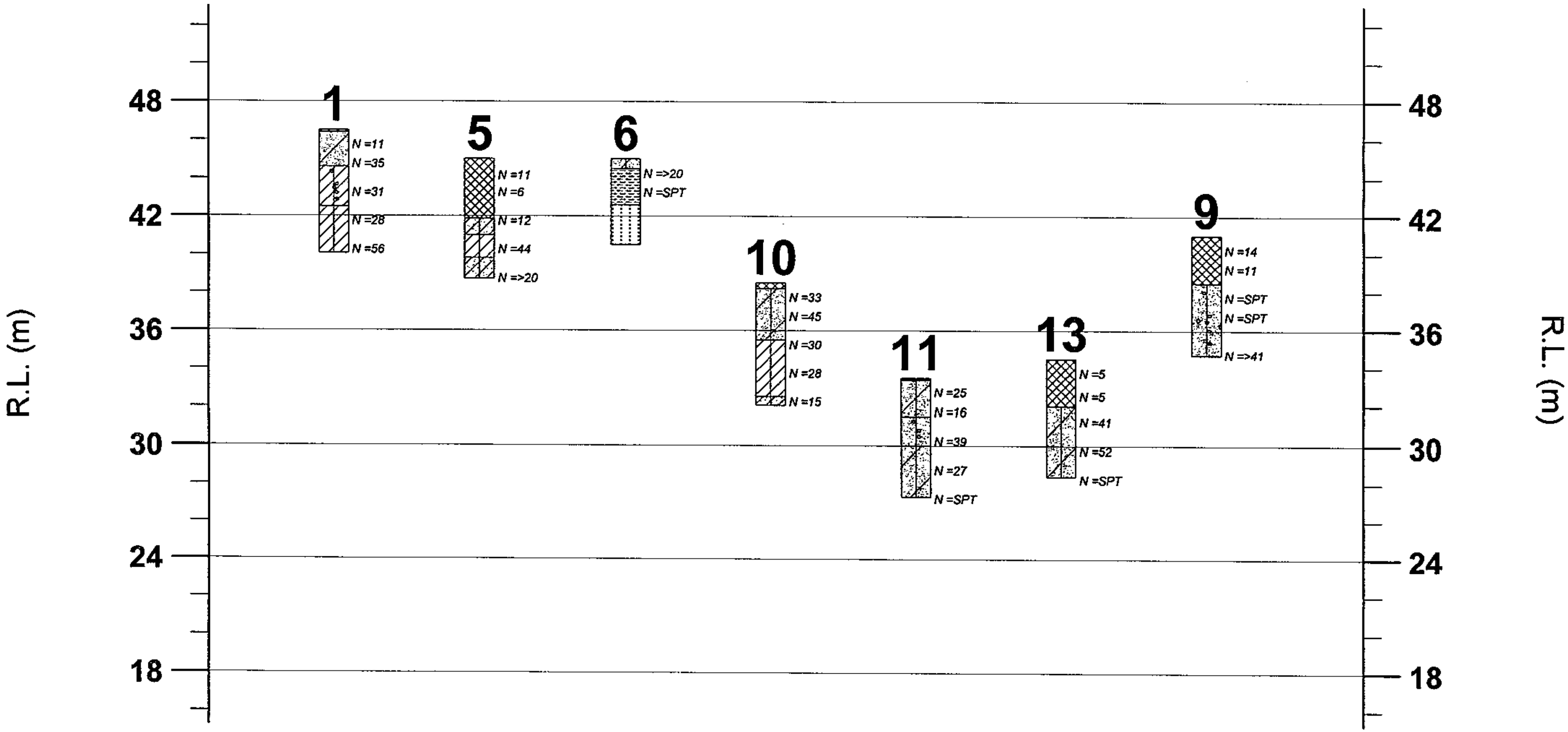


BOREHOLE LOCATION PLAN

Jeffery and Katauskas Pty Ltd

Report No. 19029V **Figure No. 1**

GRAPHICAL BOREHOLE SUMMARY



Fill

Clayey Sand

Silty Gravelly Clay

Silty Clay

Sandy Silty Clay

Clayey Silty Sand

Shale

Sandstone

Asphaltic/ Bituminous Paving or Coal

Silty Gravelly Sand

N SPT "N" VALUE

Nc SOLID CONE BLOW COUNTS PER 150mm

NOTE: REFER TO BOREHOLE LOGS

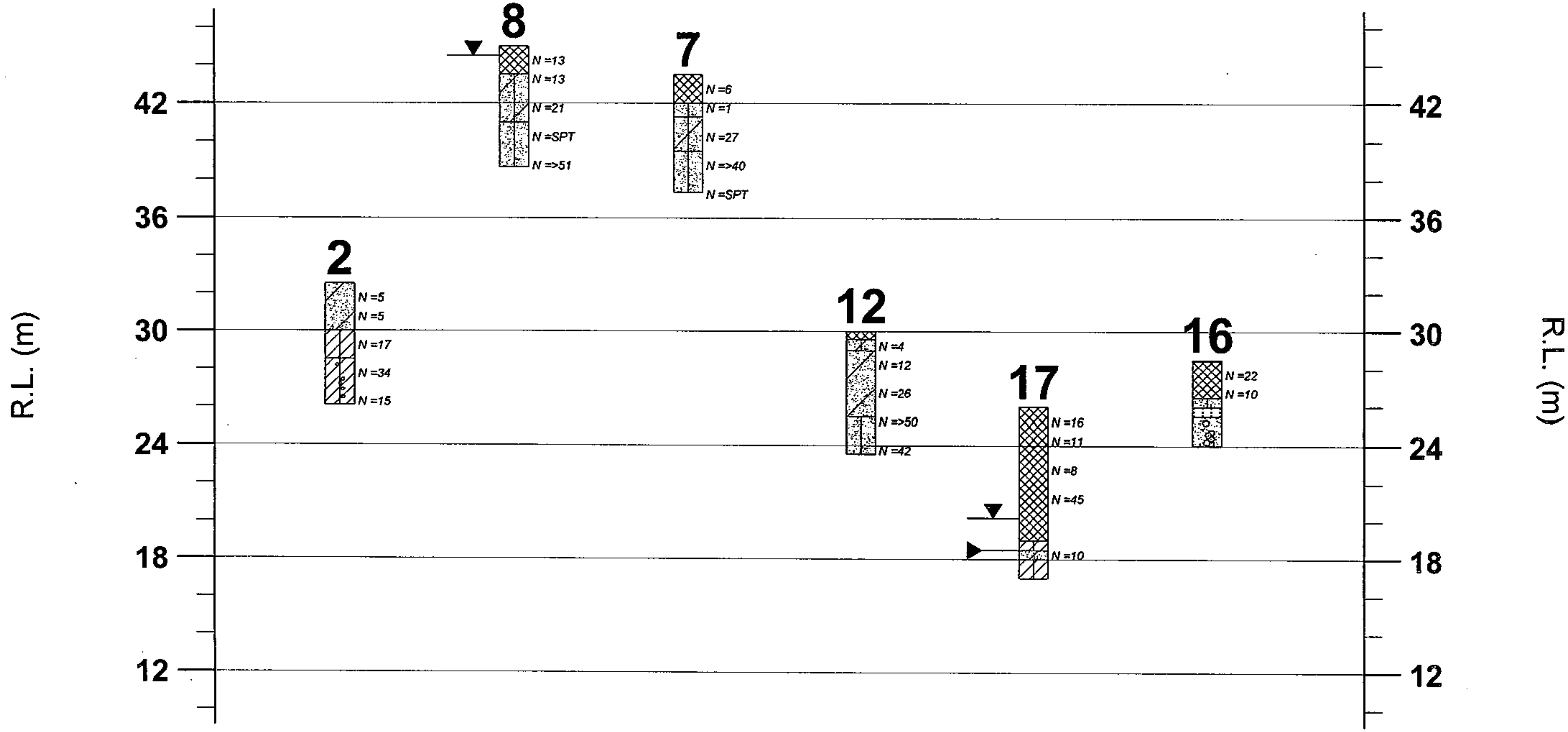
Scale: 1 : 300 (vert) ; NTS (horiz)

Jeffery and Katauskas Pty Ltd

Job No.: 19029V

Figure No.: 2a

GRAPHICAL BOREHOLE SUMMARY



Clayey Sand
Silty Clay
Silty Gravelly Clay
Fill
Clayey Silty Sand
Silty Sand
Asphaltic/ Bituminous Paving or Coal
Sandstone
Conglomerate
Observed water level
Groundwater seepage level
N SPT "N" VALUE
Nc SOLID CONE BLOW COUNTS PER 150mm

NOTE: REFER TO BOREHOLE LOGS

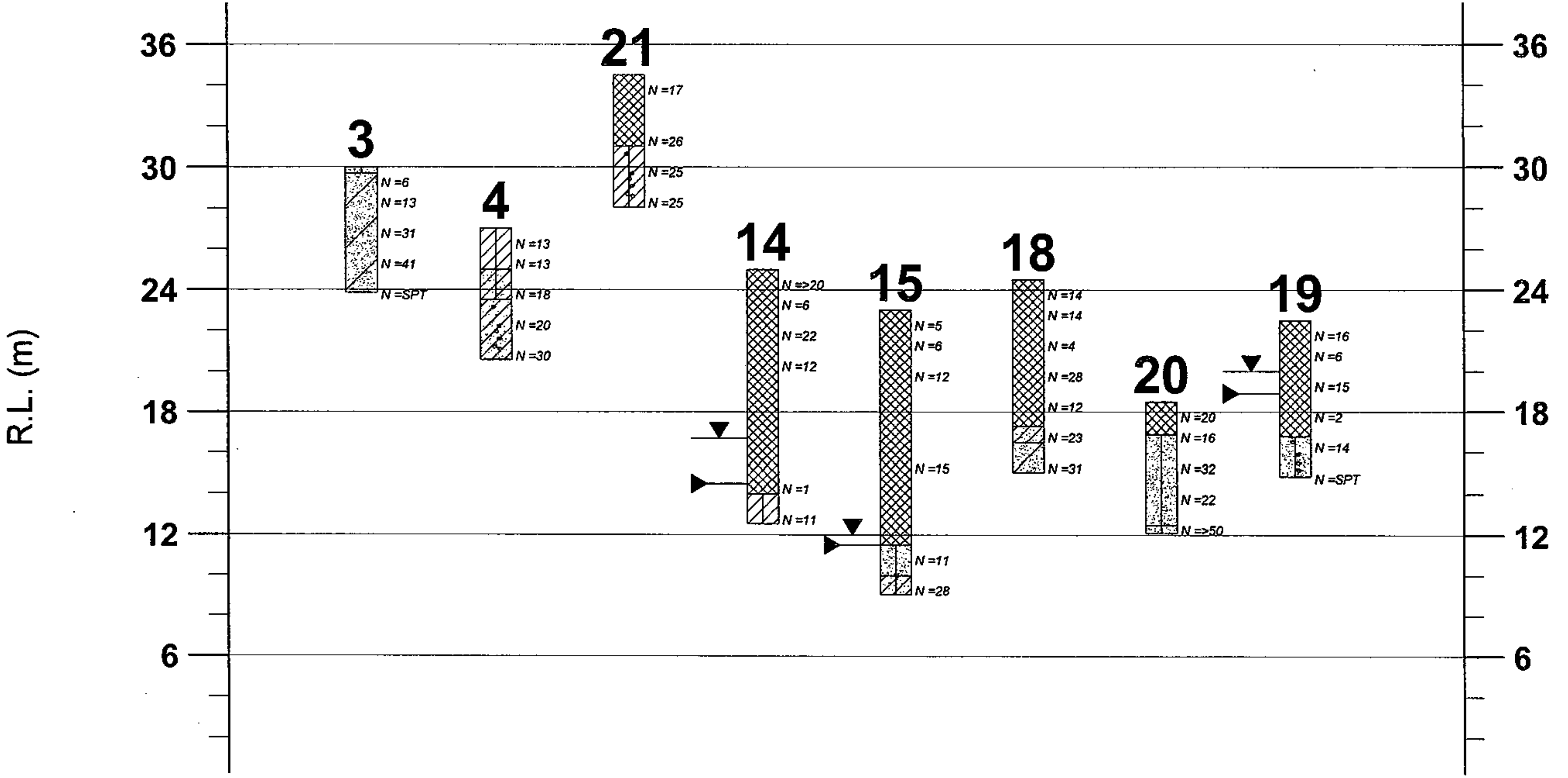
Scale: 1 : 300 (vert) ; NTS (horiz)

Jeffery and Katauskas Pty Ltd

Job No.: 19029V

Figure No.: 2b

GRAPHICAL BOREHOLE SUMMARY



Silty Sand
Sandy Silty Clay
Silty Gravelly Clay
Silty Gravelly Sand
Clayey Sand
Gravelly Sandy Clay
Sandy Clay
Silty Clay
Fill

Observed water level

Groundwater seepage level

N SPT "N" VALUE

Nc SOLID CONE BLOW COUNTS PER 150mm

NOTE: REFER TO BOREHOLE LOGS

Scale:	1 : 300 (vert) ; NTS (horiz)
Jeffery and Katauskas Pty Ltd	
Job No.: 19029V	Figure No.: 2c

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
A.B.N. 17 003 550 801 A.C.N. 003 550 801

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. 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.

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 an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm 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 an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm 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 EFCP and SPT values can be developed for both sands and clays but may be site specific.

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

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

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

Two relatively similar tests are used:

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

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible or 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.

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

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

ROCK

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

DEFECTS AND INCLUSIONS

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

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

UNIFIED SOIL CLASSIFICATION TABLE

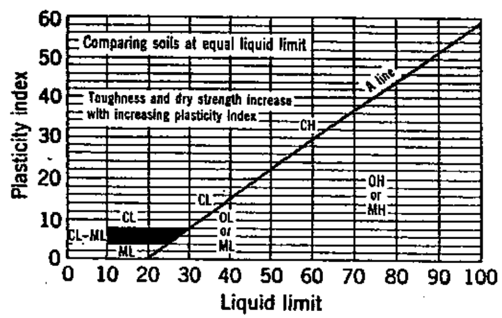
Major divisions			Field Identification Procedures (Excluding particles larger than 75 µm and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils More than half of material is *larger* than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

(The 75 µm sieve size is about the smallest particle visible to naked eye)

Laboratory classification (coarse-grained): 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 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols

Identification Procedures on Fraction Smaller than 380 µm Sieve Size

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



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. 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.

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

A.B.N. 17 003 550 801 A.C.N. 003 550 801

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.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		Density Index (I_D) Range (%) — SPT 'N' Value Range (Blows/300mm)
	VL	Very Loose <15 — 0-4
	L	Loose 15-35 — 4-10
	MD	Medium Dense 35-65 — 10-30
	D	Dense 65-85 — 30-50
	VD	Very Dense >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

Ref: Log Symbols
August 2001

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
A.B.N. 17 003 550 801 A.C.N. 003 550 801

LOG SYMBOLS

ROCK MATERIAL WEATHERING CLASSIFICATION

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

ROCK STRENGTH

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

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

ABBREVIATIONS USED IN DEFECT DESCRIPTION

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

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

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

ROCK

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

DEFECTS AND INCLUSIONS

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

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM