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REPORT

TO

WELLES THOMAS PTY LTD

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED WELLES THOMAS PLAZA

AT

THOMAS AND ALBERT STREET CARPARKS
BETWEEN THOMAS STREET AND ALBERT AVENUE,
CHATSWOOD, NSW

22 June 2010

Ref: 23473ZNrpt2

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
Postal Address: PO Box 976, North Ryde BC NSW 1670
Tel: 02 9888 5000 • Fax: 02 9888 5003 • Email: engineers@jkgroup.net.au • ABN 17 003 550 801

TABLE OF CONTENTS

TABLE A: SUMMARY OF MOISTURE CONTENT TEST RESULTS

TABLE B: SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE LOGS 1 TO 8 INCLUSIVE WITH CORE PHOTOGRAPHS

FIGURE 1: BOREHOLE LOCATION PLAN

FIGURE 2: GRAPHICAL BOREHOLE SUMMARY - EAST WEST SECTION

FIGURE 3: GRAPHICAL BOREHOLE SUMMARY – NORTH SOUTH SECTION

FIGURE 4: RECOMMENDED DESIGN PRESSURES FOR ANCHORED OR PROPPED RETAINING WALLS

REPORT EXPLANATION NOTES

VIBRATION EMISSION DESIGN GOALS SHEET

1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed Welles Thomas Plaza at the existing Albert and Thomas Street Carparks between Albert and Thomas Streets Chatswood, NSW. The investigation was commissioned by returned 'Acceptance of Proposal' dated 7 October 2009 signed by Mr Jiaxin Zheng of Welles Thomas Pty Ltd. The investigation was carried out in accordance with our proposal Ref: P30160ZN dated 7 October 2008.

From the supplied PTW Architects architectural drawings (Project No 209039 Dwg Nos A-0000, A-0001, A-0002, A-0090, A-0100 to 0108, A-0111 to 0115, A-0121 to 0126, A-0131, A-0132, A-0140 to 0143, A-0151, A-0152, A-0181, A-0182 and A-0201 to 0203, Revision B dated 18 December 2009, and Sketches SK001, SK002 and SK003 dated May 2010) we understand that it is proposed to construct two tower buildings over five common levels of basement carparking. The tower at the western end of the site is to be a commercial tower of 21 levels above ground and the tower at the northern end of the site is to be a residential tower of 29 levels above ground. The basement levels are to cover the entire site and are to have a finished floor level at RL83.40m AHD which will require excavation below existing surface levels of up to about 19m, with excavation of around 1m below this expected for the lift over-run pits.

From discussion with Aldis Birzulis of Burzulis Associates (project structural engineer), column loads of up to around 30,000kN are anticipated.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for comments and recommendations on hydrogeological conditions, excavation conditions, retention options, retention design parameters, footing options, footing design parameters, basement slab-on-grade design and other geotechnical aspects of the proposed works.

2 INVESTIGATION PROCEDURE

Prior to drilling commencing, the borehole locations were electronically scanned for buried services by a specialist subcontractor.

Eight boreholes (BH1 to BH8) were drilled using spiral augering techniques to depths between 10.54m and 13.22m using our truck mounted JK500 drill rig. All eight boreholes were subsequently extended to final depths between 21.21m and 23.45m using diamond coring techniques with water flush.

The strength of the residual silty clay was assessed by Standard Penetration Test (SPT) 'N' values and hand penetrometer tests carried out on the recovered disturbed samples from the SPT sampler. In the augered borehole sections, the strength of the shale bedrock was assessed by observation of the drilling resistance of a tungsten carbide (TC) bit attached to the auger together with examination of the recovered rock chips and subsequent correlation with laboratory moisture content testing. The strength of the cored bedrock was assessed by examination of the recovered rock core and subsequent correlation with the results of Point Load Strength Index Tests ($I_{s(50)}$) carried out in the laboratory on selected rock core. The results of the point load testing are summarised in Table B and have been plotted on the cored borehole logs. PVC standpipe piezometers were installed in boreholes BH1, BH2 and BH3 to depths between 12m and 18m on completion of borehole drilling. All of the standpipes were provided with a cast iron gatic cover at ground level.

Groundwater observations were made during and on completion of augering, on completion of coring, and at the end of the fieldwork program. As water is injected into the boreholes during coring, the groundwater levels may not have fully stabilised prior to the water level readings being taken immediately following the completion of coring. No longer term groundwater monitoring was undertaken.

The borehole locations, as shown on the attached Borehole Location Plan (Figure 1) were set out by taped measurements from existing surface features and inferred site boundaries. The approximate surface levels of the boreholes was estimated by interpolation between the spot heights on the provided Whelans Insites Pty Ltd survey plan (Dwg Ref: D645SC Issue C dated 11 July 2008). The datum of the levels is Australian Height Datum (AHD).

Our geotechnical engineers, Joseph Chaghouri and Li Yang, set out the borehole locations, directed the scanning for buried services, nominated the sampling and testing locations, and prepared logs of the strata encountered. The borehole logs, which include field test results and groundwater observations, are attached to this report together with a set of Report Explanation Notes, which describe the investigation techniques adopted and define the logging terms and symbols used.

Selected rock chip and rock core samples were tested by Soil Test Services Pty Ltd (STS), a NATA registered laboratory, to determine moisture contents and point load index strengths. The results of the laboratory testing are summarised in Tables A and B. Contamination testing of the site soils was outside the scope of this investigation.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located within gently sloping terrain around 100m east of a north-south trending ridge line. The site itself sloped down to the south east at between about 5° and 7°. The northern site boundary was formed by Thomas Street and the southern site boundary by Albert Avenue. The site is 'L' shaped in plan with the base of the 'L' running along the eastern site boundary and the upright of the 'L' along the southern site boundary. The site was around 75m north-south by 80m east-west.

At the time of the fieldwork, the site was occupied by two at grade asphaltic concrete surface car parking areas. The asphaltic concrete generally appeared to be in fair to good condition with some areas of patches and cracking of the surfacing. A number of large trees were located within the site and along the northern and southern site boundaries. A asphaltic concrete surfaced laneway, Fleet Lane ran through the centre of the site in an east-west direction.

To the east of the site were two commercial buildings. At the southern end was a three storey concrete and brick building located on the site boundary and at the northern end was an eight storey concrete and glass building located around 2m from the site boundary. Fleet Lane ran between the two buildings beyond the site boundary.

To the north west of the site (in the 'corner' of the 'L') was a two and three storey brick and concrete commercial building which was located immediately adjacent to the site boundary.

To the west of the site was Albert Lane which was around 6m wide, beyond which were a number of two and three storey brick and concrete commercial buildings.

Beyond Thomas Street to the north was a multi storey commercial and residential tower building with an unknown number of basement levels.

Beyond Albert Avenue to the south were a number of multi storey residential apartment buildings.

The number of basement levels below the adjoining and nearby buildings is unknown.

Based on cursory visual inspections from within the subject site, the neighbouring buildings all appeared to be in good external condition.

3.2 Subsurface Conditions

The 1:100,000 Geological Map of Sydney indicates that the site is underlain by Ashfield Shale.

The boreholes disclosed a subsurface profile consisting of pavement and fill overlying residual silty clay over shale bedrock at variable depth. Reference should be made to the attached borehole logs for detailed descriptions of the subsurface conditions. The more pertinent details of the encountered subsurface profile are discussed below:

Pavements and Fill

Asphaltic concrete pavement between 20mm and 100mm thick was penetrated from the surface at all of the borehole locations. Fill consisting of silty clay, gravelly sand and sand was encountered from immediately beneath the asphaltic concrete to depths between 0.2m and 0.8m.

Residual Silty Clay

Residual silty clay was encountered from immediately below the fill in all of the boreholes. The residual silty clay was assessed as being of medium or high plasticity, and of very stiff to hard or hard strength with the exception of the upper clays in BH4 which were of stiff to very stiff strength.

Shale Bedrock

Shale bedrock was encountered in all of the boreholes at depths between 2.5m (BH2) and 8.0m (BH7). The shale bedrock was generally extremely weathered and of extremely low strength or distinctly weathered and of very low strength on first contact and generally increased in strength with depth to medium or high strength. In general, the upper shales were of poor quality to significant depth (up to 17.6m).

Sandstone Bedrock

Sandstone bedrock of low to medium strength was encountered below the shale at a depth of 21.6m in BH1 only.

Groundwater

Groundwater seepage was encountered during augering at depths between 4.5m (BH6) and 12.6m(BH4) in all of the boreholes except BH2 and BH3. On completion of augering, BH2 and BH3 were dry, and standing water was present in the remaining boreholes at depths between 7.6m (BH6) and 10.7m (BH4). No groundwater observations were made on completion of coring as groundwater is injected into the boreholes during coring and the groundwater levels would not have fully stabilised following the completion of coring. Following installation of the PVC standpipes, the standpipes were bailed dry of standing water, at the completion of the fieldwork, and standing water was present at a depth of 5.4m in BH1, 11.05m in BH2 and 9.9m in BH3. This corresponds to RLs of approximately 93.3mAHD, 90.45mAHD and 91.0mAHD respectively.

3.3 Laboratory Test Results

The laboratory moisture content tests on the recovered rock chip samples from the augered portion of the boreholes generally correlated well with our field assessment of the in-situ rock strength.

The point load strength index test results generally correlated well with our field assessment of the in-situ rock strength. The estimated Unconfined Compressive Strength (UCS) of the recovered bedrock varied between <1MPa and 74MPa. The average UCS was around 20MPa.

3.4 Shale Bedrock Classification

Based on the recommendations in Foundation on Shale and Sandstone by Pells et al 1998, we have classified the shale bedrock as outlined in the following table. In general, the shale bedrock was of Class IV or V on first contact increasing to Class II or III with depth with some zone of Class I shale encountered also. A summary of the classifications in the table below is also shown on Figures 2 and 3 (Graphical Borehole Summaries).

	Pells et al Rock Class RLs (mAHD)			
Borehole No.	V	IV	III	II
1	N/A	91.7-80.25	80.25-77.0 (shale) 77.0-75.25 (sandstone)	N/A
2	99.0-92.0	92.0-88.1 84.0-82.1	88.1-87.0	87.0-84.0 82.1-79.0
3	93.0-91.4 89.1-86.8	91.4-89.1	N/A	86.8-78.4
4	93.15-91.7 86.2-83.65	91.7-86.2	83.65-79.7	79.7-77.8
5	96.3-92.3	92.3-83.55	78.7-78.05	83.55-78.7
6	93.0-91.0	91.0-80.1	77.79	N/A
7	94.1-88.3	88.3-85.8	85.8-80.15	N/A
8	97.4-94.25	94.25-87.2	87.2-84.0	84.0-78.2

4 COMMENTS AND RECOMMENDATIONS

4.1 Geotechnical Site Suitability

Geotechnically, the subsurface soil and bedrock profile encountered on site is considered suitable to support the proposed development.

4.2 Geotechnical Design Issues

The following are considered to be the principal geotechnical design issues for the proposed development:

- The shale bedrock is deeply weathered and will need to be fully retained for the full depth of the proposed basement.
- The proximity of the neighbouring buildings will require particular care with the design of retaining walls adjacent to the adjoining buildings so as to reduce and movement or settlement of the ground behind the walls.
- The shale bedrock at bulk excavation level is of variable quality, with the bedrock class ranging from Class IV to Class II across the basement excavation.

The above geotechnical design issues are covered in detail in the following sections of the report.

4.3 Dilapidation Reports

Prior to the commencement of excavation, detailed dilapidation reports should be completed on any neighbouring buildings or structures which fall within the zone of influence of the excavation. The zone of influence of the excavation is defined as a distance of 2H back from the top of the excavation where H is the depth of the excavation in metres. The respective owners should be asked to confirm that the reports present a fair record of existing conditions, These dilapidation reports may then be used as a benchmark against which to assess possible future claims for damage arising from the works. We note that Council will likely also require that dilapidation reports be completed for adjacent Council infrastructure.

4.4 Hydrogeological Conditions

Groundwater seepage was encountered at depths between 4.5m And 12.6m during drilling, and on completion of the fieldwork, standing water was present at depths between 5.4m and 11.05m (between RLs 90.45mAHD and 93.3m AHD).

Given the expected low permeability of the subsurface soil profile (residual silty clays, shale and sandstone bedrock), we consider that construction of a drained basement design would be feasible and appropriate. Groundwater seepage into the basement excavation would be expected to reduce as the excavation progresses, and the surrounding profile is drained of water. Locally higher inflows could be expected to occur through open joints or bedding planes during and following heavy rainfall events. Such a process would not be expected to cause any adverse effects on any surrounding structures or improvements.

Long term groundwater flows would be expected to be of limited volumes and would be able to be controlled by draining them to a sump at the lowest basement level for pumped disposal to the stormwater system.

Based on the above, we do not consider that the proposed development will have significant effect on regional groundwater flows. In addition, the site is located near the ridgeline in a heavily built up area, and hence, groundwater flows are expected to be of limited volume through the low permeability subsurface profile.

4.5 Excavation

All excavation recommendations should be complemented by reference to the Code of Practice *'Excavation Work'*, Cat No 312 dated 31 March 2000 by WorkCover.

4.5.1 Excavation Methods

Prior to the commencement of bulk excavation, the proposed development will require demolition of the existing pavements within the existing car park and along Fleet Lane. Following this all trees (including their root balls) and other vegetation and any deleterious or contaminated fill should be stripped and disposed appropriately off site. Reference should be made to Section 6 below for comments on the off-site disposal of soil.

To achieve the finished floor levels for the proposed lower Basement 5 Level, bulk excavation to a maximum depth of about 19m below existing grade will be required. Locally deeper excavation will be required for the proposed lift over-run pits, services and footings. Based on the borehole logs, the proposed basement excavations will therefore extend through the fill, residual soil and into the underlying Class V to Class II shale bedrock (refer table in Section 3.4 above for RLs to the various rock classifications).

Excavation of the soil profile and the Class V shale can be carried out using buckets attached to large hydraulic excavators or dozers. More effective excavation may be possible using buckets fitted with "tiger teeth".

The excavation for the deeper more competent Class IV or better shale bedrock will extend predominantly through shale ranging from low to high strength and therefore excavation productivity will be expected to be slower and higher than normal 'wear and tear' of excavation attachments is to be expected. The presence of defects and the fine grained sub-horizontally bedded laminae within the shale will help to facilitate excavation, but only marginally. We recommend that the excavation of the more competent shale bedrock be carried out by ripping using either a large dozer of at least Caterpillar D9 size or equivalent and/or a large excavator (at least 30 tonne in size). This equipment may also be required to assist excavation of any medium to high strength iron indurated bands (or other harder bands of rock) within the soil or Class V shale. We anticipate that more consistent zones of high or very high strength shale will present hard ripping or "hard rock" excavation conditions and will require the use of hydraulic rock hammers fitted to the excavators. Grid sawing techniques with ripping or hammering will also facilitate excavation.

Groundwater seepage monitoring should be carried out during bulk excavation prior to finalising the design of a pump out facility. Outlets into the stormwater system will require Council approval.

Particular care will be required during bulk excavation to avoid undermining or removing support from neighbouring buildings, footpaths etc.

4.5.2 Potential Vibration Risks

We recommend that considerable caution be taken during rock excavation on this site as there will likely be direct transmission of ground vibrations to adjoining buildings and structures. The proposed excavations will extend to the site boundaries which some of the neighbouring buildings directly adjoin.

Excavation procedures and the dilapidation reports should be carefully reviewed prior to the commencement of pavement demolition and excavation, so that appropriate equipment is used.

The excavation with hydraulic rock hammers should commence away from likely critical areas (i.e. commence over the central portion of the site) using the large hydraulic excavator fitted with a relatively low energy hydraulic rock hammer no larger than say, a Krupp 900 size or equivalent. In addition, a vertical saw cut slot should be provided along the perimeter of the excavation and the base of the slot maintained at a lower level than the adjoining rock excavation at all times. We recommend that continuous vibration monitoring be carried out during rock excavations. Subject to review of the dilapidation reports, vibrations, measured as Peak Particle Velocity (PPV), should be limited to no higher than 8mm/sec for the buildings to the north west and south east (ie the low height brick buildings) and 15mm/sec for the building to the north east (ie the framed concrete commercial building). If it is found that transmitted vibrations are excessive, then it would be necessary to use a smaller rock hammer or alternative excavation techniques. The use of a rotary grinder or rock sawing in conjunction with ripping presents an alternative low vibration excavation technique, however, productivity is likely to be slower. When using a rock saw or rotary grinder, the resulting dust must be suppressed by spraying with water.

The following procedures are recommended to reduce vibrations when rock hammers are used:

- Maintain rock hammer orientated towards the face and enlarge excavation by breaking small wedges off the face.
- Operate one hammer at a time and in short bursts only to reduce amplification of vibrations.
- Use excavation contractors with experience in confined work with a competent supervisor who is aware of vibration damage risks, possible rock face instability issues, etc. The contractor should be provided with a full copy of this report and have all appropriate statutory and public liability insurances.

4.6 Excavation Support

4.6.1 Support Systems

As the required excavations will extend to the site boundaries, temporary batter slopes of the soil and weathered rock profile will not be feasible. We therefore recommend that the proposed vertical cuts in the soil and weathered shale bedrock profiles i.e. Class V and IV shale, be supported by an engineered retention system.

Given the subsurface conditions encountered, suitable retention systems include an anchored soldier bored pile wall, with reinforced shotcrete panels. The shotcrete and anchors must be installed progressively as excavation proceeds.

As the piles will need to be drilled into shale bedrock of up to high strength at significant depth, large capacity pile rigs fitted with rock teeth will be required. The proposed piling contractor(s) should be shown a copy of this report to ensure that appropriate equipment is brought to site.

Given the depth of the weathered shale profile, we recommend that the anchored soldier pile wall extend the full depth of the basement excavation and the piles be socketed an appropriate depth below bulk excavation level to satisfy stability and foundation conditions. In the areas where Class III or better shale is present above bulk excavation level it may be feasible to reduce (possibly to zero) the lateral earth pressures in these areas, however, if this is adopted, the Class III and better shale bedrock must be regularly inspected by a geotechnical engineer as excavation proceeds as localised stabilisation measures may be required if adverse defects are found. Treatment for zones requiring stabilisation may include rock bolting, shotcreting, underpinning etc.

In addition, we forewarn that the shales in Sydney do at times contain adversely orientated continuous joints which can cause instability of rock cuttings, particularly where the joints are smooth, clay smeared or slickensided. The presence of these joints cannot readily be determined by investigation, and are usually only noted during excavation. To manage the potential risks associated with these continuous joints, every 1.8m of vertical excavation, inspection slots should be excavated perpendicular to and up against the excavation perimeter, to a depth of about 2m below the current excavation level, to allow inspection by an experienced geotechnical engineer. The slots should be completed on a hit one/miss two basis, for example, say a 2m wide slot with 4m of rock left between. This methodology was used recently on a deep basement excavation in shale in Hurstville and proved to be both efficient and successful. If a continuous joint is encountered, it may require the retrofit of significant anchors to stabilise the rock wedge formed; the equivalent lateral pressure could be in the order of 10H kPa, where H is the depth from the surface to where the joint daylights in the face, in metres. The cored boreholes show numerous inclined joints, which suggests that there will be at least some stabilisation required.

We assume that permanent support of the retention system will be provided by bracing from the proposed structure.

Consideration should be given to carrying out computer modelling (eg WALLAP or PLAXIS) of the proposed retaining wall system to analyse loads on the wall and potential movement of the wall. We can complete such modelling if commissioned to do so.

4.6.2 Retaining Wall Design Parameters

The major consideration in the selection of earth pressures for the design of the retaining walls is the need to limit deformations occurring outside the excavations. The following characteristic earth pressure coefficients and subsoil parameters may be adopted for the design of temporary or permanent retention systems.

- All retaining elements (i.e. piles, etc) should be uniformly founded on the weathered shale bedrock. For allowable bearing pressure recommendations, refer to Section 4.6 below.
- For anchored or propped walls, where minor movements can be tolerated (such as along the northern and southern street frontages, provided there are no buried movement sensitive services present within the road reserve), we recommend the use of trapezoidal earth pressure distribution of 6H (kPa) for the soil profile and Class IV and V shale bedrock, where H is the retained height in metres. These pressures should be assumed to be uniform over the central 50% of the support system, as indicated in Figure 4.
- For anchored or propped walls, supporting areas which are relatively sensitive to movement (such as along the eastern and western site boundaries), a trapezoidal earth pressure distribution of 8H (kPa) should be adopted for the soil profile and Class IV and V shale bedrock, where H is the retained height in metres. These pressures should be assumed to be uniform over the central 50% of the support system.
- Any surcharge affecting the walls (eg traffic loading, construction loads, nearby buildings, etc) should be allowed in the design using an 'at rest' earth pressure coefficient, K_o, of 0.55.
- The retaining walls should be designed as drained and measures taken to induce complete and permanent drainage of the ground behind the wall. Strip drains incorporating a geofabric to act as a filter against subsoil erosion would be appropriate for soldier pile walls. Should seepage volumes be higher than anticipated, it may be necessary to change to a blanket drain incorporating a geofabric to act as a filter against subsoil erosion.
- For piles embedded into the underlying Class IV or better shale bedrock below excavation level (including footing and service excavation), an allowable lateral toe resistance of 300kPa may be adopted. This value assumes excavation is not carried out within the zone of influence of the wall toe and the rock does not

contain unfavourable defects etc. The upper 0.3m depth below excavation level should not be taken into account to allow for tolerance and disturbance effects during excavation. The quality of the toe restraint rock should be progressively inspected by a geotechnical engineer on exposure to confirm that unexpected conditions do not exist.

- If rock anchors are to run below adjoining properties, then permission of the owners must be obtained before installation. Also, the presence of neighbouring basements and their levels must be confirmed prior to finalising anchor design.
- Anchors should preferably have their bond length within shale bedrock of at least Class IV. For the design of anchors bonded into such shale bedrock, an allowable bond stress of 300kPa is recommended, subject to the following conditions:
    - Anchor bond length of at least 3m behind the 'active' zone of the excavation (taken as a 45° zone above the base of the excavation).
    - Overall stability, including anchor group interaction, is satisfied.
    - All anchors are proof loaded to at least 1.3 times the design working load before being locked off at working load.

4.7 Footings

Based on the investigation results, , shale bedrock will be uniformly exposed at bulk excavation level. However, the quality of the shale bedrock at bulk excavation level varies considerably across the site.

Pad and strip footings and bored piles founded within the shale bedrock may be designed based on the allowable end bearing pressures outlined in the following table. For piles, a minimum socket of 0.3m into the appropriate shale stratum is required to achieve these allowable end bearing pressures. For rock sockets longer than this 0.3m, the allowable shaft adhesions outlined in the table below may be adopted provided the socket is satisfactorily cleaned and roughened. For all footings, both shallow and piles, the lowest quality shale bedrock within 1.5 times the width/diameter of the footing will give the allowable bearing pressure for the design of footings. The allowable bearing pressures and shaft adhesions are based on serviceability criteria and should result in settlements of less than 1% of the footing width/diameter.

Rock Class	Allowable Bearing Pressure (MPa)	Allowable Shaft Adhesion (compression) (MPa)	Allowable Shaft Adhesion (tension/uplift) (MPa)
V	700	70	35
IV	1500	150	75
III	3500	350	175
II	6000	600	300

Footings on the shale bedrock may also be designed using "Limit State Design" principles as detailed by Pells et al. (1998). Ultimate bearing capacities and shaft adhesion values are outlined in the following table. Settlement limitations to the structures will still need to be satisfied and can be estimated using the elastic moduli value in the table below.

It should be noted that such ultimate bearing pressures must be used in conjunction with an appropriate *"Geotechnical Strength Reduction Factor"* (ϕ_g). Provided there is good workmanship and quality control during footing construction, we recommend that a ϕ_g value of 0.6 be adopted for end bearing and shaft adhesion.

Rock Class	Ultimate Bearing Pressure (MPa)	Ultimate Shaft Adhesion (compression) (kPa)	Ultimate Shaft Adhesion (tension/uplift) (kPa)	Elastic Modulus E (MPa)
V	3	100	50	100
IV	4	250	125	300
III	25	500	250	800
II	100	1000	500	1500

Given the above, we recommend that pad and strip footings at bulk excavation level be designed based on Class III shale bedrock being present. However, all pad and strip footings will need to be spoon tested, and an allowance made for deepening (or widening) footings should the presence of adverse defects (eg extremely weathered seams or crushed seams) below the base of the footing be disclosed from the spoon tests.

The prospective piling contractors should be provided with a full copy of our report so that appropriate drilling rigs and equipment (i.e. rock augers and cleaning buckets) are brought to site. Due to the likely depth of the piles, concrete would have to be poured using tremie techniques. The piling contractors must advise as to the method and proposed equipment for pile base and socket clean out. If this option is to be further considered, then a detailed method statement must be compiled by the piling contractor.

All bored piles drilled and footings excavated, should be inspected, cleaned out, "dry" and poured on the same day as drilling. All pile holes should be cleaned out using a cleaning bucket (for all pile diameters) for effective removal of loose materials.

4.8 Basement Slab On Grade

As outlined above, we expect the proposed basement 04 level to be underlain by shale bedrock. We therefore recommend that underfloor drainage be provided. The underfloor drainage should comprise a strong, durable, single-sized washed aggregate such as 'blue metal' gravel. The underfloor drainage should include a sump and pump dewatering system. The sump/s should have an automatic level control pump to avoid flooding of the basement level. The wall drains should be connected into the underfloor drainage system.

On-grade floor slabs should be separated from all walls, columns, footings, etc., to permit relative movements (i.e. designed as 'floating' slabs). Joints in the concrete on-grade floor slabs should be designed to accommodate shear forces but not bending moments by using dowelled or keyed joints.

5 ADDITIONAL GEOTECHNICAL WORK REQUIRED

We summarise below the previously recommended additional work that needs to be carried out:

- Computer analysis of the proposed basement retaining walls.
- Dilapidation survey reports on the neighbouring buildings.
- Geotechnical inspections of rock faces during excavation.
- Vibration monitoring during rock excavation.
- Witness the proof stressing of temporary anchors.
- Geotechnical inspection of footing excavations.
- Spoon testing footing excavations.
- Groundwater monitoring into the bulk excavation.

We also recommend a meeting at the commencement of construction to discuss the primary geotechnical issues and inspection requirements.

6 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. 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.

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.

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

for **Nicholas Smith**
Senior Geotechnical Engineer

for **Agi Zenon**
Senior Associate
For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD.

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

Ref No: 23473ZN

TABLE A
SUMMARY OF MOISTURE CONTENT TEST RESULTS

AS 1289 TEST METHOD 2.1.1

BOREHOLE NUMBER	DEPTH	MOISTURE CONTENT
	m	%
1	7.00-7.50	9.8
1	10.00-10.50	10.9
2	7.00-7.50	13.7
2	10.00-10.50	9.1
3	8.50-9.00	8.3
3	11.00-11.40	7.2
4	8.50-9.00	10.6
4	11.50-12.00	11.9
5	8.50-9.00	10.5
5	10.00-10.50	9.2
6	8.50-9.00	8.8
6	11.50-12.00	10.1
7	9.80-10.20	19.9
7	11.50-11.63	13.5
8	7.00-7.50	12.1
8	10.00-10.54	10.4

115 Wicks Road
Macquarie Park, NSW 2113
PO Box 976
North Ryde, Bc 1670
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

Ref No: 23473ZN

TABLE B
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
1	12.77-12.79	0.1	2
	13.15-13.18	0.6	12
	14.41-14.43	0.4	8
	14.84-14.87	0.05	<1
	15.18-15.21	0.1	2
	15.75-15.78	0.1	2
	16.64-16.66	0.1	2
	17.38-17.41	0.2	4
	18.00-18.03	2.9	58
	18.95-18.98	3.3	66
	19.52-19.55	1.1	22
	20.85-20.88	3.0	60
	21.00-21.03	0.9	18
	21.68-21.70	0.3	6
	22.73-22.76	0.9	18
	23.36-23.38	1.6	32
2	11.85-11.87	0.1	2
	12.66-12.68	0.1	2
	13.03-13.05	2.0	40
	13.54-13.56	0.6	12
	14.18-14.20	1.6	32
	14.85-14.87	1.9	38
	15.29-15.31	1.6	32
	15.79-15.81	2.3	46
	16.41-16.43	1.2	24

NOTES: See Page 6 of 6

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Macquarie Park, NSW 2113
PO Box 976
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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
2	17.03-17.05	2.2	44
	17.87-17.89	2.0	40
	18.56-18.58	0.5	10
	19.07-19.09	1.4	28
	19.79-19.81	0.5	10
	20.04-20.06	1.0	20
	20.67-20.69	1.5	30
	21.40-21.42	1.0	20
	22.00-22.02	1.3	26
3	11.91-11.93	0.2	4
	12.47-12.49	0.1	2
	13.22-13.24	0.9	18
	14.19-14.21	1.1	22
	14.81-14.83	2.0	40
	15.26-15.29	1.1	22
	15.83-15.85	2.8	56
	16.81-16.83	1.7	34
	17.49-17.51	1.4	28
	18.05-18.07	1.1	22
	18.94-18.97	1.8	36
	19.44-19.47	1.6	32
	20.05-20.07	1.2	24
	20.83-20.85	1.5	30
	21.33-21.35	1.3	26
	22.33-22.36	1.0	20

NOTES: See Page 6 of 6

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Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

TABLE B
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
4	13.24-13.27	0.3	6
	13.79-13.82	0.3	6
	14.46-14.49	0.05	<1
	15.32-15.35	0.03	<1
	15.73-15.77	0.4	8
	15.95-15.97	0.2	4
	16.15-16.18	0.2	4
	16.83-15.86	0.9	18
	17.08-17.11	1.6	32
	17.89-17.92	2.2	44
	18.20-18.23	0.2	4
	18.26-18.29	1.2	24
	19.27-19.30	0.6	12
	19.96-20.00	1.3	26
	20.47-20.50	0.4	8
	20.81-20.83	0.8	16
	21.36-21.39	0.7	14
5	12.28-12.31	0.1	2
	12.86-12.90	0.05	<1
	13.68-13.71	0.1	2
	14.08-14.11	0.1	2
	14.79-14.82	0.3	6
	15.80-15.83	0.3	6
	16.57-15.60	0.3	6
	17.05-17.08	0.2	4

NOTES: See Page 6 of 6

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PO Box 976
North Ryde, Bc 1670
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Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

Ref No: 23473ZN

TABLE B
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
5	17.87-17.90	0.3	6
	18.21-18.24	0.4	8
	18.66-18.69	1.3	26
	19.41-19.44	0.6	12
	20.03-20.06	1.6	32
	20.83-20.86	2.8	56
	21.39-21.42	1.2	24
	22.13-22.16	0.9	18
6	13.57-13.60	0.1	2
	14.33-14.36	0.6	12
	14.90-14.93	0.04	<1
	15.61-15.64	0.05	<1
	16.31-16.34	0.5	10
	16.78-16.81	0.3	6
	17.27-17.31	0.6	12
	17.90-17.93	1.1	22
	18.65-18.68	1.6	32
	19.13-19.16	0.7	14
	19.80-19.83	0.5	10
	20.46-20.49	0.8	16
	21.17-21.20	0.9	18
7	12.32-12.36	0.1	2
	12.68-12.71	0.03	<1
	13.86-13.89	0.1	2
	14.15-14.18	0.3	6

NOTES: See Page 6 of 6

115 Wicks Road
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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S (50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
7	14.94-14.97	0.3	6
	15.60-15.63	1.5	30
	16.09-16.12	1.6	32
	16.85-16.88	1.0	20
	17.50-17.53	1.4	28
	18.09-18.12	1.8	36
	18.89-18.92	0.2	4
	18.93-18.96	0.4	8
	19.05-19.08	1.3	26
	19.87-19.90	0.7	14
	20.45-20.48	1.5	30
	21.84-21.87	1.4	28
8	10.82-10.85	0.1	2
	11.17-11.20	0.1	2
	11.80-11.83	0.1	2
	12.48-12.51	0.1	2
	13.28-13.31	0.4	8
	13.80-13.83	0.2	4
	14.53-14.56	0.4	8
	15.03-15.06	0.2	4
	15.77-15.80	0.5	10
	16.31-16.34	0.1	2
	16.79-16.83	0.9	18
	17.57-17.60	0.9	18
	18.00-18.03	0.6	12

NOTES: See Page 6 of 6

115 Wicks Road
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SOIL TEST SERVICES
ABN 43 002 145 173

Ref No: 23473ZN

TABLE B
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
8	18.90-18.93	1.1	22
	19.48-19.51	3.7	74
	20.09-20.12	2.9	58
	20.85-20.88	1.4	28
	21.31-21.34	2.8	56
	22.14-22.17	2.6	52

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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Borehole No. 1
1/4

BOREHOLE LOG

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN
Date: 19-10-09
Method: SPIRAL AUGER JK500
R.L. Surface: ≈ 98.7m
Datum: AHD
Logged/Checked by: J.C./

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		ASPHALTIC CONCRETE: 100mm.t				
				FILL: Silty clay, low plasticity, dark grey, with fine to medium grained, igneous gravel.	MC>PL	-		
	N = 7 2,2,5		CL	SILTY CLAY: medium plasticity, light brown, with a trace of root fibres.	MC>PL	St	- 120 130	RESIDUAL
		1		SILTY CLAY: medium plasticity, red brown mottled light brown.		VSt	300	
	N = 23 6,11,12		CL-CH	SILTY CLAY: medium to high plasticity, light grey mottled red brown and light brown, with fine to medium grained ironstone gravel.	MC≈PL	H	440 >600 >600	
		2						
	N = 31 9,14,17	3					>600 >600 >600	
		4	CH	SILTY CLAY: high plasticity, light grey mottled red brown, with XW shale bands and a trace of fine grained ironstone gravel.	MC<PL			
	N = 44 9,18,26						>600 >600 >600	
		5						
ON 23-10-09				SILTY CLAY: high plasticity, light grey, with XW shale bands.				
	N > 29 9, 29/150mm REFUSAL	6					480 >600 510	
		7						

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BOREHOLE LOG

Borehole No. 1

Client: WELLES THOMAS PTY LTD

Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Method:** SPIRAL AUGER JK500 | **R.L. Surface:** ≈ 98.7m

Date: 19-10-09 | **Datum:** AHD

Logged/Checked by: J.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: brown and orange brown.	DW	VL		VERY LOW 'TC' BIT RESISTANCE
			8			SHALE: grey and dark grey, with light grey and orange brown bands.				VERY LOW TO LOW RESISTANCE
			9							
			10							
ON COMPLETION OF AUGERING										
			11							
			12							
						REFER TO CORED BOREHOLE LOG				
			13							
			14							

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CORED BOREHOLE LOG

Borehole No. 1

Client: WELLES THOMAS PTY LTD

Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Core Size:** NMLC | **R.L. Surface:** ≈ 98.7m

Date: 19-10-09 | **Inclination:** VERTICAL | **Datum:** AHD

Drill Type: JK500 | **Bearing:** - | **Logged/Checked by:** J.C./

Water Loss/Level	Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Specific
	12	START CORING AT 12.14m			
		CORE LOSS 0.42m			
40% RETURN		SHALE: dark grey, with light grey laminae, bedded at 0°, with medium strength bands.	DW	VL-L	- J, 40°, P, S
	13				- Cr, 100mm.t
					- XWS, 50mm.t
					- J, 20°, P, S
					- XWS, 60mm.t
					- XWS, 30mm.t
	14				- Cr, 50mm.t
					- XWS, 30mm.t
					- Cr, 70mm.t
					- XWS, 70mm.t
					- Cr, 20mm.t
	15				
	16				- Cr, 50mm.t
					- XWS, 90mm.t
	17				- J, 45°, P, S
					- XWS, 90mm.t
					- XWS, 50mm.t
					- J, 70°, P, S
					- Cr, 50mm.t
			SW	H	- J, 80°, P, S
					- J, 50°, P, S
	18				- J, 40°, P, S
					- XWS, 10mm.t
					- J, 10°, P, S
					- J, 70°, P, S

Point Load Strength Index $I_s(50)$ scale: EL VL L M H VH EH

Defect Spacing (mm) scale: 500 300 100 50 30 10

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Borehole No. 1

CORED BOREHOLE LOG

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Core Size:** NMLC | **R.L. Surface:** ≈ 98.7m
Date: 19-10-09 | **Inclination:** VERTICAL | **Datum:** AHD
Drill Type: JK500 | **Bearing:** - | **Logged/Checked by:** J.C./

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 – Description (Type, inclination, thickness, planarity, roughness, coating) Specific / General
FULL RET-URN				SHALE: dark grey, with light grey laminae, bedded at 0°.	SW	M-H			- J, 80°, P, S - J, 50°, P, S - J, 90°, P, S - J, 35°, P, S - J, 30°, P, S
		20							
		21							- Be, 5°, P, S, 10mm.t CLAY INFILL
				SANDSTONE: fine to medium grained, light grey and orange brown.	DW	L-M VL L-M			
		22							
		23							- CS, 30mm.t - XWS, 50mm.t
				END OF BOREHOLE AT 23.45m					50mm DIA. PVC STANDPIPE PIEZOMETER INSTALLED TO 12m, SLOTTED BETWEEN 9m AND 12m. CAST IRON GATIC COVER AT SURFACE
		24							
		25							

Point load scale: EL, VL, L, M, H, VH, EH. Defect spacing scale: 500, 300, 100, 50, 30, 10.

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BOREHOLE LOG

Borehole No. **2**
1/4

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN
Date: 20-10-09
Method: SPIRAL AUGER JK500
R.L. Surface: ≈ 101.5m
Datum: AHD
Logged/Checked by: J.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 COMPLET-ION OF AUGER-ING			0			ASPHALTIC CONCRETE: 100mm.t				
	DS				-	FILL: Gravelly sand, fine to medium grained, grey, with fine to medium grained igneous gravel.	M	-	-	
	DS	N = 9 4,4,5			CH	SILTY CLAY: high plasticity, orange brown mottled red brown and light brown, with a trace of fine to medium grained ironstone gravel.	MC>PL	H	510 410 510	RESIDUAL
			1							
	DS	N = 24 5,10,14				SILTY CLAY: high plasticity, light grey mottled red brown and yellow brown.	MC≈PL		500 >600 >600	
			2							
					-	SHALE: light grey, red brown and yellow brown, with iron indurated bands and clay bands.	XW	EL	-	
	DS	N = 62 14,32,30	3						>600 >600 >600	
			4							
	DS	N = 57 11,22,35							>600 >600 >600	
			5							
						SHALE: dark grey, with light grey bands.	XW-DW	EL-VL		
	DS		6							
			7							

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BOREHOLE LOG

Borehole No. **2**

2/4

Client: WELLES THOMAS PTY LTD

Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Method:** SPIRAL AUGER JK500 | **R.L. Surface:** ≈ 101.5m

Date: 20-10-09 | **Datum:** AHD

Logged/Checked by: J.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, with light grey bands.	XW-DW	EL-VL		
			8							
			9							
								VL-L		VERY LOW TO LOW 'TC' BIT RESISTANCE
			10							
ON 23-10-09			11							
										LOW RESISTANCE
						REFER TO CORED BOREHOLE LOG				
			12							
			13							
			14							

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CORED BOREHOLE LOG

Borehole No. 2

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Core Size:** NMLC | **R.L. Surface:** ≈ 101.5m
Date: 20-10-09 | **Inclination:** VERTICAL | **Datum:** AHD
Drill Type: JK500 | **Bearing:** - | **Logged/Checked by:** J.C./

Water Loss/Level	Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Description (Specific)
	11				
	11.65	START CORING AT 11.65m			
FULL RETURN	11.65–12.95	SHALE: dark grey, with light grey laminae, bedded at 0°.	DW	VL-L	- Cr, 30mm.t - XWS, 15mm.t - XWS, 15mm.t - XWS, 70mm.t - XWS, 25mm.t - XWS, 15mm.t - XWS, 15mm.t - XWS, 30mm.t - XWS, 20mm.t - XWS, 20mm.t - XWS, 10mm.t
	12.95–14.0		SW	M-H	- J, 25°, P, S - J, 40°, P, S - J, 20°, P, S - J, 45°, P, S
	14.0–		FR	H	- J, 60°, P, S, IS
40% RETURN	15–18.5				- J, 40°, P, S - XWS, 10mm.t - XWS, 10mm.t - XWS, 20mm.t

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 – General

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CORED BOREHOLE LOG

Borehole No. **2**

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Core Size:** NMLC **R.L. Surface:** ≈ 101.5m
Date: 20-10-09 **Inclination:** VERTICAL **Datum:** AHD
Drill Type: JK500 **Bearing:** - **Logged/Checked by:** J.C./

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 DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
FULL RET-URN		18.5–22.5		SHALE: dark grey, with light grey laminae, bedded at 0°.	FR	M-H			- XWS, 20mm.t - XWS, 20mm.t - XWS, 25mm.t - Cr, 20mm.t - XWS, 20mm.t - XWS, 15mm.t - XWS, 20mm.t - XWS, 40mm.t - XWS, 85mm.t - XWS, 50mm.t - XWS, 20mm.t - J, 40°, P, S - J, 40°, P, S - J, 50°, P, S - J, 45°, P, S - J, 40°, P, S - J, 20°, P, S - J, 45°, P, S - J, 85°, P, S	
		22.5		END OF BOREHOLE AT 22.50m					50mm DIA. PVC STANDPIPE PIEZOMETER INSTALLED TO 18m, SLOTTED BETWEEN 15m AND 18m. CAST IRON GATIC COVER AT SURFACE	

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BOREHOLE LOG

Borehole No. **3**

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN
Date: 21-10-09
Method: SPIRAL AUGER JK500
R.L. Surface: ≈ 100.9m
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
DRY ON COMPLETION OF AUGERING			0			ASPHALTIC CONCRETE: 40mm.t				
						FILL: Roadbase, 120mm.t	MC>PL	-	-	
						FILL: Silty clay, low plasticity, brown, with a trace of slag and fine to medium grained igneous gravel.				
	DS	N = 9 2,3,6			CH	SILTY CLAY: high plasticity, orange brown, with a trace of fine to medium grained ironstone gravel.	MC>PL	H	475 475 480	RESIDUAL
			1							
	DS	N = 36 9,14,22				as above, but red brown mottled light grey and brown, with ironstone gravel bands.	MC≈PL		>600 >600 >600	
			2							
	DS	N > 38 13,25, 13/50mm REFUSAL	3						>600 >600 >600	
			4							
	DS	N = 50 9,17,33							>600 >600 >600	
			5							
	DS	N > 50 9,22, 28/100mm REFUSAL	6						>600 >600 >600	
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Method:** SPIRAL AUGER JK500 **R.L. Surface:** ≈ 100.9m
Date: 21-10-09 **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
					CH	SILTY CLAY: high plasticity, red brown mottled light grey and brown with ironstone gravel bands.	MC≈PL	H		
	DS	SPT 6/50mm REFUSAL			-	SHALE: light grey.	XW	EL	-	VERY LOW 'TC' BIT RESISTANCE
									>600 >600 >600	VERY LOW RESISTANCE WITH LOW BANDS
	DS		8			as above, but dark grey.	XW-DW	EL-VL		
			9							
ON 23-10-09			10				DW	VL-L		VERY LOW TO LOW RESISTANCE
	DS		11							LOW RESISTANCE WITH MODERATE BANDS
			12			REFER TO CORED BOREHOLE LOG				
			13							
			14							

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CORED BOREHOLE LOG

Borehole No. 3

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Core Size:** NMLC **R.L. Surface:** ≈ 100.9m
Date: 20-10-09 **Inclination:** VERTICAL **Datum:** AHD
Drill Type: JK500 **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
		11		START CORING AT 11.70m						
		12		SHALE: dark grey, bedded at 0-5°.	DW	VL-L	× ×		- XWS, 70mm.t - XWS, 10mm.t - XWS, 40mm.t - XWS, 30mm.t - XWS, 30mm.t - XWS, 20mm.t - XWS, 220mm.t - Cr, 60mm.t - XWS, 140mm.t	
		13				M	×		- XWS, 20mm.t - J, 40°, P, S - Cr, 60mm.t - XWS, 50mm.t - Cr, 35mm.t - Cr, 25mm.t - Cr, 120mm.t - Cr, 65mm.t	
		14		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	SW	H	× ×			
		15					× ×			
		16					×			
FULL RET-URN		17					×			

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CORED BOREHOLE LOG

Borehole No. 3

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Core Size:** NMLC **R.L. Surface:** ≈ 100.9m
Date: 20-10-09 **Inclination:** VERTICAL **Datum:** AHD
Drill Type: JK500 **Bearing:** - **Logged/Checked by:** L.Y./

Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Specific	Defect Details – General
	SHALE: dark grey.	SW	H		
~19.5		FR		- J, 90°, P, S	
				- J, 10°, P, S	
				- J, 20°, P, S	
				- J, 50°, P, S	
				- J, 70°, P, S	
				- J, 35°, P, S	
				- J, 40°, P, S	
				- J, 30°, P, S	
				- J, 40°, P, S	
				- J, 30°, P, S	
				- J, 40°, P, S	
				- J, 60°, P, R	
22.53	END OF BOREHOLE AT 22.53m			50mm DIA. PVC STANDPIPE PIEZOMETER INSTALLED TO 18m, SLOTTED BETWEEN 15m AND 18m. CAST IRON GATIC COVER AT SURFACE	

Point Load Strength Index $I_s(50)$: EL VL L M H VH EH
Defect Spacing (mm): 500 300 100 50 30 10

Depth scale: 19, 20, 21, 22, 23, 24

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BOREHOLE LOG

Borehole No.
4
1/4

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN
Date: 22-10-09
Method: SPIRAL AUGER JK500
R.L. Surface: ≈ 99.4m
Datum: AHD
Logged/Checked by: J.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		-	ASPHALTIC CONCRETE: 55mm.t	M	-	-	
		N = 8 2,3,5				FILL: Silty clayey sand, fine to medium grained, brown, with a trace of brick fragments and clay.	MC > PL			APPEARS POORLY COMPACTED
						FILL: Silty clay, low plasticity, dark brown mottled orange brown, with a trace of fine to medium grained ironstone gravel and ash.				
			1		CL-CH	SILTY CLAY: medium to high plasticity, light brown, with a trace of fine to medium grained ironstone gravel.	MC > PL	St- VSt	250 230 190	RESIDUAL
		N = 21 8,9,12	2			SILTY CLAY: medium to high plasticity, light grey mottled red brown and light yellow brown, with fine to medium grained ironstone gravel.	MC≈PL	H	500 460 >600	
		N = 27 8,11,16	3						>600 >600 >600	
			4				MC < PL			
		N = 38 8,15,23	5						>600 >600 >600	
						as above, but with XW shale bands.				
		N > 20 17,20/ 75mm REFUSAL	6						>600 >600	
					-	SHALE: light grey, with iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
			7							

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Borehole No.
4
2/4

BOREHOLE LOG

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Method:** SPIRAL AUGER JK500 **R.L. Surface:** ≈ 99.4m
Date: 22-10-09 **Datum:** AHD
Logged/Checked by: J.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: light grey, with iron indurated bands.	XW	EL		
			8			SHALE: light brown and grey, with iron indurated bands.	DW	VL		VERY LOW RESISTANCE WITH LOW BANDS
			9							
			10							
ON COMPLETION OF AUGERING			11							VERY LOW TO LOW RESISTANCE
			12							
			13			SHALE: dark grey, with light grey bands.		L-M		LOW RESISTANCE
			14			REFER TO CORED BOREHOLE LOG				

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CORED BOREHOLE LOG

Borehole No. **4**

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Core Size:** NMLC | **R.L. Surface:** ≈ 99.4m
Date: 22-10-09 | **Inclination:** VERTICAL | **Datum:** AHD
Drill Type: JK500 | **Bearing:** - | **Logged/Checked by:** J.C./

Water Loss/Level	Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Description (Type, inclination, thickness, planarity, roughness, coating) – Specific
	13	START CORING AT 13.16m			
FULL RETURN	13.16–14.3	SHALE: dark grey, with light grey and orange brown laminae, and occasional iron indurated bands bedded at 0-5°.	DW	L-M	- Cr, 20mm.t - XWS, 10mm.t - Cr, 30mm.t - Cr, 30mm.t - J, 20°, P, S - J, 35°, P, S
	14.3–15.4	SHALE: grey, with light grey laminae, bedded at 0°.	XW-DW	EL-VL	- CS, 90mm.t - J, 50°, P, S - J, 60°, P, S - J, 80°, P, S
		CORE LOSS 0.19m			
	15.6–20.5	SHALE: dark grey and grey, with light grey laminae, bedded at 0°-5°.	DW (to ~16.7) SW (~16.7–19.5) FR (from ~19.5)	L-M (to ~16.7) M-H	- XWS, 50mm.t - Cr, 50mm.t - J, 80°, P, S - J, 35°, P, S - J, 80°, P, S - J, 20°, P, S - J, 20°, P, S, CLAY INFILL - J, 20°, P, S - J, 60°, P, S - J, 20°, P, S - J, 90°, P, S - J, 65°, P, S - J, 20°, P, S - J, 50°, P, S - J, 30°, P, S

Point Load Strength Index $I_s(50)$: EL VL L M H VH EH

Defect Spacing (mm): 500 300 100 50 30 10

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Borehole No. 4

CORED BOREHOLE LOG

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Core Size:** NMLC **R.L. Surface:** ≈ 99.4m
Date: 22-10-09 **Inclination:** VERTICAL **Datum:** AHD
Drill Type: JK500 **Bearing:** - **Logged/Checked by:** J.C./

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
FULL RET-URN		21		SHALE: dark grey, with light grey laminae, bedded at 0°.	FR	H	× × ×		
		22, 23, 24, 25, 26		END OF BOREHOLE AT 21.62m					

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BOREHOLE LOG

Borehole No. 5

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Method:** SPIRAL AUGER JK500 **R.L. Surface:** ≈ 100.3m
Date: 23-10-09 **Datum:** AHD
Logged/Checked by: J.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		-	ASPHALTIC CONCRETE: 50mm.t				
	DB					FILL: Silty clay, low plasticity, dark grey, with a trace of fine to medium grained igneous gravel.	MC>PL	-		
	DB	N = 9 2,3,6			CL-CH	SILTY CLAY: medium to high plasticity, light brown mottled red brown, with fine to medium grained ironstone gravel and a trace of roots.	MC≈PL	VSt -H	260 550 450	RESIDUAL
			1							
	DB	N = 27 8,10,17			CL	SILTY CLAY: medium plasticity, light grey mottled red brown and orange brown, with fine to medium grained ironstone gravel.	MC<PL	H	>600 >600 560	
			2							
	DB	N = 40 10,16,21	3						>600 >600 >600	
			4		-	SHALE: light grey, with occasional iron indurated bands and clay bands.	XW	EL	-	
	DB	N = 48 11,18,30							>600 >600 >600	
			5							
	DB	N > 29 11,29/ 150mm REFUSAL	6						>600 >600 >600	
			7							

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BOREHOLE LOG

Borehole No. **5**

Client: WELLES THOMAS PTY LTD

Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Method:** SPIRAL AUGER JK500 **R.L. Surface:** ≈ 100.3m

Date: 23-10-09 **Datum:** AHD

Logged/Checked by: J.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: light grey, with occasional iron indurated bands and clay bands.	XW	EL		
						8			SHALE: grey, with light grey and orange brown bands.	DW	VL-L		VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
ON COMPLETION OF AUGERING						9							
						10							
						11							
						12							LOW RESISTANCE WITH VERY LOW BANDS
									REFER TO CORED BOREHOLE LOG				
						13							
						14							

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Borehole No. **5** 3/4

CORED BOREHOLE LOG

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Core Size:** NMLC **R.L. Surface:** ≈ 100.3m
Date: 23-10-09 **Inclination:** VERTICAL **Datum:** AHD
Drill Type: JK500 **Bearing:** - **Logged/Checked by:** J.C./

Water Loss/Level	Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Description (Type, inclination, thickness, planarity, roughness, coating) – Specific
	12	START CORING AT 12.13m			
FULL RETURN	12.13–18.1	SHALE: grey and dark grey, with light grey laminae, bedded at 0-15°.	DW	VL-L (from ~14.5m: L-M)	J, 20°, P, S; XWS, 20mm.t; XWS, 20mm.t; XWS, 30mm.t; J, 65°, P, S; XWS, 210mm.t; XWS, 10mm.t; XWS, 50mm.t; Cr, 20mm.t; XWS, 30mm.t; J, 70°, P, S; Cr, 30mm.t; Cr, 20mm.t; Cr, 20mm.t; Cr, 15mm.t; J, 40°, P, S, CLAY INFILL; Cr, 20mm.t; J, 50°, P, S; J, 40°, P, S; J, 70°, P, S; J, 80°, P, S; Cr, 60mm.t; CS, 10mm.t; XWS, 60mm.t
	18.1–	as above, but dark grey.	DW (from ~18.5m: SW-FR)	M-H	J, 55°, P, S; Cr, 15mm.t; J, 20°, P, S

Point Load Strength Index $I_s(50)$ scale: EL VL L M H VH EH

Defect Spacing (mm): 500 300 100 50 30 10

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CORED BOREHOLE LOG

Borehole No. **5**
4/4

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Core Size:** NMLC | **R.L. Surface:** ≈ 100.3m
Date: 23-10-09 | **Inclination:** VERTICAL | **Datum:** AHD
Drill Type: JK500 | **Bearing:** - | **Logged/Checked by:** J.C./

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 DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
FULL RET-URN		19–22.25		SHALE: dark grey, with light grey laminae, bedded at 0°.	SW-FR	H			- J, 30°, P, S - XWS, 5mm.t - J, 50°, P, S - J, 60°, P, S - J, 15°, P, S	
		22.25		END OF BOREHOLE AT 22.25m						

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BOREHOLE LOG

Borehole No. **6**

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN
Date: 27-10-09
Method: SPIRAL AUGER JK500
Logged/Checked by: J.C./
R.L. Surface: ≈ 99.0m
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		-	ASPHALTIC CONCRETE: 20mm.t	M	-	-	
						FILL: Gravelly silty sand, fine to medium grained, grey, with fine to medium grained, dark grey igneous gravel and a trace of clay.			-	
		N = 9 3,3,6			CH	SILTY CLAY: high plasticity, light orange brown mottled light brown.	MC≈PL	VSt-H	280 480 410	RESIDUAL
			1							
		N = 34 6,12,22			CL-CH	SILTY CLAY: medium to high plasticity, light grey mottled red brown and light yellow brown, with fine to medium grained ironstone gravel.		H	410 >600 >600	
			2							
		N = 47 16,19,28	3						>600 >600 >600	
			4			as above, but with a trace of roots.				
▶		N = 40 11,15,25							>600 >600 >600	
			5							
		N > 32 11,32/ 150mm REFUSAL	6		-	SHALE: light grey.	XW	EL	>600 >600 >600	VERY LOW 'TC' BIT RESISTANCE
			7							

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BOREHOLE LOG

Borehole No. **6**

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN
Date: 27-10-09
Method: SPIRAL AUGER JK500
R.L. Surface: ≈ 99.0m
Datum: AHD
Logged/Checked by: J.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 COMPLETION OF AUGERING						SHALE: light grey.	XW	EL		
			8			SHALE: grey, with light grey bands.	DW	VL-L		VERY LOW RESISTANCE WITH LOW BANDS
			9							
						SHALE: dark grey, with light grey bands.				VERY LOW TO LOW RESISTANCE
			10							
			11							
			12							LOW TO MODERATE RESISTANCE WITH VERY LOW BANDS
			13							
						REFER TO CORED BOREHOLE LOG				
			14							

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CORED BOREHOLE LOG

Borehole No. **6**

Client: WELLES THOMAS PTY LTD

Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN	**Core Size:** NMLC	**R.L. Surface:** ≈ 99.0m
Date: 27-10-09	**Inclination:** VERTICAL	**Datum:** AHD
Drill Type: JK500	**Bearing:** -	**Logged/Checked by:** J.C./

Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Description (Type, inclination, thickness, planarity, roughness, coating) – Specific
13	START CORING AT 13.22m			
13.22–16.0	SHALE: grey and dark grey, with light grey laminae, bedded at 0°.	DW	VL-L	- XWS, 10mm.t - XWS, 10mm.t - XWS, 25mm.t - Cr, 30mm.t - J, 85°, P, S - J, 50°, P, S - XWS, 5mm.t - XWS, 30mm.t - J, 80-90°, P, S - XWS, 30mm.t - XWS, 30mm.t - J, 45°, P, S - XWS, 20mm.t
16.0–17.0	SHALE: dark grey.	SW	L-M	- J, 15°, P, S - J, 80°, P, S - J, 35°, P, S
17.0–17.5		SW	M-H	- XWS, 15mm.t - XWS, 15mm.t - J, 20°, P, S - J, 20°, P, S - J, 60°, P, S
17.5–19.0		FR	M-H	- J, 15°, P, S - J, 35°, P, S - J, 10°, P, S - J, 10°, P, S - J, 20°, P, S - J, 80°, Un, S
19.0–19.7		FR	M	- J, 25°, P, S - J, 65°, P, S

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Borehole No.
6
4/4

CORED BOREHOLE LOG

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Core Size:** NMLC | **R.L. Surface:** ≈ 99.0m
Date: 27-10-09 | **Inclination:** VERTICAL | **Datum:** AHD
Drill Type: JK500 | **Bearing:** - | **Logged/Checked by:** J.C./

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
FULL RET-URN		21		SHALE: dark grey.	FR	M	× (M), × (M)		- J, 10°, P, S - J, 20°, P, S	
		22 23 24 25 26		END OF BOREHOLE AT 21.21m						

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BOREHOLE LOG

Borehole No. 7

1/4

Client: WELLES THOMAS PTY LTD

Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Method:** SPIRAL AUGER JK500 | **R.L. Surface:** ≈ 102.1m

Date: 28-10-09 | **Datum:** AHD

Logged/Checked by: J.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		-	ASPHALTIC CONCRETE: 20mm.t	M	-		
						FILL: Gravelly silty sand, fine to medium grained, green grey, fine to medium grained dark grey igneous gravel, with a trace of clay.				
		N = 9 4,4,5			CH	SILTY CLAY: high plasticity, light orange brown mottled light brown.	MC>PL	VSt-H	- 350 520 >600	RESIDUAL
			1							
		N = 23 7,11,12			CL-CH	SILTY CLAY: medium to high plasticity, light grey mottled red brown and light yellow brown, with a trace of fine to medium grained ironstone gravel and XW shale bands.	MC<PL	H	>600 >600 >600	
			2							
		N = 32 9,12,20	3						580 500 >600	
			4							
		N = 56 10,24,32							>600 >600 >600	
			5							
		N = 40 8,13,27	6						>600 >600 >600	
			7							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **7**

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN
Method: SPIRAL AUGER JK500
R.L. Surface: ≈ 102.1m
Date: 28-10-09
Datum: AHD
Logged/Checked by: J.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
▶ (water level)	DS	N > 28 16,21, 7/50mm REFUSAL			CL-CH	SILTY CLAY: medium to high plasticity, light grey mottled red brown and light yellow brown, with a trace of fine to medium grained ironstone gravel and XW shale bands.	MC<PL	H	475 485 400	
			8		-	SHALE: grey and brown, with light grey bands.	XW	EL	-	VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
			9							
▼ ON COMPLETION OF AUGERING	DS		10							VERY LOW TO LOW RESISTANCE
			11							
	DS						DW	VL		LOW RESISTANCE
						REFER TO CORED BOREHOLE LOG				
			12							
			13							
			14							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. **7**

Client: WELLES THOMAS PTY LTD

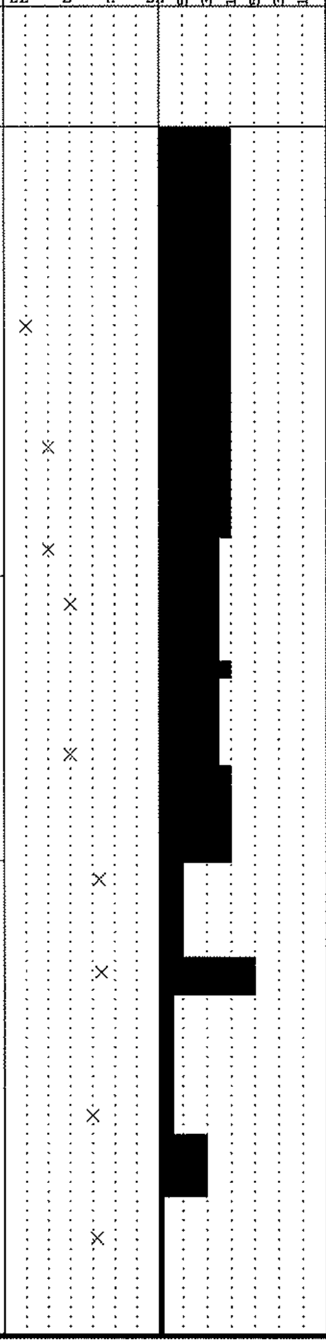
Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN	**Core Size:** NMLC	**R.L. Surface:** ≈ 102.1m
Date: 28-10-09	**Inclination:** VERTICAL	**Datum:** AHD
Drill Type: JK500	**Bearing:** -	**Logged/Checked by:** J.C./

Water Loss/Level	Depth (m)	CORE DESCRIPTION (Rock Type, grain characteristics, colour, structure, minor components.)	Weathering	Strength
	11	START CORING AT 11.63m		
FULL RET-URN	11.63	SHALE: grey, with light grey laminae, bedded at 0-20°.	DW	VL-L
	14			L-M
	14.8	SHALE: dark grey, with light grey laminae, bedded at 0-5°.	SW	
	15.5			M-H

Point Load Strength Index $I_s(50)$ (EL VL L M H VH EH) and Defect Spacing (mm) (500 300 100 50 30 10):



DEFECT DETAILS – DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) – Specific:

- XWS, 15mm.t
- XWS/Cr, 100mm.t
- XWS, 20mm.t
- XWS, 20mm.t
- XWS, 40mm.t
- XWS/Cr, 150mm.t
- XWS, 10mm.t
- XWS, 5mm.t
- XWS, 90mm.t
- XWS, 50mm.t
- XWS, 80mm.t
- XWS, 30mm.t
- 2xXWS, 20mm.t
- XWS, 30mm.t
- XWS, 70mm.t
- XWS, 60mm.t
- XWS, 20mm.t
- XWS, 30mm.t
- 5xXWS, 20mm.t
- XWS, 100mm.t
- J, 85°, P, S
- Cr, 70mm.t
- XWS, 90mm.t
- XWS/Cr, 50mm.t
- XWS, 80mm.t
- XWS, 35mm.t
- J, 10°, P, S
- J, 50°, P, S
- Cr, 110mm.t
- J, 20°, P, S
- XWS, 10mm.t
- XWS, 10mm.t
- XWS, 30mm.t
- XWS, 20mm.t
- J, 90°, P, S
- CS, 10mm.t

General

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. 7

Client:	WELLES THOMAS PTY LTD
Project:	PROPOSED MIXED USE DEVELOPMENT
Location:	THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN	**Core Size:** NMLC	**R.L. Surface:** ≈ 102.1m
Date: 28-10-09	**Inclination:** VERTICAL	**Datum:** AHD
Drill Type: JK500	**Bearing:** -	**Logged/Checked by:** J.C./

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
FULL RETURN		19, 20, 21		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	SW / FR (from ~19m)	M-H			- J, 90°, P, S - J, 90°, Un, S - J, 50°, P, S - CR, 220mm.t - J, 40°, P, S - J, 50°, P, S - XWS, 8mm.t - J, 20°, P, S - 5xJ, 20-45°, P, S - Cr, 50mm.t - J, 45°, P, S - XWS, 5mm.t - J, 10°, P, S - J, 40°, P, S - J, 70°, P, S	
		22, 23, 24		END OF BOREHOLE AT 21.95m						

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No. **8**

1/4

BOREHOLE LOG

Client: WELLES THOMAS PTY LTD

Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN **Method:** SPIRAL AUGER JK500 **R.L. Surface:** ≈ 100.4m

Date: 29-10-09 **Datum:** AHD

Logged/Checked by: J.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		-	ASPHALTIC CONCRETE: 20mm.t	MC<PL	-	-	
						FILL: Silty clay, low plasticity, brown, with fine to medium grained dark grey igneous gravel.				
		N = 19 4,6,13			CL-CH	SILTY CLAY: medium to high plasticity, light brown mottled orange brown, with a trace of fine to medium grained ironstone gravel.	MC≈PL	H	590 >600 500	RESIDUAL
			1							
		N > 41 16,22, 21/50mm REFUSAL				SILTY CLAY: medium to high plasticity, light grey mottled light yellow brown and red brown, with fine to medium grained ironstone gravel and XW shale bands.	MC<PL		>600 >600 >600	
			2							
		N = 54 14,27,27	3		-	SHALE: light grey, yellow brown and red brown, with M-H strength iron indurated bands.	XW	EL	>600 >600 >600	
			4							
		N = 58 11,23,35				SHALE: light grey, with occasional yellow brown and red brown bands.			>600 >600 >600	
			5							
		SPT 23/150mm REFUSAL	6			SHALE: dark grey and grey, with light grey bands.	DW	VL		VERY LOW 'TC' BIT RESISTANCE
			7							

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BOREHOLE LOG

Borehole No. **8**
2/4

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN
Date: 29-10-09
Method: SPIRAL AUGER JK500
Logged/Checked by: J.C./
R.L. Surface: ≈ 100.4m
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
	DS					SHALE: dark grey.	DW	VL		VERY LOW RESISTANCE WITH LOW BANDS
										VERY LOW TO LOW RESISTANCE
			8							
ON COMPLETION OF AUGERING	DS									
			9							
			10							
	DS									
						REFER TO CORED BOREHOLE LOG				
			11							
			12							
			13							
			14							

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CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. **8**

Client: WELLES THOMAS PTY LTD
Project: PROPOSED MIXED USE DEVELOPMENT
Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN | **Core Size:** NMLC | **R.L. Surface:** ≈ 100.4m
Date: 29-10-09 | **Inclination:** VERTICAL | **Datum:** AHD
Drill Type: JK500 | **Bearing:** - | **Logged/Checked by:** J.C./

Water Loss/Level	Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Specific
	10	START CORING AT 10.54m			
FULL RETURN	10.54	SHALE: grey, with light grey laminae, bedded at 0-5°.	DW	VL-L	J, 60°, P, S; Cr, 50mm.t; Cr, 15mm.t; XWS, 10mm.t; XWS, 10mm.t; XWS, 10mm.t; XWS, 10mm.t; XWS, 20mm.t; XWS, 20mm.t; XWS, 20mm.t; Cr, 20mm.t; J, 85°, P, S; J, 90°, P, S
	13.16	SHALE: dark grey, with light grey laminae, bedded at 0-5°.	DW	L-M	
	14.5		SW	L-M	J, 85°, P, S; CS, 10mm.t; J, 45°, Un, R; XWS, 15mm.t; XWS, 10mm.t; XWS, 10mm.t; 2xJ, 90°, P, S
	16.6		SW	M	

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CORED BOREHOLE LOG

Borehole No.
8
4/4

Client: WELLES THOMAS PTY LTD

Project: PROPOSED MIXED USE DEVELOPMENT

Location: THOMAS STREET CARPARK, BETWEEN THOMAS ST & ALBERT AVE, CHATSWOOD, NSW

Job No. 23473ZN	**Core Size:** NMLC	**R.L. Surface:** ≈ 100.4m
Date: 29-10-09	**Inclination:** VERTICAL	**Datum:** AHD
Drill Type: JK500	**Bearing:** -	**Logged/Checked by:** J.C./[illegible]

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
FULL RET-URN		18, 19, 20, 21, 22		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	SW / FR	M / H			- J, 65°, P, S - J, 60°, P, S - J, 70°, Un, S - J, 60°, Un, S - J, 50°, Un, S	
		23		END OF BOREHOLE AT 22.2m						


JEFFERY & KATAUSKAS PTY LTD
JOB No. 23473ZN BH1 START CORING AT 12.14m
12
CORE LOSS 0.42m
13
14
15


JEFFERY & KATAUSKAS PTY LTD
16
17
18
19
20


JEFFERY & KATAUSKAS PTY LTD
21
22
23
END OF BOREHOLE AT 23.45m


JEFFERY & KATAUSKAS PTY LTD
JOB No 23473ZN BH2 START CORING AT 11.65m
11
12
13
14


JEFFERY & KATAUSKAS PTY LTD
15
16
17
18
19


JEFFERY & KATAUSKAS PTY LTD
20
21
22
END OF BH AT 22.50m


JEFFERY & KATAUSKAS PTY LTD
JOB NO. 23473ZN BH3 Start Coring at 11.70 m
11
12
13
14


JEFFERY & KATAUSKAS PTY LTD
15
16
17
18
19

JEFFERY & KATAUSKAS PTY LTD
20
21
22
EOBH @ 22.53m
JOB NO 23473ZN
BH3


JEFFERY & KATAUSKAS PTY LTD
JOB No 23473ZN BH4 START CORING AT 13.16m
13
14
15
CORE LOSS 0.19m
16

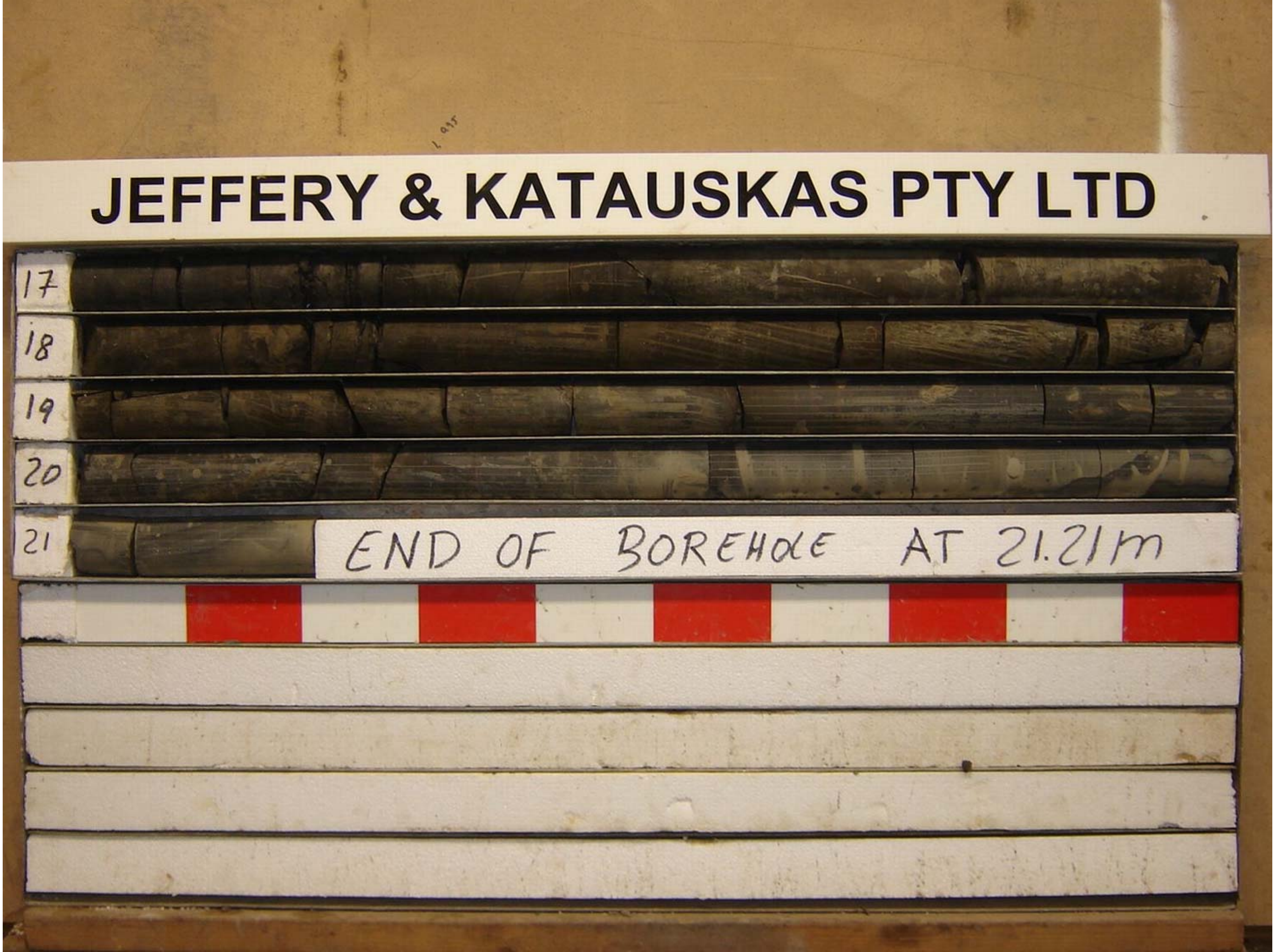

JEFFERY & KATAUSKAS PTY LTD
17
18
19
20
21
END OF BH AT 21.62m


JEFFERY & KATAUSKAS PTY LTD
JOB No 23473ZN BH5 START CORING AT 12.13m
12
13
14
15


JEFFERY & KATAUSKAS PTY LTD
16
17
18
19
20

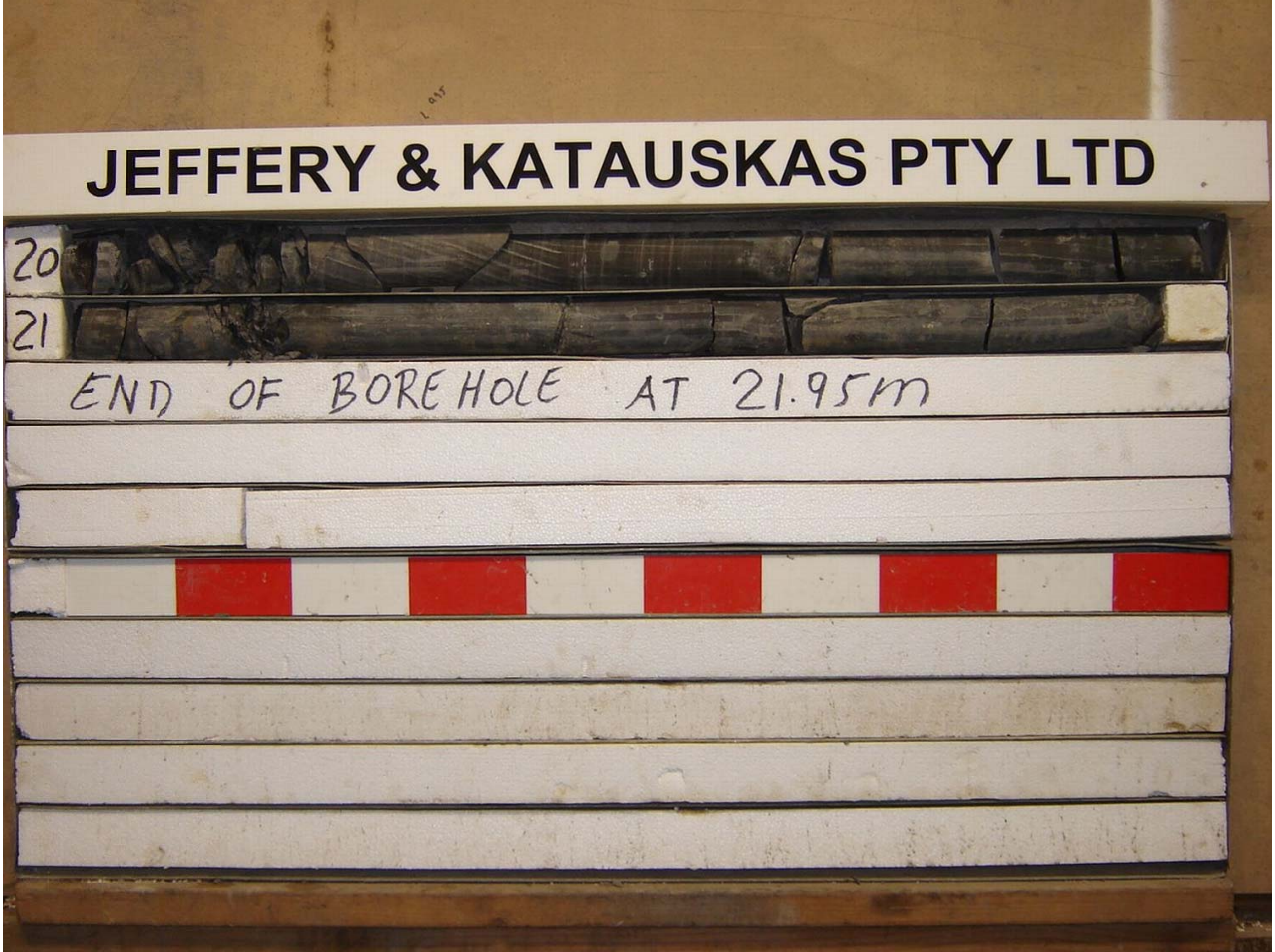

JEFFERY & KATAUSKAS PTY LTD
21
22
END OF BOREHOLE AT 22.25m


JEFFERY & KATAUSKAS PTY LTD
JOB NO.23473ZN BH6 START CORING AT 13.22m
13
14
15
16


JEFFERY & KATAUSKAS PTY LTD
17
18
19
20
21
END OF BOREHOLE AT 21.21m


JEFFERY & KATAUSKAS PTY LTD
JOB No. 23473ZN BH7 START CORING AT 11.63m
11
12
13
14

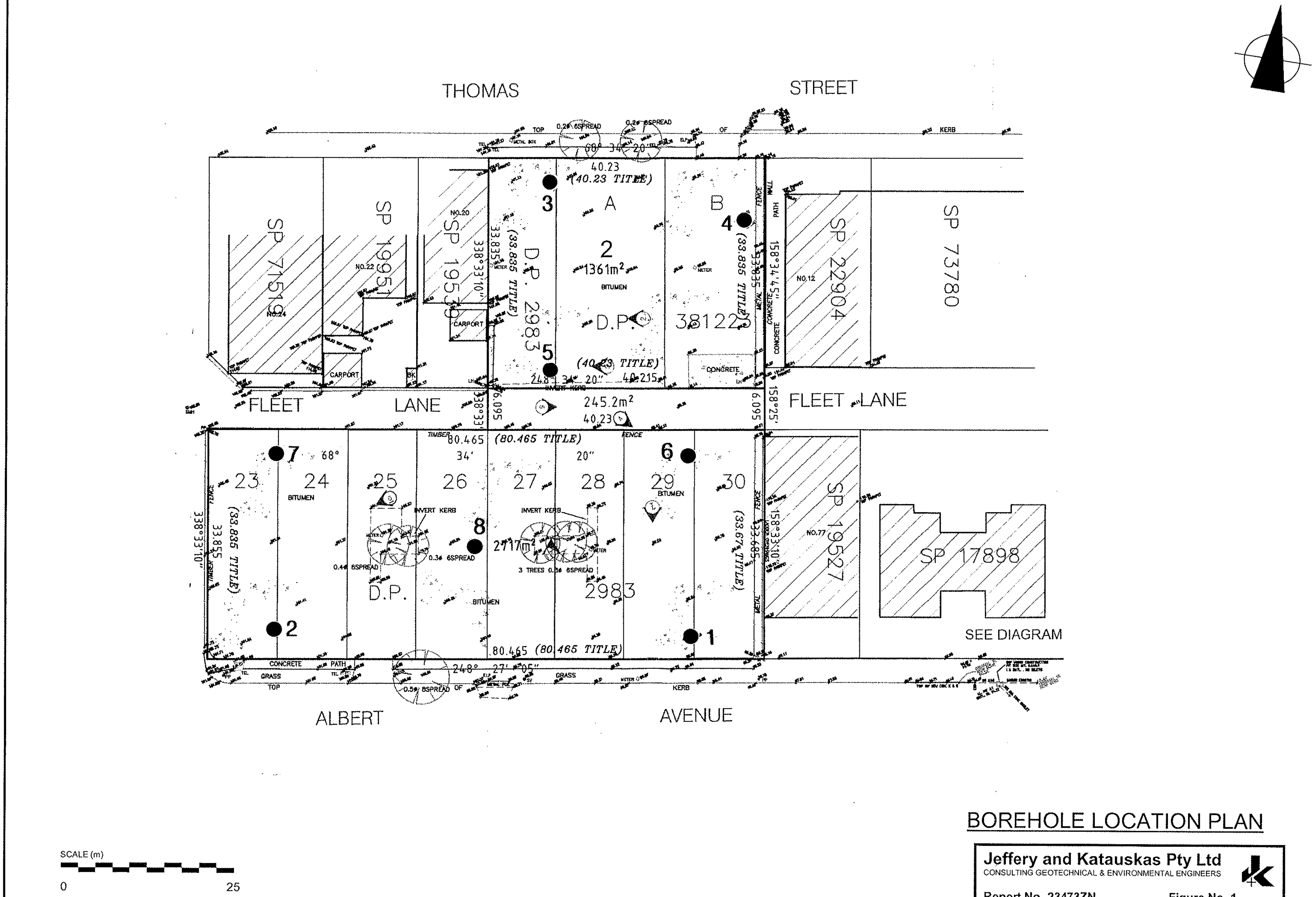

JEFFERY & KATAUSKAS PTY LTD
15
16
17
18
19


JEFFERY & KATAUSKAS PTY LTD
20
21
END OF BOREHOLE AT 21.95m


JEFFERY & KATAUSKAS PTY LTD
JOB No.23473ZN BH8 START CORING AT 10.54m
10
11
12
13


JEFFERY & KATAUSKAS PTY LTD
14
15
16
17
18


JEFFERY & KATAUSKAS PTY LTD
19
20
21
22
END OF BOREHOLE AT 22.23m



BOREHOLE LOCATION PLAN

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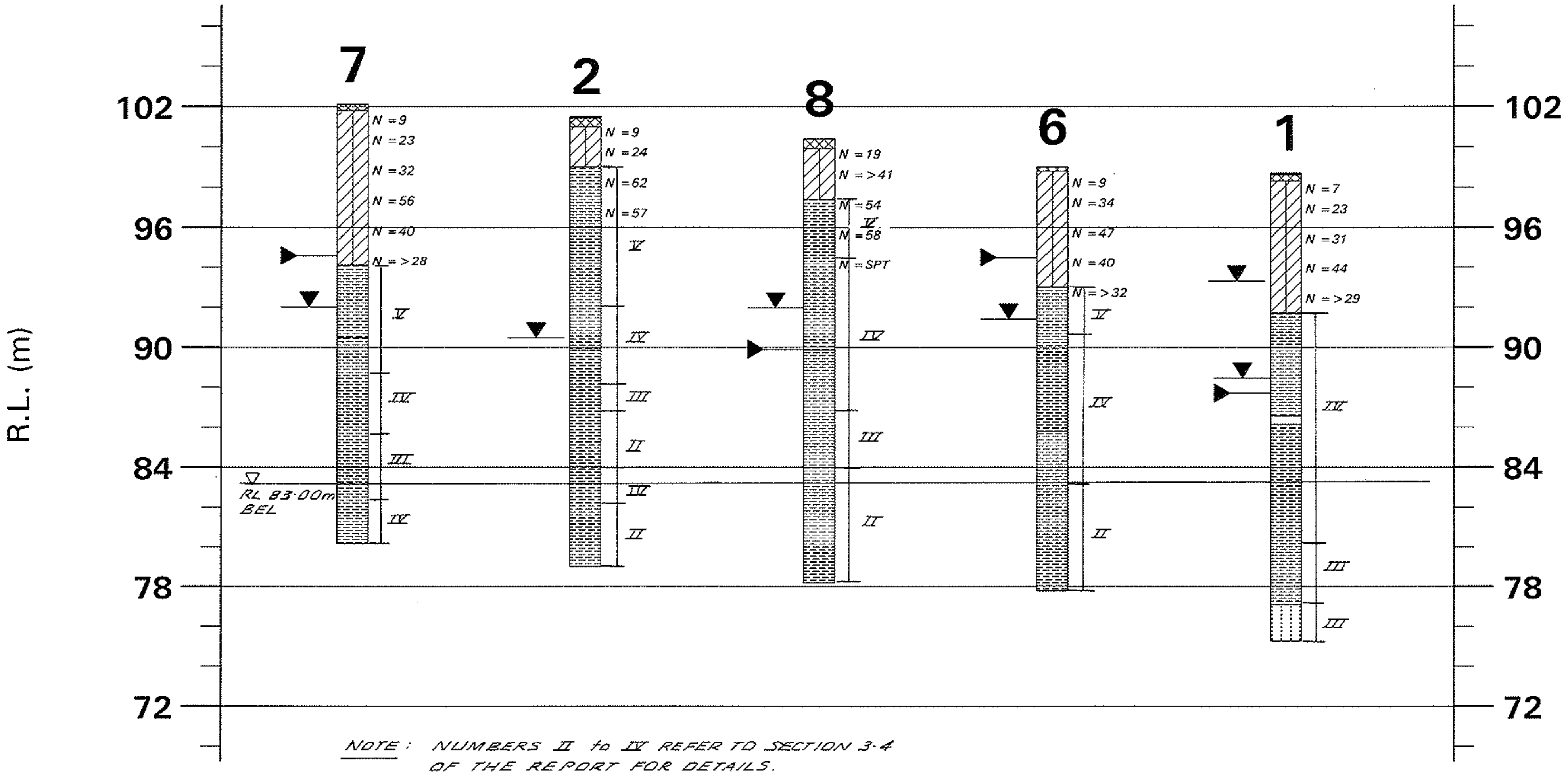
Report No. 23473ZN **Figure No. 1**

GRAPHICAL BOREHOLE SUMMARY



■	Asphaltic/ Bituminous Paving or Coal	▨	Silty Clay	⋮	Sandstone/ Greywacke	N	SPT "N" VALUE
▩	Fill	▤	Shale	▼	Observed water level	Nc	SOLID CONE BLOW COUNTS PER 150mm
		□	Core Loss/ Empty	►	Groundwater seepage level		

NOTE: REFER TO BOREHOLE LOGS

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

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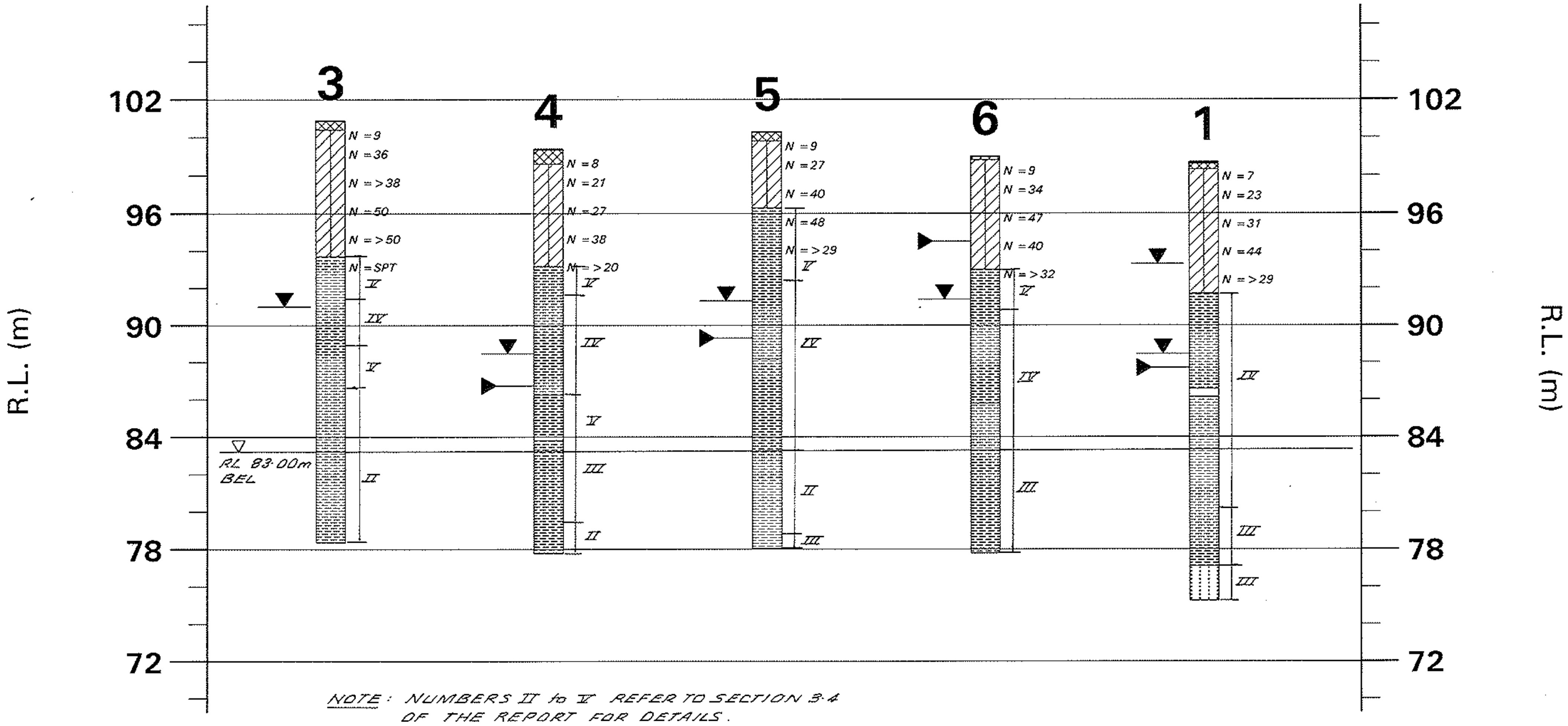
Job No.: 23473ZN **Figure No.:** 2

GRAPHICAL BOREHOLE SUMMARY



Asphaltic/ Bituminous Paving or Coal	Silty Clay	Sandstone/ Greywacke	N — SPT "N" VALUE
Fill	Shale	Observed water level	Nc — SOLID CONE BLOW COUNTS PER 150mm
	Core Loss/ Empty	Groundwater seepage level	

NOTE: REFER TO BOREHOLE LOGS

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

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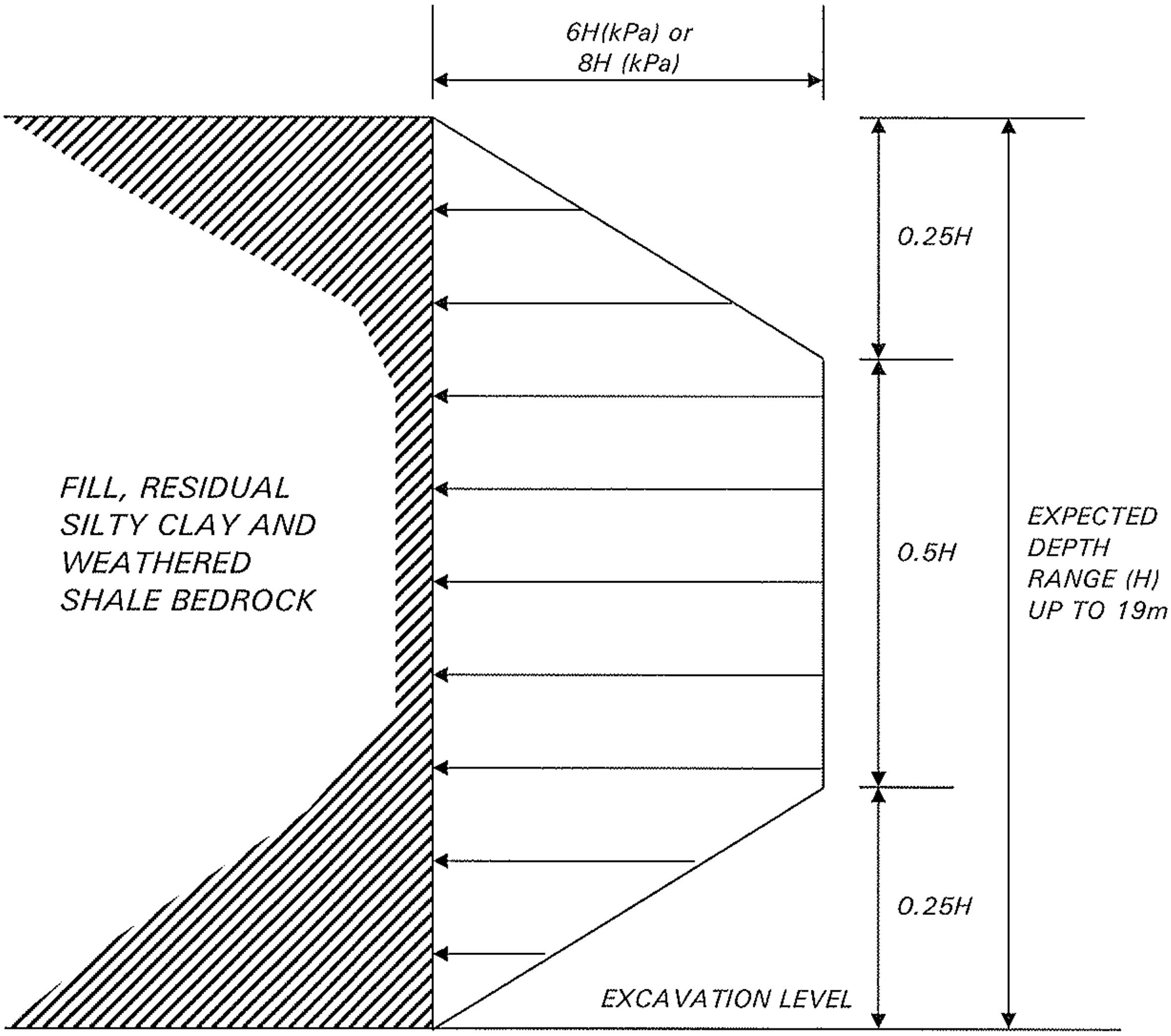
Job No.: 23473ZN

Figure No.: 3



NOTES:

1. USE 6H FOR DESIGN WHERE NO MOVEMENT SENSITIVE STRUCTURES OR SERVICES ARE LOCATED WITHIN 2H FROM LINE OF EXCAVATION.
2. USE 8H FOR DESIGN WHERE MOVEMENT SENSITIVE STRUCTURES OR SERVICES ARE LOCATED WITHIN 2H FROM LINE OF EXCAVATION.
3. SURCHARGE AND GROUNDWATER PRESSUREES MUST BE ADDED TO THE ABOVE IF APPLICABLE.
4. REFER TO TEXT OF REPORT

RECOMMENDED DESIGN PRESSURES FOR ANCHORED OR PROPPED RETAINING WALLS

Jeffery & Katauskas Pty Ltd

Report No. 23473ZN Figure No. 4

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ABN 17 003 550 801

REPORT EXPLANATION NOTES

INTRODUCTION

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

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

DESCRIPTION AND CLASSIFICATION METHODS

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

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

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

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

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

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

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

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

SAMPLING

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

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

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

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

INVESTIGATION METHODS

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

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

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

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

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 <u>or</u> where only a limited investigation has been completed <u>or</u> where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

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

Requirements could range from:

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

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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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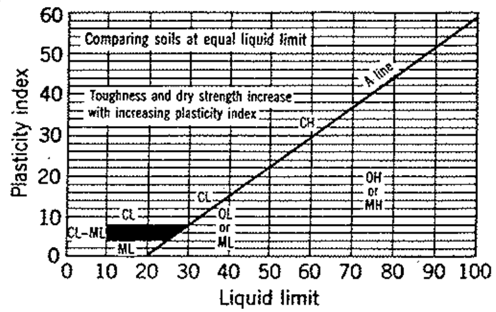
UNIFIED SOIL CLASSIFICATION TABLE

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 criteria note (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.

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



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. GW-GC, well graded gravel-sand mixture with clay fines).

2) Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

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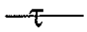
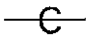
LOG SYMBOLS

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	

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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.