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REPORT

TO

PAYCE COMMUNITIES PTY LTD

ON

GEOTECHNICAL INVESTIGATION

FOR

RIVERWOOD NORTH RENEWAL PROJECT

AT

WASHINGTON AVENUE, RIVERWOOD, NSW

8 November 2010

Ref: 24375VTrpt

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1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed Riverwood North Renewal Project at Washington, Avenue, Riverwood, NSW. Mr Miled Akle of M Projects commissioned the investigation on behalf of Payce Communities Pty Ltd on the basis of our Proposal, Ref. P32984VT Riverwood.

We have been provided with architectural concept plans prepared by Turner+ Associates showing the layouts and sections for the proposed development. From these drawings, we understand that the existing buildings and site improvements are to be demolished and a series of multi-level residential buildings constructed on the site. The three Phase 01 buildings that are located in the south-east corner are to be at-grade, whilst the other buildings will mostly likely have shared single and possibly two basement car parking levels. There is to be communal open space between the buildings, a new park, a play-ground and picnic area. A new road is to be constructed between Washington Avenue and Kentucky Road between the Phase 01 and Phase 02 buildings. Although earthworks levels have not been supplied or determined we assume that some cut and fill earthworks will be required to accommodate the proposed constructions. Structural loads have not been supplied and therefore, light to moderate loads have been assumed for this type of development.

The scope of the investigation was limited to obtaining geotechnical information on subsurface conditions at 20 locations as a basis for comments and recommendations on geotechnical issues relevant to the proposed development (such as excavation, batters and shoring, vibration effects, hydro-geology, retaining wall, footing, on-ground slab and pavement design, and on soil aggressivity), and any further work deemed necessary for construction.

A summary of the principal geotechnical issues for the proposed development is provided in Section 4.1.

2 INVESTIGATION PROCEDURE

The field work for the investigation was completed over six days of drilling between 13 and 22 October 2010 and comprised the drilling of 20 boreholes (BH1 to BH20) to depths ranging from 7.8m and 9.90m below existing surface levels. The boreholes were drilled using our JK350 truck mounted drill rig and JK250 and JK305 track mounted drill rigs. The soil and weathered rock was initially augered to depths ranging from 5.83m and 8.0m after which seven of the boreholes (BHs 2, 5, 8, 10, 12, 18 and 20) were extended into the bedrock by rotary diamond coring techniques, using an NMLC triple tube core barrel with water flush. Prior to drilling, the test locations were checked by a specialist sub-contractor for buried services using electronic detection equipment, after referring to 'Dial Before You Dig' services drawings. The borehole locations are shown on Figure 1.

The compaction of the fill and the strength/relative density of the subsoil profile were assessed from the Standard Penetration Test (SPT) 'N' values, together with hand penetrometer readings on clayey soils recovered in the SPT split spoon sampler and by tactile examination.

The strength of the underlying augered bedrock was assessed by observation of penetration resistance when fitted with a tungsten carbide (TC) bit, together with examination of recovered rock cuttings. It should be noted that strengths assessed in this way are approximate and variances of one strength order should not be unexpected. The strength of the cored bedrock was assessed by examination of the recovered rock cores, together with correlations with subsequent laboratory Point Load Strength Index ($I_{s(50)}$) tests.

Groundwater observations were also made in the boreholes. Further details of the methods and procedures employed in the investigation are presented in the attached Report Explanation Notes.

The boreholes were set out using taped measurements from existing site features and boundaries. The approximate reduced levels of the boreholes were interpolated from spot heights from the survey plans (Ref. 080821, dated 3 October 2008) prepared by Denny Linker & Co. The datum is Australian Height Datum (AHD).

Our geotechnical engineers, Mr Li Yang and Mr Adrian Callus, were present full-time during the fieldwork to nominate testing and sampling, and to prepare the attached borehole logs. The Report Explanation Notes define the logging terms and symbols used.

Selected samples were returned to NATA registered laboratories, Soil Test Services Pty Ltd (STS) and Envirolab Services Pty Ltd, for soil pH, soil sulphate and chloride content, moisture content, Atterberg Limits, linear shrinkage, compaction and four day soaked CBR tests. The results are summarised in the attached Tables A and B, and on the Envirolab Services Test Report. The recovered rock cores were also returned to STS for photographing and Point Load Strength Index testing. The photographs are enclosed facing the relevant cored borehole logs. The Point Load Strength Index test results are plotted on the borehole logs and are summarised in the attached Table C. The unconfined compressive strengths (UCS), as estimated from the Point Load Strength Index test results, are also summarised in Table C. Environmental testing of site soils and groundwater was outside the scope of this investigation.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The surrounding topography consists of gently undulating terrain. The site itself slopes gently down to the north-east at slopes of about 3° to 4°. Washington Avenue forms the southern boundary. Kentucky Road runs from Washington Avenue initially to the north, turns to the west where it meets Vermont Cresent, then continues to the north-west. These two roads presently sub-divide the region into two areas. The detailed survey indicates that surface levels fall generally towards the north-east, from RL18m at the south-east corner to about RL10m along part of the north-east boundary.

At the time of the field work, the site contained several single to three storey brick residential buildings, car parks and driveways paved with asphaltic concrete or concrete, grassed areas and a basketball court. There were numerous trees scattered throughout the site areas.

The neighbouring properties to the south of Washington Avenue are occupied by multi-storey unit blocks, with a line of trees on the street frontage. The areas to the west contain one to three storey brick residential buildings, grassed areas, roads and car parks, and numerous trees scattered through the properties. Riverwood Community Gardens are located to north-west. Further to the north, there is a large grassed reserve known as "Salt Pan Creek Reserve". A concrete footpath runs from Washington Street to the north, past the eastern site boundary, turns and continues to the north-west (adjacent to the north-east boundary) providing access to the Gardens and into the reserve. The path is bounded by grass with a large pond further to its north-east. The roads are surfaced with asphaltic concrete. The area between Kentucky Road and Vermont Cresent is covered with grass and a few trees.

3.2 Subsurface Conditions

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

The boreholes revealed pavements and shallow to moderately deep fill covering residual silty clay grading into extremely weathered shale and sandstone bedrock. The strength of the shale gradually increased with depth, while the degree of weathering decreased. A summary of the substrata encountered is discussed in the following and illustrated in the graphical borehole summaries presented in the attached Figures 2A to 2D. For more detailed descriptions of the materials encountered at the specific locations, reference should be made to the borehole logs.

1. **Existing Pavement** comprising asphaltic concrete, 10mm thick, covered the ground surface at BH13.

2. **Fill**, mainly silty clay of low to medium plasticity or silty sand in places, was encountered below the AC in BH13 or from the ground surface in the other boreholes. The fill varied in depth from less than 0.1m to 1.6m and contained varying amounts of igneous, ironstone, and shale gravel, and traces of slag, roots and root fibres. The fill was generally assessed to be in the poorly to moderately compacted range. This assessment is based on in-situ SPT tests, and our observations during drilling, which do not give a precise determination of in-situ densities since they are affected by friction during driving/pushing, the presence of gravel within the fill and the moisture content of the fill. Nonetheless, they provide a qualitative guide. The fill extends down to the residual silty clay.

3. **Residual Silty Clay** of medium to high plasticity was encountered below the fill in each borehole. The silty clay was assessed to be predominantly in the very stiff to hard strength range and in places, was interbedded with ironstone bands, and grades into weathered shale bedrock. In BHs 7, 10 and 15, the clay was in a moderately moisture weakened (stiff) condition.

4. **Weathered Shale Bedrock** was encountered in the boreholes beneath the residual silty clay at depths ranging from 1.6m to 4.5m. The shale was relatively variable both in weathering and strength. On first contact, the shale was assessed to be extremely to distinctly weathered and generally of extremely low or extremely low to very low strength. Also, this poor quality shale in BHs 1, 9 and 18, was interbedded with hard clays. The shale profile was interbedded with iron indurated seams, particularly within the poorer quality rock, and in places, was interbedded with sandstone. Better quality shale of at least low strength was intersected at depths between 4.0m and 7.0m. The shale generally improved becoming medium strength or better with increasing depth. The shale was core drilled at depths between 5.83m and 7.08m. The rock defects in the recovered cores was characterised by cross bedding, extremely weathered/clay seams/crushed seams, fragmented zones, bedding partings, and inclined joints ranging from 40° to sub-vertical. The core loss zones are inferred to be extremely weathered seams or fractured bands or jointed rock ground away during the coring process.

5. **Weathered Sandstone Bedrock** was encountered at 7.45m in BH5, at 7.2m in BH6, at 6.1m in BH8, at 7.0m in BH9, and at 7.6m in BH10. The sandstone was of medium to very high strength.

6. **Groundwater** seepage was encountered at 6.3m in BH7, at 2.85m in BH8, and at 7.0m in BH11 during auger drilling. Groundwater was measured at depths between 2.0m and 7.5m on or shortly after completion of augering drilling.

Five boreholes (BHs 5, 17 to 20) were dry during and upon completion of augering. During the coring process there was no water loss in the cored boreholes indicating a relatively impermeable rock mass. Water measurements after coring do not indicate groundwater levels because of the water volume added during the rock coring process. No long-term groundwater monitoring was carried out.

3.3 Laboratory Test Results

The results of laboratory tests on the silty clays confirm their medium and high plasticity and indicated these clays to have a moderate to high potential for shrink/swell movements with changes in moisture content. The moisture content tests on the rock samples correlated reasonably with the field strength assessments. The four day, soaked CBR values were 2% for the high plasticity silty clay or 2% and 3.5% for the silty clay of medium plasticity when re-compacted to 98% of Standard Maximum Dry Density. The samples absorbed water during soaking and the vertical swell of 1.5% or 2% corroborates the inferred high potential for shrink/swell reactivity.

The Point Load Strength Index test results on the recovered rock core generally corresponded well with our field assessment of the in-situ rock strength. The approximate Unconfined Compressive Strengths (UCS) of the rock core varied significantly from less than 2MPa to 90MPa as shown on Table C.

The soil pH tests indicate that the soils are acidic, with pH values of 4.9 for the silty clay fill and 4.3 to 5.4 for the natural silty clay. Sulphate contents of the samples varied from 46mg/kg to 180mg/kg. Six of the seven chloride contents were less than 70mg/kg. A silty clay sample from BH11 had an elevated chloride content of 640mg/kg.

4 COMMENTS AND RECOMMENDATIONS

4.1 Summary of Principal Geotechnical Design Issues

Only limited details of the proposed development were available at the time of reporting and our comments provided below may require revision and amplification once exact development details, such structural layout, earthwork levels, structural loads etc., are finalised. 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.

Based on the results of the boreholes and our understanding of the proposed development, we have summarised the following principal geotechnical issues to be considered in the planning, design and construction of the development:

- The proposed development might involve excavations of substantial volumes of soil and rock, depending on final earthworks and floor levels adopted for the development. Good engineering design, construction and maintenance practices should be adopted to maintain stability to adjoining sites and structures during excavation and in the long term, as well as reducing the risk of vibration damage to adjoining structures during rock excavation.
- The investigation indicates that the underlying shale profile is variable both in weathering and strength. Support of excavation sides by cutting at shallow batter slopes (1V:1H) is expected to be feasible since the basement perimeters as currently planned appears to be several metres from the site boundaries. Where insufficient space is available for the safe batters, which may be case where deeper two level basements are proposed, the excavations should be supported by an anchored or propped retention system, installed prior to bulk excavation, with the shoring piles taken down to below the base of the excavation.

- Groundwater seepage was encountered in the boreholes at depths between 2.0m and 7.5m below existing levels. Basements that extend below these depths would have to be designed against the effects of groundwater seepage and pressures. Consideration should be given to raising proposed basement levels to avoid or reduce groundwater issues. We anticipate that where the basements are proposed, localised groundwater inflow may occur through defects in the shale exposed in the excavated cut faces and the shale floor. Further monitoring of groundwater levels should be carried out during and on completion of the excavations.
- The existing fill layers are considered unsuitable as a bearing stratum under footings and floor slabs. The fill was assessed to be generally poorly to moderately compacted at the test locations (which only represent a very limited portion of the fill). We are unaware of any records, which document the manner of placement, compaction specification and control of the fill. Accordingly, the fill is considered to be "uncontrolled". Some of this fill simply comprises root affected soil or topsoil and hence, should be fully stripped. The site would generally be classified as "Class P" in accordance with AS2870. This fill should not be relied upon to provide foundation support to footings and on-ground floor slabs unless it is fully re-compacted (or replaced) to an engineering specification in a controlled manner (refer to Sections 4.7.1 and 4.7.2).
- Any proposed lightly loaded structure separated from the proposed large and more heavily loaded, multi-level buildings may be supported on footings founded below the existing fill, within the silty clays of adequate bearing capacity (i.e. at least of stiff strength) and designed to resist potential shrink/swell movements. The results of laboratory tests on the silty clays of medium or high plasticity indicated these clays to have a moderate to high potential ("Class H" in terms of AS2870) for shrink/swell movements with changes in moisture content.

- Any structure founded within the clays should be isolated from structures with footings founded in the bedrock. Hybrid foundations must be avoided, i.e. a structure should be founded on similar materials, such as all in clay or all in bedrock.
- For movement sensitive and/or more heavily loaded structures, and also those with basements, we recommend that all footings be founded on the underlying shale and sandstone bedrock. Where bedrock is exposed or at shallow depth after site earthworks, pad or strip footings may be used, but piles will be required where the depth to rock is deeper than about 1.2m.
- The proposed pavements may be constructed on an uncontrolled fill subgrade, provided it is prepared and proof rolled as detailed in Section 4.7.1. However, even following proof rolling, and treatment as required, of the fill there will still be a risk of poor pavement performance due to the underlying uncontrolled fill. The only way to reduce such risks would be to excavate and replace the uncontrolled fill below the pavement area.

Further comments on the above and other issues are provided within the following sections of this report. A summary of additional geotechnical work recommended are provided in Section 5.

Although only a limited subsurface investigation was completed, we believe sufficient information has been gained to be reasonably confident as to subsurface conditions. However, it will be essential during excavation and construction works that regular geotechnical inspections be commissioned to check initial assumptions about excavation and foundation conditions and possible variations that may occur between inspected and tested locations and to provide further relevant geotechnical advice. Irregular or 'milestone' inspections by a geotechnical engineer are often not adequate for excavation, shoring and foundation works. It is recommended that the Client be made aware of the need to commission a geotechnical engineer for regular frequent inspections. The comments provided in this report should be reviewed following these inspections.

4.2 Excavation and Groundwater

Site preparation will require demolition of the existing buildings, including removal of old footings, services, etc. which interfere with the new construction. Following demolition, site preparation for the building and pavement areas will require clearance of any other vegetation followed by stripping of root affected topsoil or any obvious deleterious fill. These materials are not suitable for re-use as engineered fill. The existing fill may also require removal; refer to Section 4.7.1.

The materials to be excavated will comprise fill, silty clay, and the underlying shale. The soils can be readily excavated by buckets of a large hydraulic excavator. Excavation in extremely low to low strength shale could easily be achieved using a Caterpillar D9 tractor or equivalent, probably with some light to medium ripping. Much of this material can probably also be excavated with a large excavator bucket. Localised stronger bands/zones may require heavy ripping or the use hydraulic rock hammers.

If basements are to consist of two below ground levels, to say around 6m or so below existing levels, we expect that excavation of the low to medium strength or stronger rock will be required, presenting hard ripping or "hard rock" excavation conditions. Ripping may only just be possible with a Caterpillar D10 or D11 dozer and a very generous allowance should be made for rock hammer assistance to the ripping, especially where rock defect spacing (bedding and cross bedding, joints, etc) is greater than about 0.5m and/or is heavily iron indurated. The use of an impact ripper is recommended. Excavation production rates are likely to be very low and shoe wear rates high. A ripping hook on a heavy excavator (>30 tonnes) working in tandem with a large rock saw would probably be an effective low vibration method for at least some of the work. Alternatively, hydraulic rock breaking equipment will be required for productive effective excavation. This equipment would also be required for detailed excavations such as footings or services, for which rotary grinders would also be useful. The ease with which excavation of rock is achieved depends upon the equipment used, the skill and experience of the operator and the characteristics of the rock. The contractor must make his own judgement on all of these factors after inspection of the rock cores. (We only store these for one month after the formal report is issued unless other arrangements are made).

Excavation and retention recommendations provided in this report should be complemented by reference to the Code of Practice Excavation Work, Cat. No. 312 dated 31 March, 2000 by WorkCover NSW.

4.2.1 Potential Vibration Risks

If a hydraulic impact hammer is used, considerable caution should be taken during rock excavation, as there will likely be direct transmission of ground vibrations to adjoining structures and buildings.

Guideline levels of vibration velocity for evaluating the effects of vibration in structures are given in the attached Vibration Emission Design Goals sheet. This limit of vibrations should be reviewed once more definite details of the excavation and development staging are known to confirm that they are still suitable.

If large rock hammers are to be used, we recommend that the initial excavation in rock should preferably be commenced away from likely critical areas and instrument vibration monitoring undertaken to confirm whether the vibration limits are likely to be exceeded and to provide guidance on how far the rock hammer should be kept away from the site boundaries, boundary and other structures. By monitoring vibrations in this way, it will allow some freedom to the excavation contractor in the equipment he adopts, so that a balance can be made between productivity and vibration reduction.

If it is found that transmitted vibrations are unacceptable, which may occur with a 1000kg hammer (Krupp 960) within about 10m to 15m of existing structures, it may be necessary to change to a small to medium sized excavator fitted with a light rock hammer no larger than 600kg (e.g. Krupp 350 size), or to a rotary grinder or jackhammers.

Vibrations induced by excavations can be reduced by alternative methods such as the following.

- Start the rock excavation away from likely critical areas.
- Maintain rock hammer orientation into the face and enlarge excavation by breaking small wedges off faces.
- Operate hammers in short bursts only, to prevent amplification of vibrations.
- Use smaller equipment (offset by a loss in productivity and economy and greater duration of the nuisance).
- Use line drilling, especially along excavation boundaries, to aid breaking and trimming.

Another means of reducing vibrations would be to cut or excavate a trench (with low energy equipment) along the sides of the excavation using a rock saw and then carry out bulk excavation with a large (Caterpillar D11) dozer.

In addition, we recommend that only excavation contractors with appropriate insurances and experience on similar projects be used. The contractor should also be provided with a copy of this report to make his own judgement on the most appropriate excavation equipment.

4.2.2 Hydro-Geological Assessment

Groundwater was observed in the boreholes during auger drilling at depths between 2.0m and 7.5m below existing levels. Basements that extend below these depths would have to be designed against the effects of groundwater seepage and pressures.

We expect that localised seepage may possibly occur into the excavation along the soil/bedrock boundary and along existing defects, such as bedding planes and joints, which exist in the rock. Localised seepage may also occur through permeable seams in the residual clays or at the base of the fill, especially during and following periods of heavy rainfall. The extent of groundwater flow through defects cannot be accurately predicted from boreholes, which only represent a very limited portion of the site. We anticipate that groundwater seepage should decrease substantially when excavations have initially drained the local area. Seepage volumes into the excavations are expected to be controlled by the use of surface drains and sump and pump systems at basement level during construction.

An assessment of likely seepage, its quality, and required pumping capacity would best be made during and following completion of the bulk excavation, when seepage could be observed.

We recommend that complete and permanent drainage be provided behind the basement walls. In addition, drainage (such as a free draining gravel beds or perimeter subsurface drains) should be provided below the basement floor slabs to safeguard against the possibility of groundwater pressure causing an uplift pressure and to drain water charged rock defects. The inferred relatively minor to modest groundwater flows would be able to drain through a free draining gravel bed or perimeter drains below the floor slabs. The piped drains should be graded to sumps for gravity discharge, if possible, or to an automatic fail-safe pump system for discharge of collected seepage to the stormwater system. If under-floor drainage is not installed, then the on-ground floor slab will be subjected to uplift pressures from the groundwater; this may require additional mass or ground anchors. Appropriate waterproofing will also be required for the permanent walls in contact with the excavated areas.

In view of the above, we do not expect that the properly managed construction of the proposed development will untowardly affect the existing groundwater levels or flow directions to the extent that they impact on the existing developments on adjoining sites.

4.3 Temporary Excavation Batters

We recommend temporary batters in the fill, silty clay and low strength or weaker shale may be cut temporarily to a safe batter no steeper than 1 Vertical (V) in 1 Horizontal (H). However, surcharge loadings (footings, stockpiles, vehicles, etc) should not be within the zone of influence of the excavation. As a guide, surcharge loadings should be no closer than 2H from the top of any batter or the face of any excavation (including footing excavations), where H is the vertical height of the batter or depth of the excavation in the fill, silty clay and low strength or weaker shale. Flatter batters may be required where groundwater seepage is encountered. Where possible, water should be drained away from batter slopes and prevented from discharging over batter faces.

Permanent batters in the soils and extremely weathered rock would need to be flatter (that is, no steeper than 1V in 2H) and protected from erosion by vegetation or other means.

Where these batter slopes cannot be accommodated, or are not preferred, then the vertical excavation in soils and weathered shale of extremely low to very low strength will need to be supported by appropriate shoring systems or properly engineered retaining walls. Any necessary vertical support system will need to be installed prior to excavation.

4.4 Retention Systems

A suitable method of retention to support vertical cuts, prior to bulk excavation, would be bored cast in-situ or augered, grout injected (CFA), soldier pile or semi-contiguous walls with infill panels where movement is not of concern, or alternatively, contiguous or secant pile walls, particularly where the excavation is to extend below groundwater levels. Construction of the contiguous pile walls should be of high quality, taking the uttermost care to prevent soil loss through gaps that may occur between the piles as this would add to the possibility of settlement occurring outside the excavation. Such gaps should be rectified without delay, such as by mass concrete infill. Conventional driven sheet-pile walls would not be suitable as there is a need to minimise noise and avoid ground vibration damage to the neighbouring buildings and there would be issues with penetration capacity of such systems.

All retention piles should be taken down below the lowest basement level to found in shale and sandstone bedrock of adequate bearing capacity; these piles may also be used for load bearing purposes. Props or anchors may also be needed to restrain the upper sections of the walls, particularly where a second basement level is proposed. Anchors, which extend beyond the site boundary, will require permission from the neighbours prior to installation.

Drilling of rock sockets in the medium strength or stronger shale and sandstone will be difficult requiring the use of heavy drilling rigs equipped with rock augers or coring buckets. Some groundwater inflow is expected into bored pile footings and we expect that this inflow will be controllable by conventional pumping methods. Alternatively, concrete may be poured using tremie methods.

4.4.1 Retaining Wall Design Parameters

The permanent retaining walls may be constructed at the toe of the temporary batters and subsequent backfilling undertaken. Caution will be required during backfilling to prevent over compaction adjacent to retaining walls and thereby causing excessive forces on the wall.

Design of the retaining walls and shoring systems may be on the basis of an 'active' lateral pressure coefficient, K_a, of at least 0.35 for the fill, clayey soils and extremely low strength shale, provided some deflection is tolerable. The K value may be reduced to 0.2 for the rock of at least very low to low strength. A bulk unit weight of 20kN/m^3 for the soils and 23kN/m^3 for any extremely low to low strength rock may be adopted. Walls which are to be subsequently propped by the permanent structure (e.g. by the upper ground floor slab) should be designed based on a higher lateral pressure coefficient, K, of at least 0.6 (or 0.4 for rock of at least very low to low strength). The good quality shale or sandstone of at least medium strength can be taken to be self-supporting and no 'K' values need to be taken into consideration. However, retention systems in the medium strength rock may be designed by assuming a nominal uniform lateral pressure of 10kPa to account for small-scale wedges of shale which could be isolated by inclined joints and horizontal bedding planes. The quality of the rock should be confirmed during geotechnical inspections during construction.

For propped or anchored walls, we recommend the use of a trapezoidal lateral earth pressure of at least 4H (kPa), where H is the retained height in metres in the soils and poor quality shale. For propped or anchored walls in areas, which are highly sensitive to lateral movement (such as adjacent to neighbouring building footings located within 2H metres of the excavation), a trapezoidal lateral earth pressure of at least 8H (kPa) should be used. These 4H and 8H pressures should be assumed to be uniform over the central 50% of the full, retained height in the soils and poor quality (extremely low to low strength) shale.

The recommended lateral earth pressure coefficients and trapezoidal pressures assume almost horizontal ground surfaces behind the crest of the walls. 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.

Applicable hydrostatic pressures should be added to the lateral earth pressures, unless specific measures are taken to introduce complete and permanent drainage of the ground behind the walls. Any surcharge affecting the walls (e.g. footings, retaining walls and their backfill, the ground slope behind the wall, etc.) should also be considered in the design.

Anchors bonded into at least very low strength shale bedrock, may be designed based on a maximum allowable bond stress of 150kPa. The bond stress may be increased to 350kPa for the medium strength shale. All anchors should be proof loaded to at least 1.3 times their working load. Anchors must be bonded behind a 45° line drawn upwards from the base of retention system. Anchor group interaction must also be taken into account. Permanent anchors should have appropriate corrosion provisions.

4.5 Footing Design

4.5.1 Site Classification

The unaltered site as seen is classified as Class "P" in terms of AS2870 due to the presence of uncontrolled fill. However, after replacement or removal of the uncontrolled fill, the site classification may be upgraded as discussed in the following.

The residual silty clays of medium to high plasticity encountered in the boreholes extend to depths between about 1.6m and 4.5m and have a moderate to high potential for shrink-swell reactive movements as a result of seasonal or local changes in subsoil moisture. Although the behaviour of reactive clays and its effects on a building or other movement sensitive structures is very complex, the prediction of ground movements may be undertaken in accordance with the method suggested in AS2870 "Residential Slabs and Footings – Construction". There are also nearby trees. The roots of the trees and in particular the roots of the large trees, absorb water causing shrinkage of the clay soils. Any new tree plantings should be kept well away, that is, at least their mature height from movement sensitive structures. This distance should be increased by 50% if lines or groups of tree plantings are proposed. Note that as their root systems continue to grow, the effect of this moisture depletion will extend closer, and may lead to uneven movements below the proposed buildings or other structures founded in the natural clays. If trees are subsequently removed, the effect of the readjustment in soil moisture in the underlying clays should be carefully assessed. Continued growth of the trees will increase the possibility of building damage in the future due to abnormal moisture changes and tree root penetration. We recommend that root barriers be installed to provide protection where trees are not to be removed. Advice should be sought from an arborist on suitable barrier systems, both for the street and for the site.

The lightly loaded structures may be may be supported on a strip and pad footings or a stiffened raft footing system founded in engineered fill or the residual silty clays of adequate bearing capacity. Alternatively, a bored pile and beam footing system may be adopted. However, if construction proceeds during a relatively 'dry' period, the beams between piles should be designed to withstand potential uplift pressures associated with possible subsequent swell of the clayey subgrade as it 'wets up'.

Alternatively, the beams should be underlain with void formers or similar (at least 70mm thick) to minimise the impact of uplift pressures.

Footings for the same structure must be founded on the same quality material, that is, all footings on rock or all footings on natural clay soils.

Shallow footings, including the edge and internal beams of stiffened raft slabs, founded within natural clay profile of at least stiff strength may be designed for an allowable bearing pressure of 150kPa for an embedment of at least 0.8m (or deeper to suit the type of structure in accordance with AS2870) below the surrounding ground surface. This bearing value may be increased to 200kPa for the very stiff to hard clays. The footing system should be designed by engineering principles to resist the potential shrink/swell movements, which are normally 40mm-70mm (free surface movements) in "Class H" clay sites in accordance to AS2870. The guidelines given in AS2870 for a "Class H" site may also be of assistance in designing the footings.

Footings may also be founded in a building platform, where the existing fill has been fully excavated and replaced with properly and uniformly compacted engineered fill prepared and compacted in accordance with the procedures outlined in Section 4.7.1 and under Level 1 geotechnical supervision. A safe bearing pressure of 100kPa may also be adopted for the engineered fill. The footing embedment in the engineered filled platform should generally be not less than 0.8m if on-site or reactive clay materials are used in the engineered fill. This footing embedment depth in the fill may, subject to geotechnical review, be reduced, where the engineered fill consists of at least 1m of granular fill over the underlying natural silty clays.

The following measures may be considered to help control but not eliminate moisture movement. These would include but would not be limited to:

- Regrading earthworks platforms, wherever practicable, to maintain cross-falls away from the structure, building perimeters and pavements to promote run-off and reduce ponding.
- Construction of paving around the structure or building to protect the periphery of at-grade floor slabs. We recommend that the paving extending for a width of 1.5m around the buildings. A waterproof membrane installed beneath the floor slabs and the paving.
- The surface water discharging from the roof and all paved areas should be dispersed in such a way as to avoid concentrated flows and erosion near the building and external pavements.
- Attention is drawn to other precautionary, site and foundation maintenance measures, including effects of trees and vegetation, as outlined in AS2870.
- Flexible and movement tolerant forms of construction should be adopted for movement-sensitive structures founded in the clays.

Engineering inspections should be undertaken to confirm the bearing pressures and foundation soil. All shallow footings should be poured with minimal delay (ie preferably on the same day of excavation) or the base of the footing should be protected by a concrete blinding layer after cleaning of loose spoil and inspection.

4.5.2 Multi-Level Residential Buildings

It is recommended that all footings for the multi-level buildings or other heavily loaded structures and/or movement sensitive structures be founded within the shale and sandstone bedrock to provide uniform support and reduce the potential for differential footing settlements. Where single level basements are proposed, it is likely that at least some sections of the proposed excavations will encounter shale and in other areas of the buildings, the excavations will extend close to the underlying shale. The shale is likely to extend across the basement floor where two below ground levels are proposed. Where the depth to the rock is shallow, say less than about 1.2m, pad or strip footings may be used. Where the rock is at greater depths bored piers would be more practical.

Strip and pad footings or bored piles or augered, grout inject (CFA) piles may be designed for maximum allowable working bearing pressures for the shale given in Table 1.

Table 1 – Footing Founding Depths and Safe Bearing Pressures

Borehole Number	Depth (in metres) below existing ground level for Safe Bearing Pressure of 700kPa	Depth (in metres) below existing ground level for Safe Bearing Pressure of 1500kPa	Depth (in metres) below existing ground level for Safe Bearing Pressure of 3500kPa
1	3.5 (RL9.6)	5.6 (RL7.5)	5.8 (RL7.3)
2	3.5 (RL11.3)	5.8 (RL9.0)	7.8 (RL7.0)
3	3.0 (RL11.4)	6.2 (RL8.2)	7.5 (RL6.9)
4	3.2 (RL9.6)	5.0 (RL7.8)	6.8 (RL6.0)
5	5.0 (RL5.6)	5.8 (RL4.8)	7.1 (RL3.5)
6	4.2 (RL7.2)	5.8 (RL5.6)	7.3 (RL4.1)
7	4.5 (RL7.3)	6.0 (RL5.8)	7.1 (RL4.7)
8	4.3 (RL6.5)	4.5 (RL6.3)	6.4 (RL4.4)
9	3.8 (RL8.1)	4.3 (RL7.6)	5.3 (RL6.6)
10	3.2 (RL8.1)	5.0 (RL6.3)	5.3 (RL 8.0)
11	4.0 (RL8.2)	5.3 (RL6.9)	6.0 (RL6.2)
12	3.5 (RL9.7)	4.3 (RL8.9)	5.9 (RL7.3)
13	4.2 (RL9.0)	4.3 (RL8.9)	7.4 (RL5.8)
14	3.9 (RL11.2)	5.1 (RL10.0)	6.6 (RL8.5)
15	3.8 (RL9.7)	6.1 (RL7.4)	7.2 (RL6.3)
16	3.8 (RL11.5)	5.8 (RL9.5)	7.1 (RL8.2)
17	3.5 (RL13.0)	7.0 (RL9.5)	7.2 (RL9.3)
18	3.2 (RL12.3)	6.1 (RL9.4)	7.6 (RL7.9)
19	3.2 (RL13.0)	6.4 (RL9.8)	7.8 (RL8.4)
20	4.0 (RL14.1)	7.0 (RL11.1)	9.5 (RL8.6)

Where footings are founded close to the top of an excavated rock face, the allowable bearing pressure below these footings will need to be carefully assessed. The safe bearing pressure would need to take into account rock strength, the inclination of the rock face, jointing and the influence of clay seams as well as the magnitude and inclination of the applied loadings.

An allowable shaft adhesion of 10% of the allowable bearing values in compression may be adopted for design of pile sockets through the extremely low, very low to low or medium strength or stronger shale, respectively, provided excavation is not carried out or a rock face is located within the zone of influence of the footing.

For wall footings fully embedded into the underlying shale and sandstone bedrock below the lowest building floor level, including footing and service trenches, an estimated allowable lateral stress of one third of the safe bearing pressure may be adopted for rock. These passive resistance values assume excavation is not carried within the zone of influence of the wall toe and the rock does not contain unfavourable defects etc. The upper 0.3m depth of the socket should not be taken into account to allow for disturbance effects during excavation.

If the designer wishes to adopt the limit state design methods, such as in the Piling Code, AS2159-1995, then the ultimate values of end bearing pressure and lateral stress may be estimated by multiplying the above recommended allowable values by Factors of Safety of 3. A Factor of Safety of 2 should be applied to the shaft adhesion values. We recommend that the ultimate values be multiplied by a geotechnical strength reduction factor, Φ_g, of 0.5. Higher reduction factors may be adopted but these will depend on the intensity and type of proving of the footings and their foundation. An appropriate load factor should also be applied to the proposed footing loadings.

The bearing pressures given above are based on a serviceability criteria of deflections at the footing base/pile toe of less than or equal to 1% of the least footing dimension (or pile diameter). Footings on rock can also be designed using 'Limit State Design' principles as detailed in the paper "Foundation on Sandstone and Shale in the Sydney Region' by Pells, Mostyn and Walker, Australian Geomechanics, Number 33, Part 3, December 1998 (Pages 17-29). It must be emphasised that the use of limit state design to adopt relatively high bearing pressures (above the serviceability criteria described above) is not currently standard practice, and there is an increased risk of inadequate footing performance.

If bored or augered grout piles are to be socketed into the rock then we recommend that drilling rigs with rock augers be used to drill the piles. Heavy drill rigs may be required for drilling through medium strength or stronger rock or through the iron indurated bands.

All footing excavations should be free from all loose or softened materials prior to placement of concrete. We recommend that all footing excavations be checked and approved prior to concrete being poured. In addition to inspection, the sandstone foundation under at least one third of footings designed using a safe bearing pressure of 3.5MPa should be spoon tested in jackhammer holes taken to 1.5 times the footing width. This testing is to confirm that no adverse seams or defects are present below the founding levels. The presence of such seams would require a reduction in allowable bearing capacity or an increase in footing depth.

The initial stages of footing excavation 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 future geotechnical inspections if you wish to commission us at the appropriate time.

4.6 Basement Floor Slabs

The basement slabs that are below groundwater levels should be designed to resist hydrostatic uplift pressures (this may require additional mass or ground anchors) or an underfloor drainage system provided. A fail safe automatic pump-out system may have to be adopted to reduce the likelihood of flooding of the basement. We recommend that under-floor drainage or uplift resistance requirements be reviewed following inspection of the completed excavation when such issues can be more readily considered.

Basement floor slabs are expected to be constructed at least partly over the shale and no special treatment is required other than the removal of loose and softened material. Areas, which have to be built-up to infill low points in the excavation should be filled with properly compacted sub-base material (see Section 4.7.2). The basement floor slabs will also be founded over the fill or residual clays; such sections should be isolated from floor slabs founded on the shale and sandstone.

4.7 On-Ground Slabs and Pavements

The design of pavements and on-ground slabs will depend on subgrade preparation, subgrade drainage, the nature and composition of new fill imported to the site, as well as vehicle loadings and use.

On-ground slabs and pavements for the basement ramps and external paving may be founded on the silty clay subgrade on condition that the subgrade is prepared in accordance with the following recommendations and provided they are isolated from slabs, walls or column founded on bedrock to allow for differential movements. Slabs over the compacted silty clay subgrade should be designed for moderate shrink/swell reactivity associated with the silty clays of medium to high plasticity.

4.7.1 Subgrade Preparation, Proof Rolling and Fill Earthworks

The existing fill is generally variably compacted and we are unaware of records that document the manner of placement, compaction specification and control of the fill. Hence, the fill is considered to be "uncontrolled" and should not be relied upon to provide foundation support to on-ground floor slabs or footings unless it is fully re-compacted to an engineering specification in a controlled manner below the building area and preferably at least 2m beyond its periphery. A specification for engineered fill is provided in Section 4.7.2.

Excavation and re-compaction of the fill would not be required where slabs and footings are to be fully suspended and do not rely on the fill for support.

Any remaining existing fill may be left in place below lightly loaded (car only) pavements on the condition that the subgrade is proof rolled. However, there is a chance that some settlement may still occur under pavements bearing on the existing fill, even after it is treated by proof rolling.

Following excavation to the design levels, the exposed subgrade should be inspected by a geotechnical engineer and if deemed necessary proof-rolled prior to placing fill.

Proof-rolling should be carried out with a minimum 5 tonne dead weight smooth drum vibratory roller. The final pass of the proof rolling should be carried out without vibration and within the presence of a geotechnical engineer or experienced geotechnican. The purpose of the proof rolling should be to improve the compaction of the near surface soils and to detect any weak or unstable areas which were not disclosed by this investigation. During proof rolling care should be taken to avoid damage to nearby structures and buried services by vibrations transmitted by the roller. If necessary, the vibrations should be reduced or ceased.

Where unstable areas are encountered the area should be locally excavated down to a sound base and replaced with engineered fill as detailed in Section 4.7.1.

From the borehole results we expect few, if any, unstable areas to occur provided good site drainage is maintained and the earthworks are carried out during good weather. Should any soft areas be found then further advice and inspections will be required to assess the most suitable method of subgrade improvement. Allowance should be made for either, tyning, aerating and drying the subgrade, or removal and replacement with engineered fill. If the clayey subsoil is exposed to prolonged periods of rainfall, softening will result and site trafficability will be poor. If soil softening occurs, the subgrade should be over-excavated to below the depth of moisture softening and the excavated material replaced with engineered fill.

If shrinkage cracking of the clay surface occurs during dry weather, then prior to pouring concrete slabs, the exposed surface should be sprayed with water and re-rolled to close up the surface cracks.

4.7.2 Engineered Fill and Compaction Control

Engineered fill should preferably comprise well-graded granular material (such as ripped or crushed sandstone), free of deleterious substances and having a maximum particle size of 75mm. All granular fill used to raise site levels or backfill excavations should be compacted in layers of not greater than 200mm loose thickness, to a minimum density at least 98% of Standard Maximum Dry Density (SMDD).

The existing fill may be reused as engineered fill. However, the silty clays, which are to be excavated have very low soaked CBR values and have a variable moderate to high shrink swell potential and therefore, are not desirable, but may be reused as engineered fill provided the following measures are undertaken:

- Over-wet and over-size materials should be removed;
- Where possible, the silty clays should be used in the lower fill layers and granular fill placed in layers over this;
- The re-used silty clay should be placed in 150mm loose thickness layers and compacted to between 98% and 102% of SMDD and within 2% of Standard Optimum Moisture Content (SOMC).
- For backfilling confined excavations such as service trenches, a similar compaction to engineered fill should be adhered to, but if light compaction equipment is used then the layer thickness should be limited to 100mm loose thickness.

The use of these clay soils for engineered fill will be more time consuming, weather dependent and will entail more rigorous earthworks supervision and compaction control than granular fill.

All platform fill should either be retained or battered to a slope of compacted fill of no steeper than 1 Vertical (V) in 2 Horizontal (H) to prevent instability. All engineered fill areas should be over-filled and compacted and then the loose outer face of the fill should be cut back so that only well-compacted fill remains. We recommend a horizontal compacted fill platform extend beyond the building/pavement periphery preferably by at least 2m. All exposed fill should be protected from erosion by quickly establishing a grass cover.

Density tests should be regularly carried out on the fill at not less than the frequencies given in AS3798 to confirm that the recommended compaction densities are achieved. At least Level 2 testing (or Level 1 if building footings and floor slab are to be founded in engineered fill) of earthworks should be carried out in accordance with AS3798. 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.

Earthworks recommendations provided in this report should be complemented by reference to AS3798.

4.7.3 Site Drainage

Due to the presence of moderately to highly reactive clays, it will be important to pay careful attention to drainage during construction. The site may become untrafficable when wet and appropriate cross-falls should be maintained at all times. We recommend that if soil softening occurs, the subgrade be over-excavated to below the depth of moisture softening and that the excavated material be replaced with clean, well-graded fill compacted as specified in Section 4.7.1. Desirably, the earthworks should be completed rapidly and the surface sealed as soon as possible. It is preferred that a granular working platform be provided to cover and protect the underlying clay and provide a trafficable surface during construction. The earthworks should be carefully planned and scheduled to maintain cross-falls during construction.

We recommend that reference be made to AS2870 for drainage and vegetation precautions on "Class H" (highly reactive) sites.

4.7.4 Pavement Design

Based on the laboratory test results, pavements may be designed using a lower bound characteristic CBR value of 2% or a coefficient of subgrade reaction of

20kPa/mm (750mm plate) or a long term Young's modulus of 15MPa for the proof rolled and/or treated clayey subgrade.

For flexible pavements, insitu lime stabilisation of the clayey subgrade could be undertaken to reduce total pavement thickness. Alternatively, an appropriate select fill layer comprising good quality well-graded granular material may be used below the pavement.

Improvement of the subgrade CBR design value and consequent reduction of the crushed rock pavement thickness may be achieved by stabilising the clay subgrade with lime to a minimum depth of say 200mm to 300mm. To determine the optimum lime addition rate to achieve the beneficial effect desired, laboratory tests should be carried out. However, an indicative proportion to achieve a CBR of 10% would probably be the addition of 4% of quick lime by dry weight of the clay. The lime must be thoroughly mixed with the clay using specialist blending machines and then compacted to not less than 98% SMDD at ±2% of SOMC. Only contractors experienced with lime stabilisation should be used. We note that use of lime close to residential areas is generally not preferred unless an acceptable method of dust suppression can be adopted.

Concrete pavements and on-ground floor slabs subject to traffic loadings should be supported on a sub-base layer of RTA Specification 3051 unbound or equivalent good quality crushed rock, compacted to a density of at least 100% SMDD. Concrete pavements should be provided with effective shear connection at joints by using dowels or keys. Concrete pavements should preferentially be used in areas where heavy vehicles manoeuvre such as garbage bin and truck unloading areas.

Subsoil drains should be provided on the uphill side or along the perimeter of pavements, with inverts not less than 0.3m below clay subgrade level. The drainage trench should be excavated with a longitudinal fall to appropriate discharge points so as to minimise the risk of water ponding. The pavement subgrade should be graded to promote water flow or infiltration towards subsoil drains.

4.8 Soil Aggression

The soil chemical tests have revealed acidic subsoil conditions with pH values between 4.3 and 5.4. Sulphate contents of the samples varied from 46mg/kg to 180mg/kg. Chloride contents were generally less than 70mg/kg with one sample giving 640mg/kg.

When assessed in accordance with the criteria for concrete piling exposure classifications given in Table 6.4.2 (C) of AS2159-2009 "Piling-Design and Installation", these soil pH, sulphate and chloride tests have revealed that these samples are mildly and moderately aggressive to buried concrete.

Any concrete exposed to these conditions (e.g. piles) should have a characteristic concrete strength and cover as recommended in Table 6.4.3. For example, cast-in-place piles should have a characteristic concrete strength of at least 40MPa and a cover of 65mm for a 50 design year or 85mm for a 100 year design life, respectively.

5 FURTHER GEOTECHNICAL WORK

As detailed in this report, further geotechnical work is recommended as follows:

- Quantitative monitoring of transmitted vibrations during rock excavation using rock hammers.
- Assessment of groundwater inflow to confirm drainage requirements following excavation.

- Inspection of footing excavations to ascertain that the recommended foundation has been reached and to check initial assumptions regarding foundation conditions and possible variations that may occur.
- Carry out laboratory tests to establish the optimum lime addition rates for pavement subgrades.
- Inspect proof rolling of silty clay subgrade to detect soft spots requiring treatment.
- Density tests to control compaction of any pavement or engineered fill layers.

We recommend that Jeffery & Katauskas Pty Ltd view the proposed earthworks and structural drawings and section details in order to confirm they are within the guidelines of this report.

6 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and 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 judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

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

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

A waste classification will need to be assigned to any soil excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous Waste. If the natural soil has been stockpiled, classification of this soil as Excavated Natural Material (ENM) can also be undertaken, if requested. However, the criteria for ENM are more stringent and the cost associated with attempting to meet these criteria may be significant. Analysis takes seven to 10 working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) should be expected. We strongly recommend that this issue is addressed prior to the commencement of excavation on site.

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.

Tony Walker
Associate

Reviewed by:

Fernando Vega
Senior Associate
For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD.

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SOIL TEST SERVICES
ABN 43 002 145 173

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 %
1	5.70-6.00	5.7				
2	1.50-1.95	20.4	57	21	36	15.0
2	5.50-6.00	8.3				
3	7.00-7.30	6.7				
4	7.70-7.90	4.2				
5	5.50-5.80	9.8				
6	5.50-6.00	9.2				
6	7.20-7.50	10.8				
7	5.60-6.00	4.1				
8	4.00-4.50	8				
9	5.50-6.00	5.8				
10	5.20-5.50	5.6				
11	5.80-6.00	5.7				
12	0.50-0.95	13.6	44	16	28	12.0
12	4.20-4.50	8.1				
13	6.10-6.40	5.0				
14	6.50-7.00	7.2				
15	6.50-6.80	4.7				
16	0.50-0.95	25.6	64	22	42	16.5
16	5.50-6.00	9.3				
18	4.20-4.50	11.1				
18	5.80-6.00	11.3				
19	7.80-8.00	8.4				

Notes:
- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions

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TABLE B
SUMMARY OF FOUR DAY SOAKED C.B.R.TEST RESULTS

BOREHOLE NUMBER	17	18	20
DEPTH (m)	0.50 - 1.00	0.50 - 1.50	0.50 - 1.50
Surcharge (kg)	4.5	4.5	4.5
Maximum Dry Density (t/m^3)	1.562 STD	1.484 STD	1.585 STD
Optimum Moisture Content (%)	22.3	25.8	20.9
Moulded Dry Density (t/m^3)	1.53	1.45	1.56
Sample Density Ratio (%)	98	98	98
Sample Moisture Ratio (%)	101	101	98
Moisture Contents			
Insitu (%)	23.5	23.5	19.9
Moulded (%)	22.5	26.0	20.5
After soaking and After Test, Top 30mm(%)	27.8	34.4	26.1
Remaining Depth (%)	27.4	30.3	22.8
Material Retained on 19mm Sieve (%)	0	0	0
Swell (%)	2.0	1.5	1.5
C.B.R. value: @5.0mm penetration	2.0	3.5	2.0

NOTES:

- Refer to appropriate Borehole logs for soil descriptions
- Test Methods :
  - (a) Soaked C.B.R. : AS 1289 6.1.1
  - (b) Standard Compaction : AS 1289 5.1.1
  - (c) Moisture Content : AS 1289 2.1.1

NATA

NATA Accredited Laboratory
Number:1327

Approved Signatory
(A.Tatikonda)

Date: 2/11/10

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TABLE C
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S\,(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
2	6.47-6.50	0.1	2
	6.86-6.90	0.2	4
	7.17-7.21	0.2	4
	7.88-7.92	0.3	6
	8.07-8.11	0.8	16
	8.65-8.70	1.2	24
	9.15-9.19	1.5	30
5	6.00-6.04	0.6	12
	6.38-6.42	0.5	10
	7.05-7.09	0.4	8
	7.34-7.38	0.7	14
	7.62-7.67	0.7	14
	8.05-8.10	0.7	14
	8.48-8.52	1.7	34
	8.74-8.78	3.8	76
8	6.09-6.14	0.2	4
	6.39-6.43	0.4	8
	7.05-7.09	0.8	16
	7.63-7.67	1.1	22
	8.31-8.35	1.8	36
10	5.92-5.96	2.1	42
	6.16-6.21	0.7	14
	6.90-6.95	1.8	36
	7.15-7.21	0.6	12
	7.91-7.96	4.5	90

NOTES: See Page 2 of 2

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TABLE C
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
10	8.16-8.20	3.9	78
	8.69-8.74	4.2	84
12	5.94-5.98	1.5	30
	6.09-6.13	2.2	44
	6.91-6.95	0.7	14
	7.07-7.11	1.5	30
	7.76-7.80	1.3	26
	8.10-8.14	0.5	10
	8.57-8.61	2.6	52
18	7.07-7.11	0.2	4
	7.60-7.64	0.5	10
	7.88-7.92	1.9	38
	8.07-8.11	0.9	18
	8.91-8.95	1.4	28
	9.16-9.19	0.9	18
	9.54-9.57	0.9	18
20	7.14-7.16	0.6	12
	7.74-7.77	1.8	36
	9.51-9.53	0.7	14
	9.84-9.86	0.7	14

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RTA T223.
4. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :
   U.C.S. = 20 $I_{S(50)}$

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CERTIFICATE OF ANALYSIS 47301

Client:
Environmental Investigation Services
PO Box 976
North Ryde BC
NSW 1670

Attention: Tony Walker

Sample log in details:

Your Reference:	**24375VT, Riverwood**
No. of samples:	7 Soils
Date samples received:	21/10/2010
Date completed instructions received:	21/10/2010

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by:	28/10/10
Date of Preliminary Report:	Not issued
Issue Date:	28/10/10

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

Results Approved By:

Nick Sarlamis
Inorganics Supervisor

Miscellaneous Inorg - soil						
Our Reference:	UNITS	47301-1	47301-2	47301-3	47301-4	47301-5
Your Reference	-------------	BH3	BH3	BH11	BH11	BH19
Depth	------------	0.5-0.95	1.5-1.95	1.5-1.95	3.0-3.35	0.5-0.95
Date Sampled		13/10/2010	13/10/2010	15/10/2010	15/10/2010	17/10/2010
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	26/10/2010	26/10/2010	26/10/2010	26/10/2010	26/10/2010
Date analysed	-	26/10/2010	26/10/2010	26/10/2010	26/10/2010	26/10/2010
pH 1:5 soil:water	pH Units	4.4	5.4	4.3	4.3	4.3
Chloride, Cl 1:5 soil:water	mg/kg	7.0	15	29	640	13
Sulphate, SO4 1:5 soil:water	mg/kg	72	46	120	180	61

Miscellaneous Inorg - soil			
Our Reference:	UNITS	47301-6	47301-7
Your Reference	-------------	BH19	BH10
Depth	------------	1.5-1.95	0.5-0.95
Date Sampled		17/10/2010	15/10/2010
Type of sample		Soil	Soil
Date prepared	-	26/10/2010	26/10/2010
Date analysed	-	26/10/2010	26/10/2010
pH 1:5 soil:water	pH Units	5.0	4.9
Chloride, Cl 1:5 soil:water	mg/kg	13	63
Sulphate, SO4 1:5 soil:water	mg/kg	53	110

Method ID	Methodology Summary
LAB.1	pH - Measured using pH meter and electrode in accordance with APHA 20th ED, 4500-H+.
LAB.81	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA 21st ED, 4110-B.

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			26/10/2010	47301-1	26/10/2010 || 26/10/2010	LCS-1	26/10/2010
Date analysed	-			26/10/2010	47301-1	26/10/2010 || 26/10/2010	LCS-1	26/10/2010
pH 1:5 soil:water	pH Units		LAB.1	[NT]	47301-1	4.4 || 4.3 || RPD: 2	LCS-1	101%
Chloride, Cl 1:5 soil:water	mg/kg	2	LAB.81	<2.0	47301-1	7.0 || 7.0 || RPD: 0	LCS-1	104%
Sulphate, SO4 1:5 soil:water	mg/kg	2	LAB.81	<2.0	47301-1	72 || 71 || RPD: 1	LCS-1	97%

Report Comments:

Asbestos ID was analysed by Approved Identifier:	Not applicable for this job
Asbestos ID was authorised by Approved Signatory:	Not applicable for this job
Asbestos counting was analysed by Approved Counter:	@ERROR
Asbestos counting was authorised by Approved Signatory:	@ERROR

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

Quality Control Definitions

Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.

Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.

Matrix Spike: A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.

LCS (Laboratory Control Sample): This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.

Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria

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

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes and LCS: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and speciated phenols is acceptable.

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **1**

1/2

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT

Date: 13-10-10

Method: SPIRAL AUGER JK350

R.L. Surface: ≈ 13.1m

Datum: AHD

Logged/Checked by: L.Y./

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 clay, low plasticity, dark brown and grey, with a trace of fine to medium grained igneous gravel.	MC>PL			GRASS COVER
	DS	N = 20 6,9,11								
			1		CH	SILTY CLAY: high plasticity, orange brown mottled yellow brown.	MC>PL	(VSt-H)		RESIDUAL
	DS	N = 29 9,15,14				as above, but light grey mottled red brown, with ironstone bands.	MC<PL	H	>600 >600 >600	
			2							
	DS		3		-	INTERBEDDED SHALE AND CLAY: light grey with ironstone bands.	XW/ MC<PL	EL/H		VERY LOW 'TC' BIT RESISTANCE
	DS		4							
			5							
	DS		6		-	SHALE: dark grey.	SW	M	-	LOW TO MODERATE RESISTANCE
			7					M-H		MODERATE RESISTANCE

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **1**
2/2

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 13-10-10
Method: SPIRAL AUGER JK350
Logged/Checked by: L.Y./
R.L. Surface: ≈ 13.1m
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
ON COMPLE-TION						SHALE: dark grey.	SW-FR	M-H		
			8			END OF BOREHOLE AT 8.0m				
			9							
			10							
			11							
			12							
			13							
			14							

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BOREHOLE LOG

Borehole No. **2**

1/2

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

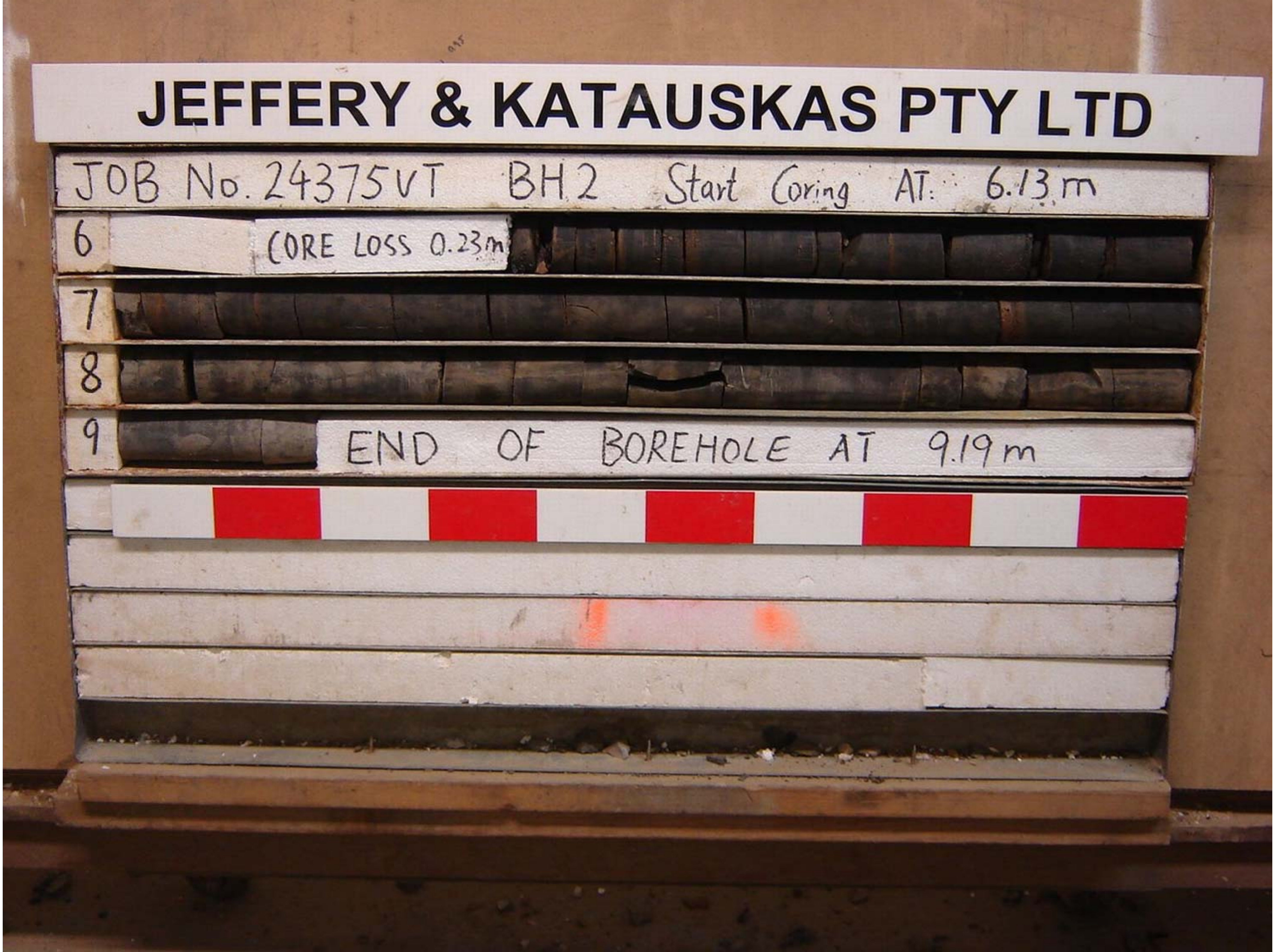
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT | **Method:** SPIRAL AUGER JK350 | **R.L. Surface:** ≈ 14.8m

Date: 13-10-10 | **Datum:** AHD

Logged/Checked by: L.Y./

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 OF AUGERING-			0			FILL: Silty clay, low plasticity, dark brown mottled orange brown and light grey, with a trace of roots, slag, fine to medium grained igneous and ironstone gravel.	MC>PL			GRASS COVER APPEARS MODERATLY COMPACTED
	DS	N = 8 2,4,4	1							
	DS	N = 10 3,5,5			CH	SILTY CLAY: high plasticity, orange brown, mottled light grey.	MC>PL	VSt	- 300 320 380	RESIDUAL
			2			as above, but with ironstone bands.				
	DS		3		-	SHALE: light grey, with M strength ironstone bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE WITH MODERATE TO HIGH BANDS
ON COMPLE-TION OF AUGER-ING			4							
	DS		5				DW	L		LOW RESISTANCE
	DS		6			REFER TO CORED BOREHOLE LOG				
			7							


JEFFERY & KATAUSKAS PTY LTD
JOB No. 24375VT BH2 Start Coring AT: 6.13 m
6
CORE LOSS 0.23m
7
8
9
END OF BOREHOLE AT 9.19 m

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. **2**
2/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT | **Core Size:** NMLC | **R.L. Surface:** ≈ 14.8m
Date: 13-10-10 | **Inclination:** VERTICAL | **Datum:** AHD
Drill Type: JK350 | **Bearing:** | **Logged/Checked by:** L.Y/

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT SPACING (mm)	DEFECT DETAILS: Specific	DEFECT DETAILS: General
		6		START CORING AT 6.13m						
				CORE LOSS: 0.23m					-Cr,14mm.t	
FULL RE TURN		7		SHALE: dark grey, with some iron staining.	SW-FR	L	× × ×		-Be,0°,P,S,IS -Be,0°,P,S,IS -Cr,10mm.t -Be,2°,P,S,IS -J,40°,P,S,IS -Be,0°,P,S,IS	
		8				M-H	× × × ×			
		9		END OF BOREHOLE AT 9.19m						
		10								
		11								
		12								

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
3

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 19-10-10

Method: SPIRAL AUGER JK250

R.L. Surface: ≈ 14.4m
Datum: AHD

Logged/Checked by: A.P.C/

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 clay, low to medium plasticity, dark brown with fine to medium grained shale and igneous gravel, with a trace of root fibres.	MC>PL			GRASS COVER
					CH	SILTY CLAY: high plasticity, orange brown, mottled brown with a trace of fine to coarse grained ironstone gravel.	MC>PL	H	-	RESIDUAL
	DS	N = 10 3,5,5							480 460 500	
			1			SILTY CLAY: medium to high plasticity, light grey mottled red brown.	MC<PL			
	DS	N = 36 12,16,20							>600 >600 >600	
			2		-	SHALE: light grey with ironstone bands.	XW-DW	EL-VL	-	VERY LOW 'TC' BIT RESISTANCE
	DS	N >15 15/150mm REFUSAL	3							
			4							
	DS									
			5			SHALE: dark grey with iron indurated bands,	DW	VL-L		
	DS									MODERATE RESISTANCE
			6					L-M		
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
3

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 19-10-10
Method: SPIRAL AUGER JK250
R.L. Surface: ≈ 14.4m
Datum: AHD
Logged/Checked by: A.P.C/

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
ON COMPLE-TION						SHALE: dark grey with iron indurated bands.	DW	L-M		MODERATE TO HIGH RESISTANCE
								M		HIGH RESISTANCE
			8			END OF BOREHOLE AT 8.0m				
			9							
			10							
			11							
			12							
			13							
			14							

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BOREHOLE LOG

Borehole No.
4
1/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 19-10-10
Method: SPIRAL AUGER JK250
R.L. Surface: ≈ 12.8m
Datum: AHD
Logged/Checked by: A.P.C/

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 clay, low to medium plasticity, dark brown, with fine to coarse grained shale and igneous gravel with traces of root fibres.	MC<PL			GRASS COVER
		N = 22 12,11,11			CH	SILTY CLAY: high plasticity, orange brown, with traces of ironstone gravel and root fibres.	MC>PL	H	- >600 >600 >600	RESIDUAL
		N = 32 12,15,17	1 2			SILTY CLAY: high plasticity, light grey and red brown, with traces of root fibres and ironstone gravel.	MC<PL		>600 >600 >600	
		10/100mm REFUSAL	3 4		-	SHALE: light grey, with L-M strength iron indurated bands.	XW-DW	EL-VL	-	VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
			5 6			SHALE: grey with iron indurated bands.	DW	L-M		LOW RESISTANCE WITH MODERATE BANDS
			7				DW-SW	M		MODERATE RESISTANCE

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
4
2/2

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 19-10-10
Method: SPIRAL AUGER JK250
R.L. Surface: ≈ 12.8m
Datum: AHD
Logged/Checked by: A.P.C/

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
ON COMPLE-TION									SHALE: dark grey, with iron indurated bands.	DW-SW	M		MODERATE TO HIGH RESISTANCE
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
5
1/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 19-10-10
Method: SPIRAL AUGER JK305
Logged/Checked by: L.Y/
R.L. Surface: ≈ 10.6m
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
			0			FILL: Silty clay, low plasticity, brown, with fine to medium grained igneous gravel, with traces of roots and slag.	MC≈PL			GRASS COVER APPEARS WELL COMPACTED
	DS	N = 14 4,7,7								
			1		CH	SILTY CLAY: high plasticity, red brown mottled yellow brown and light grey, with ironstone gravel.	MC>PL	H	-	RESIDUAL
	DS	N = 18 6,9,9							415 430 530	
			2							
ON COMPLE-TION OF COR-ING										
	DS	N = 18 7,8,10	3			as above, but light grey.		VSt	270 315 300	
			4							
	DS	N >15 15/150mm REFUSAL			-	SHALE: light grey.	XW	EL	>600 >600 >600	
			5							
	DS					as above, but dark grey and brown.	DW	L-M		LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
						REFER TO CORED BOREHOLE LOG				
			6							
			7							


JEFFERY & KATAUSKAS PTY LTD
JOB No: 24375VT BH5 Start Coring AT: 5.89 m
6
CORE LOSS 0.45 m
7
8
EOBH@8.83m

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 5
2/2

CORED BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 19-10-10
Drill Type: JK305
Core Size: NMLC
Inclination: VERTICAL
Bearing:
R.L. Surface: ≈ 10.6m
Datum: AHD
Logged/Checked by: L.Y/

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL VL L M H VH EH)	DEFECT SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
				START CORING AT 5.89m						
FULL RE TURN		6		SHALE: dark grey.	SW	M	× ×		-Cr,20mm.t -J,77°,P,R,IS	
				CORE LOSS: 0.45m						
		7		SHALE: dark grey.	SW	M	× ×		-J,45°,P,R,IS	
		8		SANDSTONE: fine grained, light grey and dark grey.		M-H H-VH	× × × ×		-CS,15mm.t	
		9		END OF BOREHOLE AT 8.83m						
		10								
		11								
		12								

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **6**
1/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 18-10-10
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 11.4m
Datum: AHD
Logged/Checked by: L.Y/

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 brown and light grey with traces of roots.	M			GRASS COVER APPEARS WELL COMPACTED
	DS	N = 19 6,9,10				FILL: Silty clay, low to medium plasticity, dark brown mottled dark grey with traces of roots and fine to medium grained igneous gravel.	MC<PL			
			1							
	DS	N = 20 4,9,11			CL	SILTY CLAY: low to medium plasticity, red brown mottled yellow brown and light grey with ironstone gravel bands.	MC<PL	H	505 565 500	RESIDUAL
			2							VERY LOW TO LOW BANDS
	DS	N = 25 14,12,23	3					VSt- H	470 350 360	
▼ AFTER 10 MINS	DS		4		-	SHALE: dark grey and light grey.	DW	VL	-	VERY LOW 'TC' BIT RESISTANCE
			5							
	DS					as above, but dark grey and brown.	DW	L-M		LOW RESISTANCE WITH MODERATE BANDS
			6					H		HIGH BANDS
								L-M		LOW RESISTANCE WITH MODERATE BANDS
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **6**
2/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 18-10-10
Method: SPIRAL AUGER JK305
Logged/Checked by: L.Y/
R.L. Surface: ≈ 11.4m
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
					-	SHALE: dark grey and brown.	DW	L-M		MODERATE RESISTANCE
	DS				-	SANDSTONE: fine to medium grained, light grey.	FR	M		MODERATE TO HIGH RESISTANCE
			8			END OF BOREHOLE AT 8.0m				
			9							
			10							
			11							
			12							
			13							
			14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. 7
1/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 19-10-10
Method: SPIRAL AUGER JK250
Logged/Checked by: A.P.C./
R.L. Surface: ≈ 11.8m
Datum: AHD

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		CONCRETE: 160mm.t.				70mm DIAMETER TOP COVER 8mm DIAMETER REINFORCEMENT
			-	FILL: Silty gravel, fine to coarse grained, dark grey, igneous gravel.	M	-	-	
	N = 5 1,2,3			FILL: Silty clay, medium plasticity, dark brown	MC>PL	-	-	
		1		FILL: Silty clay, high plasticity, orange brown and red brown, with fine to coarse grained igneous gravel and traces of root fibres.	MC>PL			
	N >17 7,17/ 150mm REFUSAL		CL-CH	SILTY CLAY: medium to high plasticity, light grey and orange brown, with fine to coarse grained ironstone gravel and traces of root fibres.	MC>PL	VSt	- 250 300	RESIDUAL
ON COMPLE -TION		2	-	SHALE: dark grey/brown with L-M strength iron indurated bands.	DW	VL		LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
		3	CH	SILTY CLAY: high plasticity, orange brown.	MC>PL	(St)	-	
		4	-	SHALE: dark brown with L-M strength iron indurated bands.	XW-DW	EL-VL	-	LOW RESISTANCE
		5		SHALE: dark grey with iron indurated bands.	DW	VL-L		LOW RESISTANCE WITH MODERATE BANDS
						M		HIGH RESISTANCE
		6						LOW RESISTANCE
		7						

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT

Date: 19-10-10

Method: SPIRAL AUGER JK250

R.L. Surface: ≈ 11.8m

Datum: AHD

Logged/Checked by: A.P.C./

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
								-	SHALE: dark grey.	DW	M-H		HIGH RESISTANCE
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
8
1/2

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 18-10-10
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 10.8m
Datum: AHD
Logged/Checked by: L.Y/

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 clay, low to medium plasticity, dark brown with traces of roots and fine to medium grained igneous gravel.	MC>PL			GRASS COVERED APPEARS MODERATLY COMPACTED
	DS	N = 10 3,4,6								
ON COMPLE-TION OF COR-ING	DS	N = 21 9,9,12	1		CL	SILTY CLAY: medium plasticity, orange brown mottled yellow brown and grey with ironstone gravel.	MC>PL	H	510 450 480	RESIDUAL
			2							VERY LOW TO LOW BANDS
	DS	N = 24 10,12,12	3			as above, but light grey mottled yellow brown with ironstone gravel.		VSt	290 320 400	
	DS		4		-	SHALE: brown and dark grey.	DW	L		LOW 'TC' BIT RESISTANCE
ON COMPLE TION OF AUGER ING-	DS		5					M		LOW RESISTANCE WITH MODERATE BANDS
			6			REFER TO CORED BOREHOLE LOG				
			7							


JEFFERY & KATAUSKAS PTY LTD
JOB No. 24375VT BH8 Start Coring AT 5.83m
CORE LOSS 0.12 m
6
7
8
EOBH @ 8.68m

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. 8

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT	**Core Size:** NMLC	**R.L. Surface:** ≈ 10.8m
Date: 18-10-10	**Inclination:** VERTICAL	**Datum:** AHD
Drill Type: JK305	**Bearing:**	**Logged/Checked by:** L.Y/

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS – DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
				START CORING AT 5.83m						
FULL RE TURN				CORE LOSS: 0.12m						
		6		SHALE: dark grey.	SW	L				
				SANDSTONE: fine grained, grey and brown, with occasional laminae at 0-3°.		M			-J,67°,P,S -Cr,330mm.t -J,85°,P,S	
		7							-J,75°,P,S -J,75°,P,S -2xJ,70°,P,S -Cr,30mm.t	
				as above, but light grey and brown.		H			-J,sub vertical,P,S	
		8							-Cr,30mm.t	
				END OF BOREHOLE AT 8.68m						
		9								
		10								
		11								
		12								

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
9
1/2

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT

Date: 19-10-10

Method: SPIRAL AUGER JK250

R.L. Surface: ≈ 11.9m

Datum: AHD

Logged/Checked by: L.Y/

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	N = 7 4,4,3	0		FILL: Silty clay, low plasticity, dark brown mottled orange brown, with a trace of slag and roots.	MC≈PL			GRASS COVER APPEARS POORLY COMPACTED
	N = 15 9,9,6	1	CH	SILTY CLAY: high plasticity, red brown mottled brown, with ironstone gravel.	MC>PL	VSt- H	- 360 420 450	RESIDUAL
ON COMPLE -TION	N = 20 11,9,11	3	-	INTERBEDDED SHALE AND CLAY: light grey and dark grey, with ironstone gravel.	XW/ MC>PL	EL/H	550 580 >600	
		4	-	SHALE: dark grey.	DW	L		LOW 'T'C BIT RESISTANCE WITH VERY LOW BANDS
		5			SW	M		MODERATE RESISTANCE WITH HIGH BANDS
		6				H		HIGH RESISTANCE
		7						

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. 9

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 19-10-10
Method: SPIRAL AUGER JK250
R.L. Surface: ≈ 11.9m
Datum: AHD
Logged/Checked by: L.Y/

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
								-	SANDSTONE: fine grained, light grey.	SW	H		
						8			END OF BOREHOLE AT 7.8m				'TC' BIT REFUSAL
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. **10**

1/2

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT

Date: 15-10-10

Method: SPIRAL AUGER JK305

R.L. Surface: ≈ 11.3m

Datum: AHD

Logged/Checked by: L.Y/

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 clay, low to medium plasticity, dark brown, with a trace of roots.	MC>PL			GRASS COVER APPEARS POORLY COMPACTED
	DS	N = 5 2,2,3				FILL: Silty clay, medium plasticity, orange brown mottled grey and dark brown with a trace of fine to medium grained igneous gravel.	MC>PL			
ON COMPLE -TION OF AUGER -ING	DS	N = 16 4,7,9	1 2		CL-CH	SILTY CLAY: medium to high plasticity, red brown mottled orange brown and light grey, with a trace of ironstone gravel.	MC>PL	St	150 160 180	
ON COMPLE -TION OF COR -ING	DS	N = 29 14,13,16	3		-	SHALE: light grey and dark grey.	XW	EL	- 460 520 550	VERY LOW 'TC' BIT RESISTANCE
			4			SHALE: dark grey.	DW	VL-L	-	VERY LOW TO LOW RESISTANCE WITH MODERATE BANDS VERY LOW TO LOW RESISTANCE
			5				SW-FR	L-M		LOW RESISTANCE WITH HIGH BANDS LOW TO MODERATE RESISTANCE
	DS							M-H		MODERATE TO HIGH RESISTANCE
			6 7			REFER TO CORED BOREHOLE LOG				


JEFFERY & KATAUSKAS PTY LTD
JOB No. 24375VT BH10 Start Coring at 5.84m
6
CL 0.05 m
7
CL 0.05 m
8
EOBH @ 8.88 m

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. **10**

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT | **Core Size:** NMLC | **R.L. Surface:** ≈ 11.3m

Date: 15-10-10 | **Inclination:** VERTICAL | **Datum:** AHD

Drill Type: JK305 | **Bearing:** | **Logged/Checked by:** L.Y/

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL VL L M H VH EH)	DEFECT SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		5		START CORING AT 5.84m						
FULL RE-TURN		6		SHALE: dark grey.	FR	M-H	× ×		-J,80°,P,S	
				CORE LOSS: 0.05m					-Cr,60mm.t	
		7		SHALE: dark grey.	FR	M-H	× ×		-Cr,5mm.t	
				SANDSTONE: fine grained, light grey, with laminae at 0-10°.		H				
				CORE LOSS: 0.05m						
		8		SANDSTONE: fine grained, light grey, with laminae at 0-10°.	FR	VH	× × ×			
		9		END OF BOREHOLE AT 8.88m						
		10								
		11								

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **11**
1/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 12.2m
Date: 14-10-10 **Datum:** AHD
Logged/Checked by: L.Y/

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		FILL: Silty clay, low plasticity, dark brown, with a trace of roots and fine to medium grained igneous gravel.	MC<PL			GRASS COVER APPEARS MODERATLY COMPACTED
	N = 14 6,6,8	1	CL-CH	SILTY CLAY: medium to high plasticity, brown mottled orange brown.	MC>PL	H	520 530 585	RESIDUAL
ON COMPLE -TION	N = 14 5,6,8	2		as above, but red brown mottled orange brown and light grey, with a trace of XW ironstone.				
	N = 24 8,12,12	3					520 550 600	
			-	SHALE: light grey.	XW	EL		
		4		SHALE: dark grey.		EL-VL		VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
		5				L		LOW RESISTANCE
		6			SW	M-H		MODERATE RESISTANCE
		7		SHALE: dark grey, with interbedded fine grained sandstone.		H		MODERATE TO HIGH RESISTANCE

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
11

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 14-10-10
Method: SPIRAL AUGER JK305
Logged/Checked by: L.Y/
R.L. Surface: ≈ 12.2m
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
								-	SHALE: dark grey, with interbedded fine grained sandstone.	SW	H		MODERATE TO HIGH RESISTANCE
													HIGH RESISTANCE
											L-M		LOW TO MODERATE RESISTANCE
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. **12**

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT | **Method:** SPIRAL AUGER JK305 | **R.L. Surface:** ≈ 13.2m

Date: 15-10-10 | **Datum:** AHD

Logged/Checked by: L.Y/

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		FILL: Silty clay, low plasticity, dark brown, with a trace of roots and fine to medium grained igneous gravel.	MC<PL			GRASS COVER
	N = 19 6,9,10	1	CL	SILTY CLAY: medium plasticity, orange brown mottled red brown, with fine to medium grained ironstone and igneous gravel.	MC<PL	H	540 >600 >600	RESIDUAL
	N = 25 10,12,13			as above, but light grey mottled yellow brown and red brown.	MC>PL		>600 >600 >600	
		2		as above, but orange brown mottled yellow brown.	MC<PL			
	N = 26 7,11,15	3	-	SHALE: light grey, with ironstone bands.	XW	EL	-	
				as above, but dark grey and brown.		VL		
AFTER 10 MINS OF AUG -ERING		4			DW	L		LOW 'TC' BIT RESISTANCE
		5		as above, but dark grey.	SW	L-M		LOW RESISTANCE WITH MODERATE BANDS
		6		REFER TO CORED BOREHOLE LOG				
		7						


JEFFERY & KATAUSKAS PTY LTD
JOB No. 24375VT BH12 Start Coring at 5.9 m
6
7
CL 0.04 m
8
EOBH@ 8.89 m

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CORED BOREHOLE LOG

Borehole No. 12 2/2

Client:	PAYCE COMMUNITIES PTY LTD
Project:	PROPOSED RESIDENTIAL DEVELOPMENT
Location:	WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT	**Core Size:** NMLC	**R.L. Surface:** ≈ 13.2m
Date: 15-10-10	**Inclination:** VERTICAL	**Datum:** AHD
Drill Type: JK305	**Bearing:**	**Logged/Checked by:** L.Y/

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL VL L M H VH EH)	DEFECT SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		5		START CORING AT 5.9m						
FULL RETURN		6		SHALE: dark grey.	FR	M-H	× ×		-J,55°,P,S,IS	
									-J,55°,P,S,IS	
		7					× ×		-J,70°,P,S	
				CORE LOSS: 0.04m						
		8		SHALE: dark grey.	FR	M-H	× × ×			
		9		END OF BOREHOLE AT 8.89m						
		10								
		11								

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BOREHOLE LOG

Borehole No. **13**

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 14-10-10
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 13.2m
Datum: AHD
Logged/Checked by: L.Y/

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		ASHPHALTIC CONCRETE: 10mm.t				
			-	FILL: Silty sand, fine to medium grained, dark brown, with a trace of fine to medium grained igneous gravel.	-	-	-	
	N = 30 8,14,16		CL	SILTY CLAY: medium plasticity, red brown mottled orange brown, with ironstone gravel.	MC<PL	H	- >600 >600 >600	RESIDUAL
	N = 20 6,9,11	1–2		as above, but light grey mottled red brown, with ironstone gravel.			>600 >600 >600	
AFTER 10 MINS	N = 30 6,10,20	3					490 540 500	
			-	SHALE: light grey.	XW	EL-L	-	VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
		4		SHALE: dark grey and brown.	DW	L		LOW RESISTANCE
						L-M		
		5				M		MODERATE RESISTANCE
						L-M		LOW RESISTANCE WITH MODERATE BANDS
		6		as above, but dark grey.	SW	M-H		MODERATEY TO HIGH RESISTANCE WITH HIGH BANDS
						L-M		LOW TO MODERATE RESISTANCE
		7						

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Borehole No.
13

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 14-10-10
Method: SPIRAL AUGER JK305
Logged/Checked by: L.Y/
R.L. Surface: ≈ 13.2m
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
								-	SHALE: dark grey.	SW	L-M M-H		MODERATE TO HIGH RESISTANCE SAMPLE NOT RECOVERED
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **14**
1/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 14-10-10
Method: SPIRAL AUGER JK305
Logged/Checked by: L.Y/
R.L. Surface: ≈ 15.1m
Datum: AHD

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	DS	N = 9 6,4,5	0		FILL: Silty clay, low plasticity, dark brown and grey, with fine to medium grained igneous gravel and a trace of slag and roots.	MC>PL			GRASS COVER APPEARS MODERATLY COMPACTED
			1	CL	SILTY CLAY: medium plasticity, orange brown mottled yellow brown, with a trace of fine to medium grained igneous gravel.	MC>PL	H	480 420 460	RESIDUAL
	DS	N = 26 8,12,14			as above, but red brown mottled orange brown with ironstone gravel.			>600 >600 >600	
	DS	N = 24 9,12,12	2	-	SHALE: light grey, with a trace of tree roots.	XW	EL	-	VERY LOW 'TC' BIT RESISTANCE
			3					>600 >600 >600	
	DS		4		as above, but with ironstone bands.				VERY LOW RESISTANCE WITH LOW TO MODERATE BANDS
	DS		5		as above, but dark grey and brown.	DW	L		LOW RESISTANCE
	DS		6		as above, but dark grey.	SW	L-M		LOW RESISTANCE WITH MODERATE BANDS
							M		MODERATE RESISTANCE
			7						

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
14
2/2

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT **Method:** SPIRAL AUGER JK305 **R.L. Surface:** ≈ 15.1m
Date: 14-10-10 **Datum:** AHD
Logged/Checked by: L.Y/

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
▼ AFTER 10 MINS								-	SHALE: dark grey.	SW	M M-H		MODERATE RESISTANCE WITH HIGH BANDS
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **15**
1/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 14-10-10
Method: SPIRAL AUGER JK305
Logged/Checked by: L.Y/
R.L. Surface: ≈ 13.5m
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
			0			FILL: Silty sand, fine to medium grained, dark brown, with a trace of roots and fine grained igneous gravel.	M			GRASS COVER
	DS	N = 29 8,13,16			CL	SILTY CLAY: medium plasticity, orange brown, mottled yellow brown, with ironstone gravel.	MC<PL	H	- >600 >600 >600	RESIDUAL
	DS	N = 25 5,12,13	1 2							
AFTER 10 MINS	DS	N >3 7,3/ 100mm REFUSAL	3			as above, but orange brown, mottled light grey.		St		
					-	SHALE: light grey, with ironstone bands.	XW	EL-VL	-	VERY LOW RESISTANCE WITH LOW BANDS
	DS		4 5			as above, but dark grey and brown.	DW	VL-L		VERY LOW TO LOW RESISTANCE
	DS		6			as above, but dark grey.		L-M		LOW RESISTANCE
	DS		7							LOW RESISTANCE WITH MODERATE BANDS

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **15**

2/2

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT

Date: 14-10-10

Method: SPIRAL AUGER JK305

R.L. Surface: ≈ 13.5m

Datum: AHD

Logged/Checked by: L.Y/

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
								-	SHALE: dark grey.	DW	L		
										SW	M		MODERATE RESISTANCE
											H		HIGH RESISTANCE
											L-M		LOW TO MODERATE RESISTANCE
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **16**
1/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 14-10-10
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 15.3m
Datum: AHD
Logged/Checked by: L.Y/

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		FILL: Silty clay, low plasticity, dark grey, with a trace of roots and fine to medium grained igneous gravel.	MC>PL			GRASS COVER
	N = 16 6,7,9		CH	SILTY CLAY: high plasticity, orange brown, with a trace of ironstone gravel and roots.	MC>PL	VSt	340 350 370	RESIDUAL
	N = 18 6,10,8	1				H	570 600 600	
		2		as above, but light grey mottled orange brown.		VSt	370 350 380	
	N > 24 18,14, 10/75mm REFUSAL	3	-	SHALE: light grey.	XW	EL	-	VERY LOW 'TC' BIT RESISTANCE
AFTER 10 MINS		4						VERY LOW RESISTANCE WITH LOW BANDS
		5		SHALE: light grey.	DW	L-M		LOW RESISTANCE
		6						LOW RESISTANCE WITH MODERATE BANDS
		7						

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **16**

2/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 14-10-10
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 15.3m
Datum: AHD
Logged/Checked by: L.Y/

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
								-	SHALE: light grey.	DW	M-H		MODERATE RESISTANCE WITH HIGH BANDS
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. **17**

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT **Method:** JK250 **R.L. Surface:** ≈ 16.5m
Date: 19-10-10 **Datum:** AHD
Logged/Checked by: A.P.C/

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 COMPLE -TION			0			FILL: Silty clay, medium plasticity, dark brown with fine to medium grained shale and igneous gravel, trace of roots and root fibres.	MC>PL			GRASS COVER
		N = 9 4,4,5			CH	SILTY CLAY: high plasticity, red brown and orange brown.	MC>PL	H	460 470 440	RESIDUAL
			1			SILTY CLAY: high plasticity, light grey mottled red brown.	MC≈PL			
		N = 31 8,14,17							>600 >600 >600	
			2							
		10/100mm REFUSAL	3		-	SHALE: light grey with occassional iron indurated bands.	DW-SW	EL-VL		VERY LOW 'TC' BIT RESISTANCE
			4							VERY LOW RESISTANCE WITH LOW STRENGTH BANDS
								VL		LOW RESISTANCE WITH MODERATE STRENGTH BANDS
			5							
			6							
			7			SHALE: dark grey.	SW	L-M		LOW TO MODERATE

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BOREHOLE LOG

Borehole No. **17**

2/2

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT **Method:** JK250 **R.L. Surface:** ≈ 16.5m

Date: 19-10-10 **Datum:** AHD

Logged/Checked by: A.P.C/

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
								-	SHALE: dark grey.	SW	L-M		RESISTANCE
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

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Borehole No. **18**
1/2

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 13-10-10
Method: SPIRAL AUGER JK350
R.L. Surface: ≈ 15.5m
Datum: AHD
Logged/Checked by: L.Y/

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 OF AUGERING			0			FILL: Silty clay, low plasticity, dark brown, with a trace of fine to medium grained igneous gravel and roots.	MC<PL			GRASS COVER
		N = 23 15,10,13			CL-CH	SILTY CLAY: medium to high plasticity, orange brown mottled brown, with a trace of ironstone gravel.	MC<PL	H	- >600 >600 >600	RESIDUAL
		N = 38 14,17,21	1–2		-	INTERBEDDED SHALE AND CLAY: light grey, with ironstone bands.	XW/ MC<PL	EL-H	>600 >600 >600	
ON COMPLETION OF CORING			3		-	SHALE: light grey, with ironstone bands.	XW	EL-VL	-	VERY LOW RESISTANCE
			4				DW	VL		
			5					VL-L		VERY LOW TO LOW RESISTANCE WITH LOW BANDS
			6					L		LOW RESISTANCE
			7			REFER TO CORED BOREHOLE LOG				


JEFFERY & KATAUSKAS PTY LTD
JOB No. 24375VT BH18 Start Coring AT: 6.73m
CORE LOSS 0.27m
7
8
9
EOBH @ 9.69m

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CORED BOREHOLE LOG

Borehole No. 18 2/2

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT **Core Size:** NMLC **R.L. Surface:** ≈ 15.5m
Date: 13-10-10 **Inclination:** VERTICAL **Datum:** AHD
Drill Type: JK350 **Bearing:** **Logged/Checked by:** L.Y/

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		6		START CORING AT 6.73m						
				CORE LOSS: 0.27m						
FULL RE TURN		7		SHALE: dark grey.	DW	L-M			-Cr,25mm.t -Cr,100mm.t -Cr,10mm.t -Cr,20mm.t	
		8			FR	M-H				
		9								
		10		END OF BOREHOLE AT 9.69m						
		11								
		12								

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Borehole No. **19**

1/2

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT **Method:** SPIRAL AUGER JK250 **R.L. Surface:** ≈ 16.2m

Date: 19-10-10 **Datum:** AHD

Logged/Checked by: A.P.C/

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 COMPLE -TION			0			FILL: Silty clay, medium plasticity, dark brown with fine to coarse grained shale and igneous gravel with a trace of root fibres.	MC<PL			
					CH	SILTY CLAY: high plasticity, orange brown mottled red brown.	MC<PL	H	-	RESIDUAL
	DS	N = 12 4,6,6							540 560 570	
			1			SILTY CLAY: medium plasticity, light grey and red brown.	MC>PL		-	
	DS	N = 22 9,10,11							>600 >600 >600	
			2		-	SHALE: light grey with occassional ironstone bands.	XW-DW	EL-VL	-	VERY LOW 'TC' BIT RESISTANCE
	DS	SPT 10/100mm REFUSAL	3				DW	EL-VL		
			4							
	DS									
			5					VL-L		LOW RESISTANCE WITH MODERATE BANDS
	DS					SHALE: dark grey and dark brown with iron indurated bands.	DW			
			6							MODERATE RESISTANCE WITH LOW BANDS
								L		
			7							

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Borehole No. 19

BOREHOLE LOG

Client: PAYCE COMMUNITIES PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT

Date: 19-10-10

Method: SPIRAL AUGER JK250

Logged/Checked by: A.P.C/

R.L. Surface: ≈ 16.2m

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
								-	SHALE: dark grey, with iron indurated bands.	DW-SW	L		MODERATE RESISTANCE WITH LOW BANDS
													MODERATE RESISTANCE
						8			END OF BOREHOLE AT 8.0m				
						9							
						10							
						11							
						12							
						13							
						14							

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BOREHOLE LOG

Borehole No. **20**
1/3

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Date: 22-10-10
Method: SPIRAL AUGER JK305
R.L. Surface: ≈ 18.1m
Datum: AHD
Logged/Checked by: L.Y./

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLE-TION OF AUGER-ING		0		FILL: Silty clay, low plasticity, dark brown, with a trace of roots.	MC>PL			GRASS COVER
	N = 17 8,8,9		CL-CH	SILTY CLAY: medium to high plasticity, orange brown mottled red brown, with ironstone gravel.	MC≈PL	H	- >600 >600 >600	RESIDUAL
		1						
	N = 25 10,11,14			as above, but light grey mottled red brown, with ironstone gravel.	MC<PL		>600 >600 >600	
		2						
				as above, but red brown mottled light grey, with ironstone gravel bands.				
ON COMPLE-TION OF CORING								
	SPT 6/100mm REFUSAL	3					450 500 500	VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
			-	SHALE: light grey, with M-H strength ironstone bands.	XW	EL-VL	-	
								LOW RESISTANCE
		4						LOW RESISTANCE WITH MODERATE BANDS
		5						
					DW	VL		
		6						
				as above, but dark grey and brown.		L-M		LOW TO MODERATE RESISTANCE
		7						

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BOREHOLE LOG

Borehole No. **20**

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT | **Method:** SPIRAL AUGER JK305 | **R.L. Surface:** ≈ 18.1m
Date: 22-10-10 | **Datum:** AHD

Logged/Checked by: L.Y./

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
									SHALE: dark grey.	DW	L-M		
									REFER TO CORED BOREHOLE LOG				
						8							
						9							
						10							
						11							
						12							
						13							
						14							


JEFFERY & KATAUSKAS PTY LTD
JOB No. 24375VT BH20 Start Coring at: 7.08 m
7
8
CORE LOSS 1.42 m
9
EOBH@ 9.9m
10

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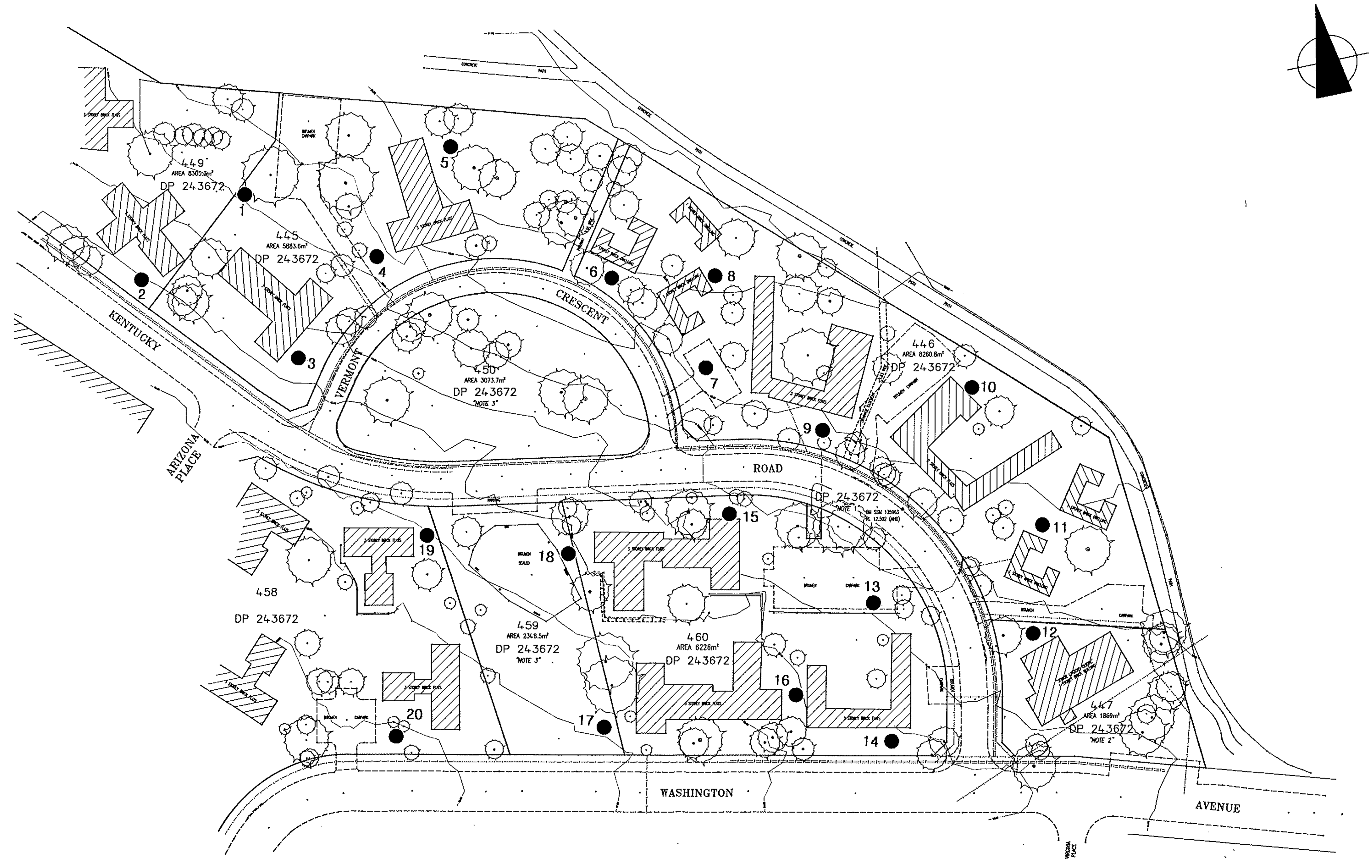
CORED BOREHOLE LOG

Borehole No. 20
3/3

Client: PAYCE COMMUNITIES PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: WASHINGTON AVENUE, RIVERWOOD, NSW

Job No. 24375VT
Core Size: NMLC
R.L. Surface: ≈ 18.1m
Date: 22-10-10
Inclination: VERTICAL
Datum: AHD
Drill Type: GEO305
Bearing:
Logged/Checked by: L.Y/

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL VL L M H VH EH)	DEFECT SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		6							NOTE: ALL DEFECTS NOT INDIVIDUALLY DESCRIBED ARE Be, 0-5°, P, IS, UNLESS OTHERWISE NOTED.
		7		START CORING AT 7.08m					
FULL RE TURN				SHALE: dark grey.	DW	M-H	× ×		- J, 70°, P, S - J, 70°, P, S - 2xJ, 70°, P, IS - Cr, 0°, 20mm.t - XWS, 5mm.t
		8		CORE LOSS 1.42m					
		9							
				SHALE: dark grey.	DW	M	× ×		- FRAGMENTED ZONE, 380mm.t
		10		END OF BOREHOLE AT 9.90m		VL			
		11							
		12							



BOREHOLE LOCATION PLAN

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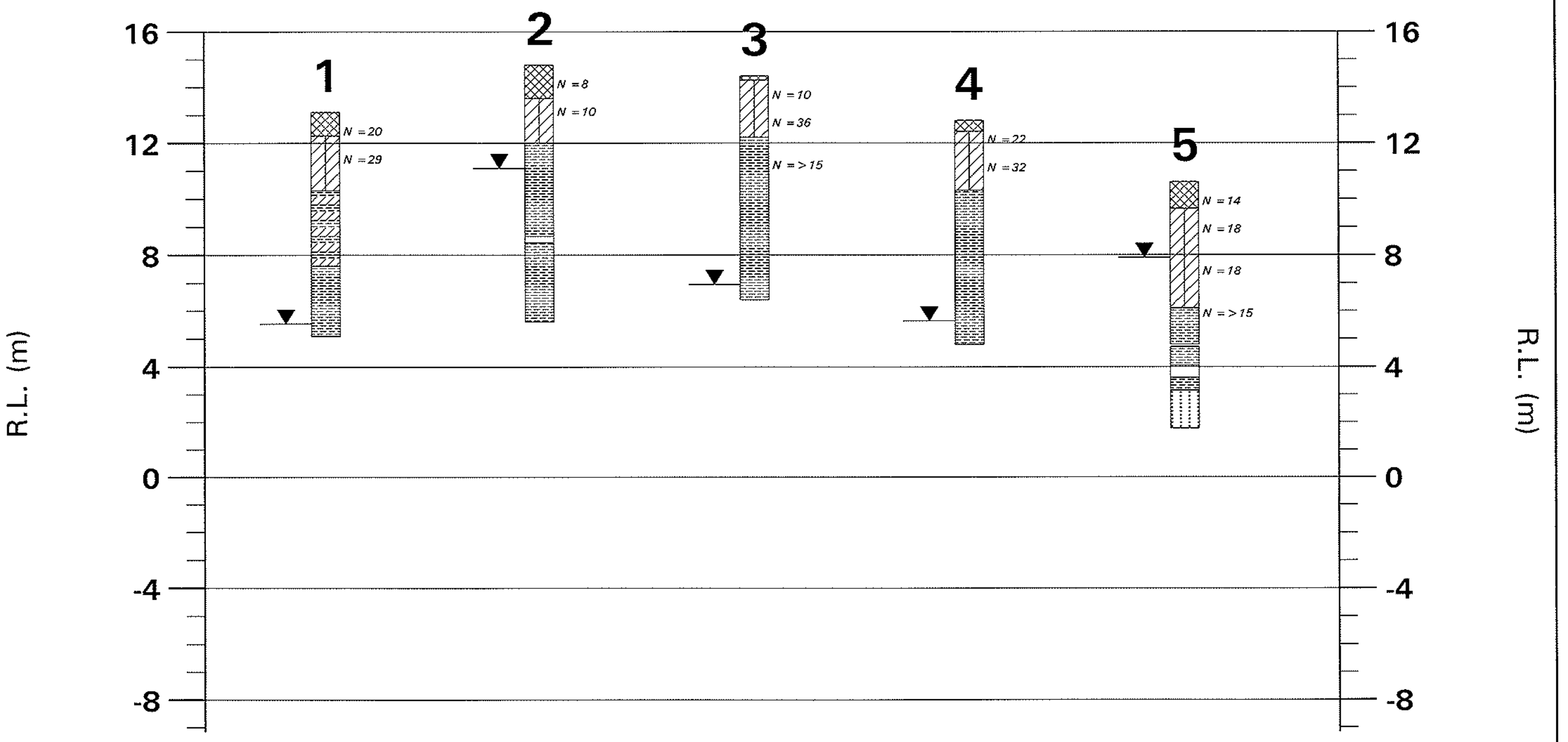
Report No. 24375VT **Figure No. 1**

GRAPHICAL BOREHOLE SUMMARY



Fill

Description not given for: "O="

Description not given for: "-"

EXTRA: narrow-spaced horizontal dashed lines

Blank

Sandstone

Description not given for: "WATERJK"

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 200 (vert) ; NTS (horiz)

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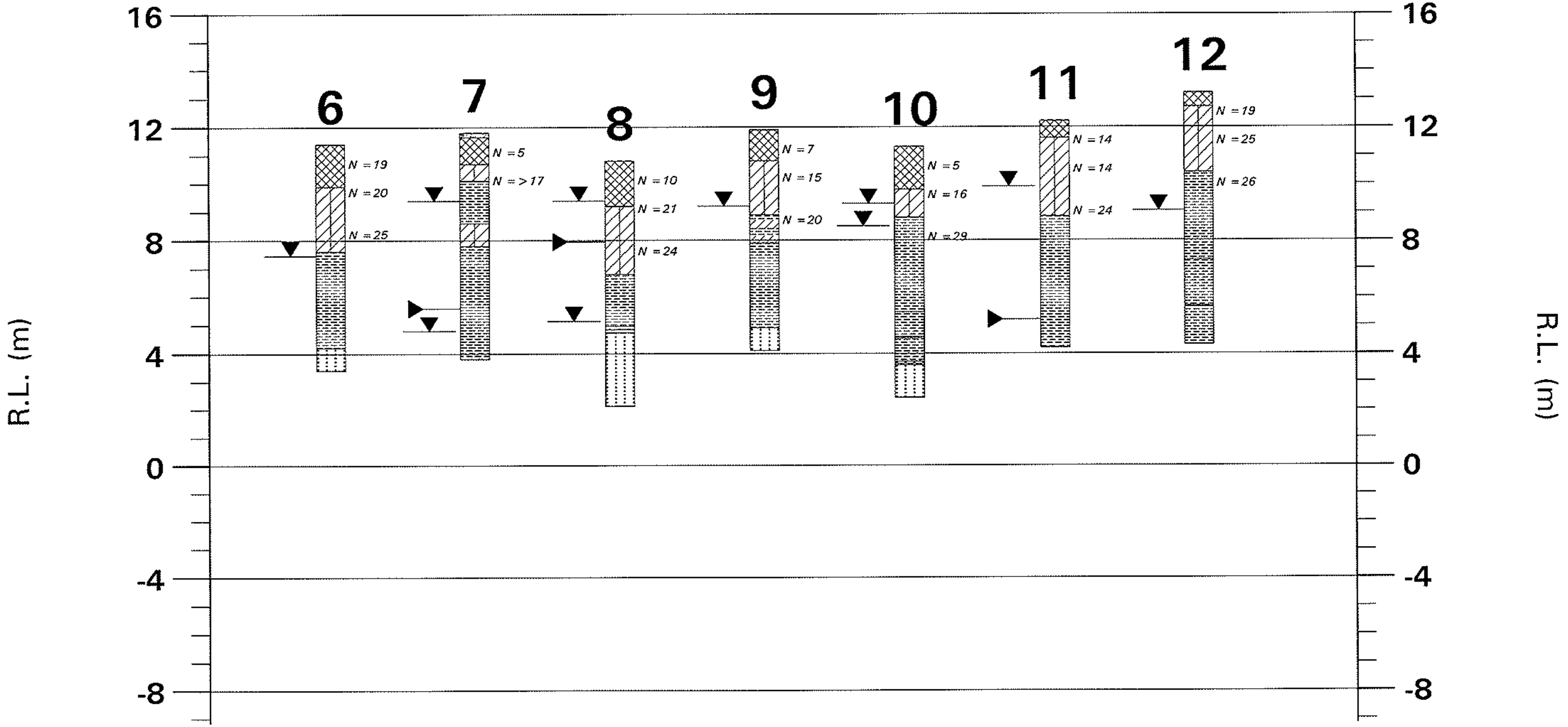
Job No.: 24375VT

Figure No.: 2A

GRAPHICAL BOREHOLE SUMMARY



Fill

Description not given for: "O="

EXTRA: narrow-spaced horizontal dashed lines

Sandstone

Description not given for: "1:"

Blank

Description not given for: "."

Description not given for: "WATERJK"

Description not given for: "J&KSEEP"

NOTE: REFER TO BOREHOLE LOGS

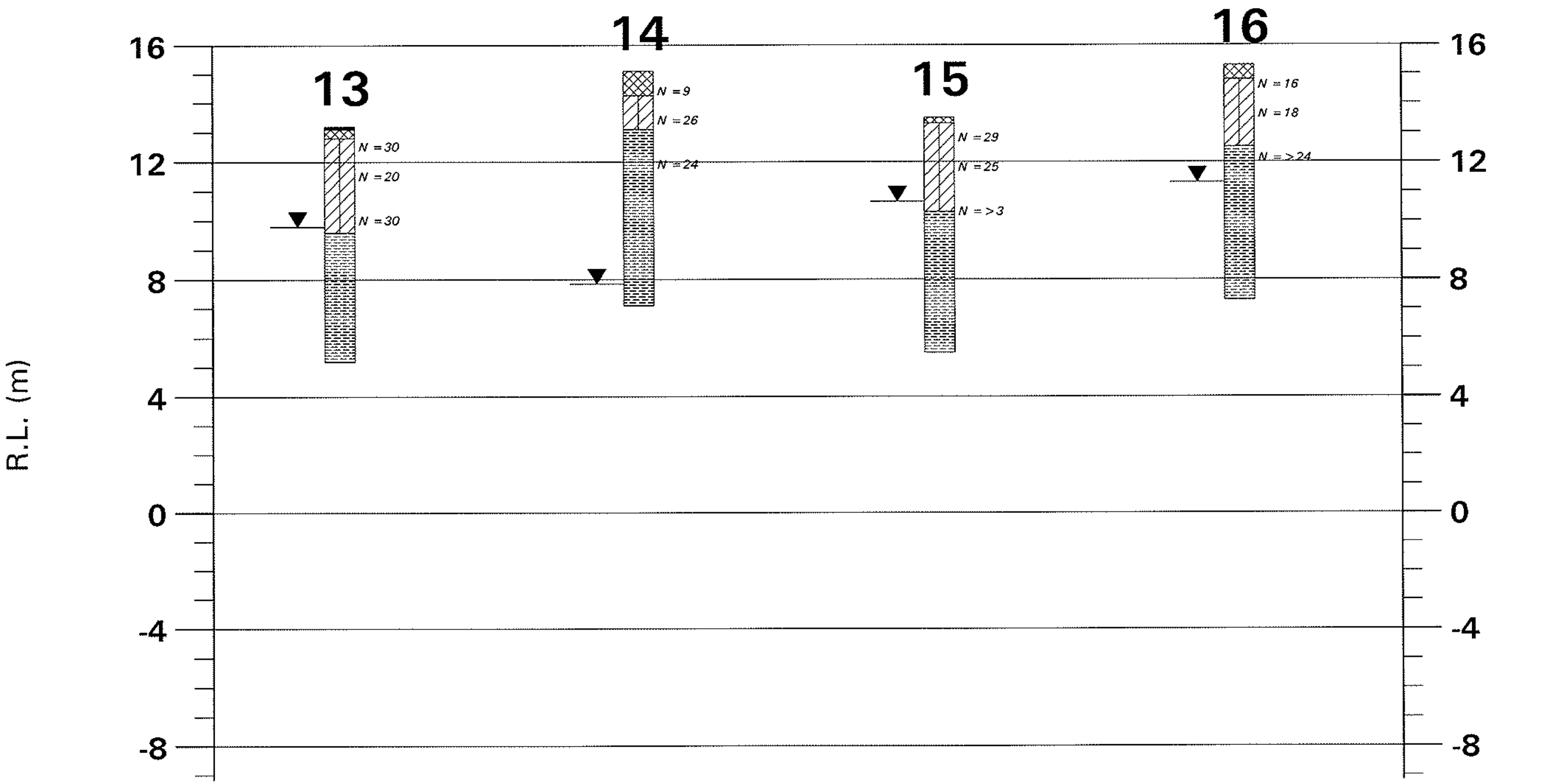
Scale: 1 : 200 (vert) ; NTS (horiz)

Jeffery and Katauskas Pty Ltd

Job No.: 24375VT

Figure No.: 2B

GRAPHICAL BOREHOLE SUMMARY



Paving

Fill

Description not given for: "O="

EXTRA: narrow-spaced horizontal dashed lines

Description not given for: "WATERJK"

NOTE: REFER TO BOREHOLE LOGS

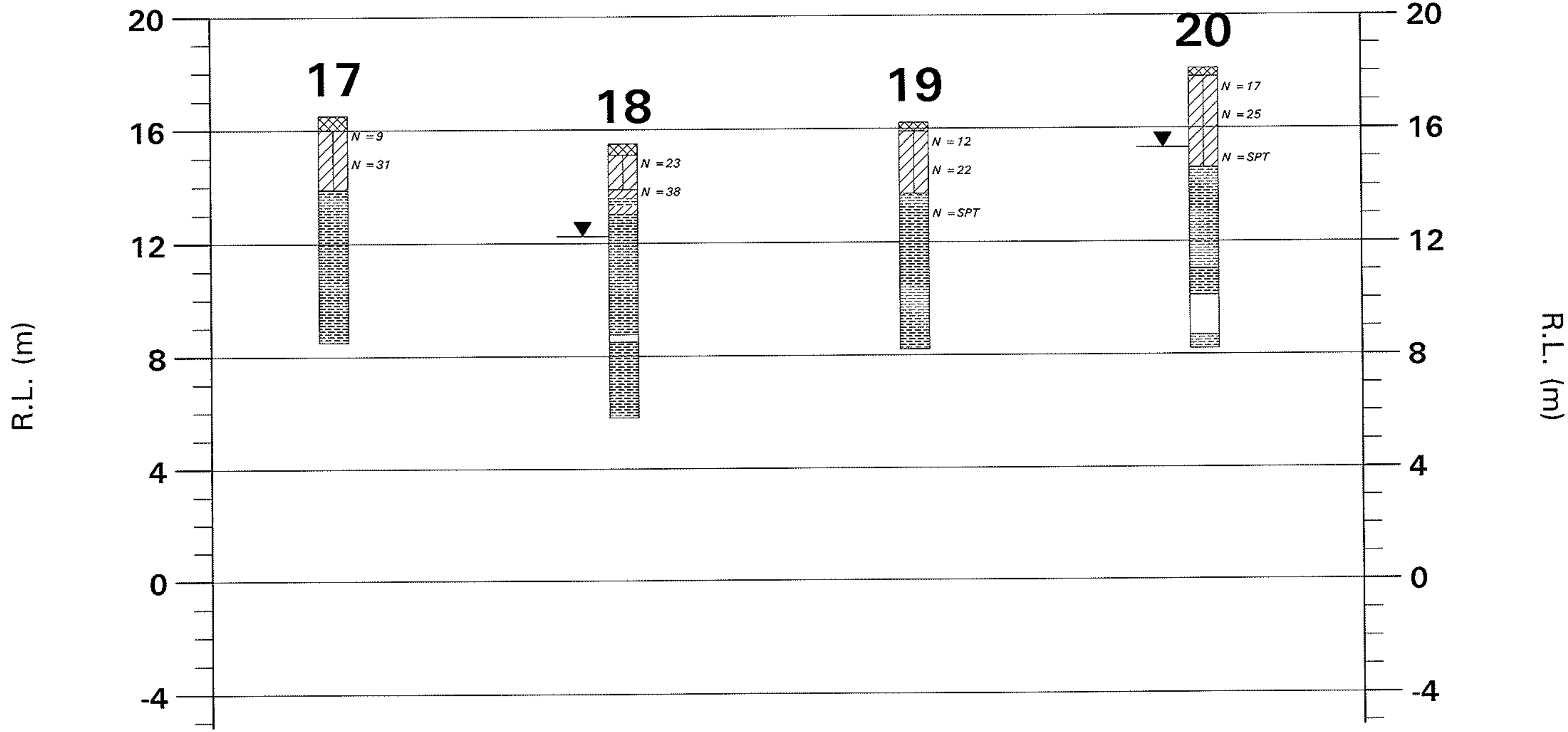
Scale: 1 : 200 (vert) ; NTS (horiz)

Jeffery and Katauskas Pty Ltd

Job No.: 24375VT

Figure No.: 2C

GRAPHICAL BOREHOLE SUMMARY



Fill

Description not given for: "O="

EXTRA: narrow-spaced horizontal dashed lines

Description not given for: "„

Blank

Description not given for: "WATERJK"

NOTE: REFER TO BOREHOLE LOGS

Scale: 1 : 200 (vert) ; NTS (horiz)

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Job No.: 24375VT

Figure No.: 2D

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VIBRATION EMISSION DESIGN GOALS

German Standard DIN 4150 – Part 3: 1986 provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 1 below.

It should be noted that peak vibration velocities higher than the minimum figures in Table 1 for low frequencies may be quite "safe", depending on the frequency content of the vibration and the actual condition of the structure.

It should also be noted that these levels are "safe limits", up to which no damage due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. Should damage be observed at vibration levels lower than the "safe limits" then it may be attributed to other causes. DIN 4150 also states that when vibration levels higher than the "safe limits" are present, it does not necessarily follow that damage will occur. Values given are only a broad guide.

Table 1 DIN 4150 – Structural Damage – Safe Limits for Building Vibration

Group	Type of Structure	Peak Vibration Velocity in mm/s			
		At Foundation Level At a Frequency of			Plane of Floor of Uppermost Storey
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design.	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use.	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 and 2 and have intrinsic value (eg buildings that are under a preservation order).	3	3 to 8	8 to 10	8

Note: For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column should be used.

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REPORT EXPLANATION NOTES

INTRODUCTION

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

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

DESCRIPTION AND CLASSIFICATION METHODS

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

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

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

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

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

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

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'Shale' is used to describe thinly bedded to laminated siltstone.

SAMPLING

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

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

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

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

INVESTIGATION METHODS

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

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

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

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

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

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

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

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

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

  N = 13
  4, 6, 7

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

  N>30
  15, 30/40mm

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

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

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

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using 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 to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

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

GROUNDWATER

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

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

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

FILL

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

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

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soil for Engineering Purposes'*. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

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

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

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

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

SITE ANOMALIES

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

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document *'Guidelines for the Provision of Geotechnical Information in Tender Documents'*, published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

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

REVIEW OF DESIGN

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

SITE INSPECTION

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

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii) full time engineering presence on site.

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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

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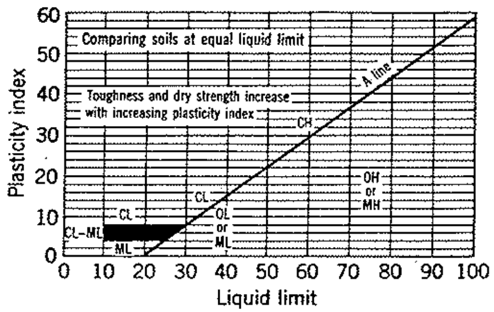
UNIFIED SOIL CLASSIFICATION TABLE

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] (The 75 µm sieve size is about the smallest particle visible to naked eye)	Gravels. More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or *PI* less than 4. Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	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

Laboratory Classification Criteria (coarse-grained soils): 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.

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

Major divisions		Identification Procedures on Fraction Smaller than 380 µm Sieve Size: 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	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

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

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LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** — **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose — <15 — 0-4
	L	Loose — 15-35 — 4-10
	MD	Medium Dense — 35-65 — 10-30
	D	Dense — 65-85 — 30-50
	VD	Very Dense — >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

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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	