REPORT

TO
DRILL PTY LTD

ON
GEOTECHNICAL INVESTIGATION

FOR
PROPOSED MIXED USE DEVELOPMENT

AT
24-26 RAILWAY PARADE, WESTMEAD, NSW

19 May 2017
Ref: 30341ZNrpt

JK Geotechnics
GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

PO Box 976, North Ryde BC NSW 1670
Tel: 02 9888 5000 Fax: 02 9888 5003
www.jkgeotechnics.com.au
Jeffery & Katauskas Pty Ltd, trading as
JK Geotechnics ABN 17 003 550 801

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Report prepared by:

Nicholas Smith
Associate | Geotechnical Engineer

Report reviewed by:

Agi Zenon
Principal I Geotechnical Engineer

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

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TABLE OF CONTENTS

1 INTRODUCTION

This report presents the results of a geotechnical investigation for the proposed mixed use development at 24-26 Railway Parade, Westmead, NSW. A Site Location Plan is presented as Figure 1. The investigation was commissioned by Mr. Mark Hovey of Drill Pty Ltd by signed 'Acceptance of Proposal' form dated 29 March 2017. The commission was on the basis of our fee proposal (Ref. P44623ZN Westmead) dated 24 March 2017.

From the provided architectural drawings (Project No. 16-021, Drawing No.'s DA006 and DA007 [dated 22 February 2017], and DA111 to DA119, DA120 to DA124, DA151, DA152, DA161 and DA162, all Revision 1 dated 23 February 2017) prepared by Sissons Architects, we understand that the proposed development will comprise a 16 storey mixed use building over 4 basement levels. The lowest basement will have a finished floor at (Reduced Level (RL) 18.85m, and excavation to depths between about 12.5m and 16.5m below existing surface levels are expected to be required. The proposed basement will extend to, or close to, the site boundaries on all sides.

From an email from Mr Robert Facioni of Structural Design Solutions, we understand that allowable bearing pressures on the order of 5,000kPa are sought for pad footings to support the proposed building.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for comments and recommendations on excavation conditions, hydrogeological conditions, retention options, lateral earth pressures, footings and on-grade floor slabs.

2 INVESTIGATION PROCEDURE

Prior to any drilling commencing, the borehole locations were electromagnetically scanned for buried services.

The fieldwork for the investigation was carried out on 18 to 21 and 24 April 2017 and comprised the auger drilling of five boreholes (BH1 to BH5) to depths between 4.21m (BH1) and 8.47m (BH4) using our truck-mounted JK350 and track-mounted JK205 drilling rigs. All five boreholes were subsequently extended to depths between 16.50m (BH3) and 18.92m (BH1) using rotary diamond coring techniques with water flush. The strength of the residual silty clay was assessed from the results of Standard Penetration Tests (SPT's) completed in the boreholes, augmented by the results of hand penetrometer tests completed on clayey samples from the SPT split spoon sampler. The strength of the augered bedrock was assessed from observation of the resistance of a twin-pronged tungsten carbide (TC) drill bit attached to the augers, tactile examination of recovered rock chips and correlation with the results of subsequent moisture content tests. The strength of the cored bedrock was assessed from tactile examination of the rock core and the results of Point Load Strength Index ($I_{S(50)}$) tests.

Groundwater observations were made during and on completion of drilling of the boreholes. Class 18 machine slotted PVC standpipe piezometers with sand filter packs were installed in BH1, BH3 and BH4 and groundwater levels were measured in these standpipes at the end of the fieldwork program. No longer-term groundwater monitoring was completed.

The borehole locations, as shown on the attached Borehole Location Plan (Figure 2) were set out by tape measurements from existing surface features. The surface reduced levels (RL's) at the borehole locations were estimated by interpolation between spot heights shown on the supplied survey plan (Ref. 20746/DET/2) dated August 2001, prepared by Proust and Gardner Consulting Pty Ltd, and are therefore only approximate. The survey datum is Australian Height Datum (AHD).

Our geotechnical engineer, Arthur Kourtesis, was present full-time on-site during the fieldwork and set out the borehole locations, directed the electromagnetic scanning, nominated the sampling and testing, and prepared the borehole logs. The borehole logs are attached to this report along with our 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 returned to Soil test Services Pty Ltd (STS) a NATA registered laboratory for moisture content and $I_{S(50)}$ tests, the results of which are presented on the attached STS Tables A and B and are plotted on the borehole logs ($I_{S(50)}$ results only). Selected samples were also returned to Envirolab Services Pty Ltd, a NATA-registered laboratory, for pH, sulphate content, chloride content and resistivity testing. The results of the testing are presented in the attached Envirolab Certificate of Analysis No. 166179 (Appendix A). Contamination testing was outside the scope of the investigation.

3 RESULTS OF INVESTIGATION

3.1 Site Description

The site is located in a gently undulating topography on an east-facing hillside which sloped down at approximately 5°. Railway Parade formed the southern site boundary and Ashley Lane the eastern site boundary. The Main West Line rail corridor is located beyond Railway Parade to the south.

At the time of the fieldwork, the site was occupied by a two-storey brick shopping centre over its southern two-thirds and a concrete and asphaltic concrete (AC) surfaced at-grade car park over the northern third. A small brick storage building was also located in the north-eastern corner of the site. All structures on site appeared to be in good condition based on a cursory external inspection. The western AC surfaced portion of the car park was in poor condition, with extensive crocodile cracking and a pothole. The eastern concrete surfaced portion of the car park was in good condition.

The site itself sloped down to the east at about 5^0 overall, but with more level areas supported by masonry retaining walls a maximum of about 0.9m high. Masonry retaining walls supported the subject site above the site to the west to a maximum height of 0.4m, the footpath along the southern side of the site to a maximum height of 0.8m and the south-eastern corner of the site to a maximum height of 0.5m. The retaining walls appeared to be in good condition.

To the north of the site was a one and two storey brick commercial building abutting the site boundary. Ground levels were similar across the northern boundary, and no basement level was apparent within the site to the north.

To the west of the site was a three to four storey rendered commercial building set back approximately 4m from the common boundary, with a concrete surfaced driveway between the boundary and the building. No basement level was apparent within the site to the west.

All neighbouring structures appeared to be in good condition when viewed from within the subject site and adjacent streets.

3.2 Subsurface Conditions

The 1:100,000 Geological Map of Penrith indicates the site to be underlain by Ashfield Shale of the Wianamatta Group.

The boreholes encountered a generalised subsurface profile comprising fill and residual silty clay over shale bedrock at shallow depth. For details of the encountered subsurface profile, reference should be made to the attached borehole logs. A summary of the encountered conditions is presented below:

Pavement: AC and concrete pavements between 50mm and 200mm thick were encountered from surface in all of the boreholes.

Fill: Fill comprising silty clay was encountered below the pavement in BH1 and BH4 and extended to depths of 0.4m and 0.5m, respectively.

Residual Silty Clay: Residual silty clay of high plasticity and very stiff to hard strength was encountered below the pavement in BH2, BH3 and BH5 and below the fill in BH1 and BH4, and extended to depths between 0.5m (BH5) and 1.2m (BH1).

Shale Bedrock: Shale bedrock was encountered in all of the boreholes at depths between 0.5m (BH5) and 1.2m (BH1), and extended to the borehole termination depths. The shale bedrock was initially of extremely low and very low strength on first contact, and to depths between 3.5m (BH1) and 5.0m (BH2). The majority of the bedrock was of medium and high strength below these depths, however, high to very high strength bedrock was encountered over the basal 1.5m to 3m of BH2, BH3 and BH4.

Numerous defects, including extremely weathered seams and inclined joints were encountered over the cored portion of the boreholes, but with the spacing between defects generally increasing with depth.

Groundwater: All of the boreholes were 'dry' during and on completion of auger drilling. On completion of coring, standing water was measured at depths between 0.95m (BH4) and 5.15m (BH5). We note that water was injected into the boreholes during coring and the measured standing water levels had most likely not stabilised in the limited observation period. After water from BH1 was manually bailed out, the standing water level was measured at 15.15m. Standing water was subsequently measured at 7.55m three days later. In BH3, standing water was measured at a depth of 5.0m, 4 days after coring, and in BH4, standing water was measured at a depth of 4.5m, 3 days after coring. The estimated 80% to 100% return of drill flush water during coring indicates the bedrock profile to be relatively impermeable.

3.3 Laboratory Test Results

The results of the laboratory moisture content tests correlated well with our field assessment of the in-situ bedrock strength.

The results of the $I_{S(50)}$ tests also correlated well with field assessment of the in-situ bedrock strength. The estimated Unconfined Compressive Strength of the bedrock based on the broadly accepted approximate relationship of UCS = 20 x $I_{S(50)}$, ranged from 2MPa to 104MPa, with an average UCS of about 22MPa.

The results of the Envirolab testing are tabulated below:

	BH1 0.1m to 0.2m depth	BH1 0.5m to 0.95m depth	BH2 0.75m to 1.0m depth	BH4 0.5m to 0.7m depth	BH4 2.0m to 2.5m depth	BH5 0.5m to 0.85m depth
pH Units	8.7	5.1	6.4	5.6	6.5	6.3
Chloride Content (mg/kg)	<10	25	<10	10	<10	<10
Sulfate Content (mg/kg)	45	190	26	33	42	10
Resistivity (ohm.cm)	7,500	7,900	42,000	18,000	23,000	63,000

3.4 Bedrock Classification

Based on the Pells et al 1998 system, the bedrock classifications in the table below apply to the shale bedrock encountered.

Borehole	Depth (m) and RL (mAHD) of Rock Class			
	Class V	Class IV	Class III	Class II
1	1.2 – 3.5 (32.7 – 30.4)	3.5 – 4.3 (30.4 – 29.6)	4.3 – 8.0 (29.6 – 25.9) 11.4 – 13.0 * (22.5 – 20.9)	8.0 – 11.4 (25.9 – 22.5) 13.0 – 18.92 (20.9 – 14.98)
2	0.6 – 5.0 (31.2 – 26.8)	5.0 – 6.0 (26.8 – 25.8) 12.0 – 13.8 * (19.8 – 18.0)	6.0 – 8.0 (25.8 – 23.8)	8.0 – 12.0 (23.8 – 19.8) 13.8 – 16.78 (18-0 – 15.02)
3	0.7 – 3.8 (31.3 – 28.2)	3.8 – 8.0 (28.2 – 24.0)	-	8.0 – 16.5 (24.0 – 15.5)
4	0.7 – 3.5 (32.1 – 29.3)	3.5 – 8.0 (29.3 – 24.8)	-	8.0 – 17.29 (24.8 – 15.51)
5	0.5 – 4.0 (32.3 – 28.8)	4.0 – 11.0 (28.8 – 21.8)	11.0 – 14.7 (21.8 – 18.1)	14.7 – 17.76 (18.1 – 15.04)

* Note: Lower quality bedrock below higher quality bedrock.

4 COMMENTS AND RECOMMENDATIONS

4.1 Dilapidation Reports

Prior to any demolition and excavation commencing, we recommend that detailed dilapidation reports be prepared for the adjoining buildings and improvements to the north and west of the site. Such reports can be used as a baseline against which to assess possible future claims for damage arising from the works. The respective building owners should be provided with a copy of the dilapidation reports and be asked to confirm that the reports present a fair representation of existing conditions. We could complete the dilapidation reports if commissioned to do so. We note that Council may also require that dilapidation reports be prepared for their adjoining assets.

4.2 Excavation

4.2.1 Excavation Conditions

Excavation for the proposed basements is expected to extend to a maximum depth of about 16.5m below existing levels, with locally deeper excavations required for lift overrun pits and services. Excavation to such depths will extend through the fill and natural soil profile then into the underlying bedrock.

Excavation of the fill and natural soils, as well as the upper extremely low to very low strength bedrock is expected to be readily achievable using conventional techniques such as the buckets of hydraulic excavators.

Excavation through bedrock of low and greater strength will be expected to be slower, and we recommend ripping/hammering using a large excavator (at least 30 tonne in size). Grid sawing techniques with ripping and/or hammering will facilitate excavation.

4.2.2 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 services.

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

Excavation with hydraulic rock hammers should be completed using a hydraulic excavator fitted with a relatively low energy hydraulic rock hammer no larger than say, a Krupp 600 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.

The use of a rotary grinder or grid 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.
- When operating more than one hammer at a time, operate hammers in different areas of the site 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.

We recommend that continuous vibration monitoring be carried out during demolition, piling and excavation works. Vibrations, measured as Peak Particle Velocity (PPV), can be limited to no higher than 10mm/sec for the adjoining commercial buildings. However, we recommend that this vibration limit be reviewed following completion of the dilapidation reports on the nearby buildings. If higher vibrations are recorded, they should be assessed against the attached Vibration Emission Design Goals as higher vibrations may be feasible depending on the associated vibration frequency. If it is confirmed that transmitted vibrations are excessive, then it would be necessary to use a smaller plant or alternative techniques.

4.2.3 Seepage

No groundwater was encountered within the soil profile during or on completion of auger drilling in either of the boreholes. At the end of the fieldwork program, standing water was measured at depth between 4.5m and 7.55m in the installed standpipes. Therefore, during and following heavy or extended rain periods, seepage flows along the soil/bedrock interface, and possibly through open defects in the bedrock profile could occur.

Given the expected generally low permeability of the bedrock profile, 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 volume and would be able to be controlled by draining them to a sump, or sumps for periodic pumped disposal to the stormwater system.

Groundwater seepage into the excavation should be monitored by the site foreman and geotechnical engineer as excavation progresses to confirm that seepage volumes are within the range anticipated.

4.3 Retention

4.3.1 Retention Options

Where space permits, temporary batter slopes within the fill, natural soils and Class V bedrock of 1 Vertical (V) to 1 Horizontal (H) are recommended in the short term, provided that no surcharge loads, including construction loads and existing footing loads, are placed at the top of the batters. However, as the proposed basement will extend to, or close to, the site boundaries, such batter slopes will not be feasible. Therefore, we consider that the excavation will need to be supported by an engineer designed shoring system installed prior to excavation commencing.

The shoring system(s) may be incorporated into the permanent basement retention system. The effect of ground movements on any structures and services that lie within the influence zone of the excavation must also be taken into account. The influence zone of the excavation may be defined as a horizontal distance of 2H (where ‘H’ is the depth of the excavation in metres) behind the wall. Suitable retention systems, given the subsoil conditions encountered, would include a soldier pile wall with shotcrete infill panels. Conventional bored piles are considered suitable for use on this site.

To reduce excavation induced movements along site boundaries, the shoring system(s) must be anchored or braced as the excavation progresses. Approval from neighbouring land owners would be required prior to the installation of anchors into their property.

The piles should be installed to sufficient depth below bulk excavation level, including below footing and service excavations, to satisfy stability and founding considerations.

Drilling of rock sockets will be difficult through the medium to high strength or stronger rock requiring the use of heavy drilling rigs equipped with rock augers and coring buckets. Some groundwater inflow is expected into bored piles and we expect that this inflow will be controllable by conventional pumping methods.

Given the expected depth of the shoring piles, pouring using tremie methods is recommended.

4.3.2 Lateral Earth Pressures

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

- For anchored or propped soldier pile walls where minor movements can be tolerated, e.g. landscaped areas or similar, we recommend the use of a trapezoidal earth pressure distribution of 6HkPa for the soil profile and the Class IV and V shale bedrock, where ‘H’ is the retained height in metres. These pressures should be assumed to be uniform of the central 50% of the support system. Where movements are to be limited, e.g. where neighbouring structures or movement sensitive services are located within 2H of the wall, a trapezoidal earth pressure distribution of 8HkPa should be adopted. The shotcrete infill panels can be designed for 4H and 6H respectively.
- The Class III and Class II shale bedrock is likely to be self-supporting, however, for retention through the Class III and Class II shale bedrock, a uniform lateral pressure of 10kPa should be adopted to account for smaller wedges which could be formed between inclined defects.
- A bulk unit weight of 20kN/m^3 should be adopted for the soil and shale bedrock profiles.
- Any surcharge affecting the walls (e.g. traffic loading, construction loads, adjacent high level footings, etc.) should be allowed for in the design using an 'at-rest' earth pressure coefficient, K_0, of 0.5.
- The retaining walls should be designed as 'drained' and measured taken to provide permanent and effective drainage of the ground behind the walls. The subsoil drains should incorporate a non-woven geotextile fabric (e.g. Bidim A34) to act as a filter against subsoil erosion.

- Lateral toe restraint of the walls may be achieved by embedding the piles into the bedrock below bulk excavation level. An allowable lateral resistance of 500kPa can be adopted for the Class III and Class II shale bedrock. For piles embedded into bedrock below bulk excavation level, a minimum embedment depth of 1.0m is recommended. Care is required not to over-excavate in front of the piles, and all excavations in front of the walls, such as for footings, tanks, buried services, etc. must be taken into account in the wall design.
- Anchors bonded into Class IV or better quality shale bedrock may be designed on the basis of a maximum allowable bond stress of 200kPa. All anchors should be proof loaded to at least 1.3 times their working load and then locked off/prestressed to 85% of their working load. Proof loading should be carried out in the presence of an engineer independent of the anchor contractor. Anchors must be bonded behind a line drawn up at 45° from the base of the excavation, with all anchors having a minimum free length and bond length of 3m. Lift off tests should be carried out on at least 10% of all anchors to confirm that they are maintaining their load.

Alternatively, the retaining walls could be designed using computer based Finite Element analysis methods (e.g. Wallap or Plaxis), which could result in cost savings compared to a design based on the above simplified earth pressure assumptions. Such analysis methods can model the actual excavation stages, including progressive anchoring/shoring, and outputs include structural loads in the piles and wall movements. For initial analysis, we recommend the following basic material parameters be adopted

Material	Drained Cohesion c′ (kPa)	Drained Internal Friction ϕ′ (Degrees)	Bulk Unit Weight (kN/m^3)	Elastic Modulus (MPa)
Fill	–	28	18	20
Residual Soils	3	28	18	50
Class V Shale Bedrock	10	28	20	150
Class IV Shale Bedrock	10	28	20	350
Class III Shale Bedrock	50	35	24	1,000
Class II Shale Bedrock	1000	35	24	2,000

4.3.3 Bedrock Cut Faces

It is likely that the Class III and Class II shale bedrock will be able to be cut vertically and left unsupported in the short term between soldier piles. However, such vertical cuts would require periodic inspection by a geotechnical engineer to confirm their stability and check for the presence of inclined joints or other defects which could result in loads greater than the nominated 10kPa being imposed on the retention system. If adverse defects are identified during inspections, then additional stabilisation may be required, e.g. reinforced shotcrete engaged with the soldier piles, rock bolts, additional temporary anchors etc.

We forewarn that the shales in Sydney can contain adversely orientated continuous joints which can result in instability of excavations, particularly where the joints are smooth or clay smeared. The inclination of such joints can range from 30^0 to 50^0. Such joints, if present at the site, are not readily identifiable from boreholes, and are typically only observed during excavation.

To manage the potential risk associated with such defects, we recommend that geotechnical inspection of the cut faces in the Class III and Class II bedrock be completed at no greater than 1.5m depth increments.

If continuous inclined joints are identified, the shoring would need to be redesigned to resist the additional load imposed by the rock wedge formed by the defect(s). In extreme cases, this could require the installation of additional shoring piles. One option would be to include a design case for the additional load from a wedge of rock. Geotechnical inspections should then be carried out, and if necessary install larger capacity anchors or rockbolts. As a preliminary guide, the design wedge of rock may be defined by the following:

- The wedge may be present anywhere in the vertical shale faces around the perimeter of the excavation;
- the top of the wedge would occur along a horizontal defect in the shale;
- the sides of the wedge would be vertical, assumed to be formed at vertical joints;
- the wedge exposed in the face would be at least 3m high and would extend at least 5-6m along the excavation perimeter;
- the persistent joint would extend up from the base of the wedge at any angle between 30° to 50° above the horizontal; and
- the persistent joint is clay coated and smooth with a friction angle of 30°

Further, a design case should also be considered with a single continuous joint, inclined up to ground surface level from the base of the excavation at an angle of 45^0. Given the extreme nature of this design case, the design should be checked against the ultimate capacity of the soldier pile wall system.

4.4 Footings

On completion of bulk excavation, Class II shale bedrock is expected to be uniformly exposed over the entire basement excavation, or be present at shallow depth below bulk excavation level. We therefore recommend that the proposed building be uniformly supported on footings founded in the Class II shale bedrock profile.

Pad and strip footings and piles founded within the bedrock may be designed based on the allowable end bearing pressures outlined in the table below. For piles, a minimum socket of 0.3m into the appropriate 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 (Class R2 or better). For all footings, both shallow and piles, the lowest quality bedrock within 1.5 times the width/diameter of the footing/pile will give the allowable bearing pressure for the design of footings. The following 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.

Pells (1998) et al Rock Class	Allowable Bearing Pressure (kPa)	Allowable Shaft Adhesion (compression) (kPa)	Allowable Shaft Adhesion (tension/uplift) (kPa)
Class V Shale	700	70	35
Class IV Shale	1,000	100	50
Class III Shale	3,000	300	150
Class II Shale	5,000	500	250

It may be possible to adopt higher allowable bearing pressures if detailed settlement analyses are carried out. Such analyses will required the input of the actual column loads.

Footings on the 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 table below. Settlement limitations to the structures will still need to be satisfied and can be estimated using the provided elastic moduli values.

It should be noted that such ultimate bearing pressures must be used in conjunction with an appropriate "*Geotechnical Strength Reduction Factor*" (ϕ_g) as defined in AS2159-2009 *Piling – Design and Installation*. Provided there is good workmanship and quality control during footing construction, we recommend that a maximum ϕ_g value in the range of 0.5 to 0.6 be adopted for end bearing and shaft adhesion.

Pells et al Rock Class	Ultimate Bearing Pressure (MPa)	Ultimate Shaft Adhesion (compression) (kPa)	Ultimate Shaft Adhesion (tension/uplift) (kPa)	Elastic Modulus E (MPa)
Class V Shale	3	100	50	150
Class IV Shale	6	150	75	350
Class III Shale	25	500	250	800
Class II Shale	100	800	400	1,500

All shallow footings and conventional bored piles should be clean of any loose or water softened material, and free of any standing water prior to pouring concrete. If delays in pouring high level footings are anticipated, consideration should be given to placing a protective layer of blinding concrete over the base of the footing.

The initial stages of shallow footing excavation and conventional bored pile drilling should be inspected by a geotechnical engineer to confirm that the appropriate foundation material is being achieved. The need for further inspection can be confirmed at this time. We can complete these inspections, if required. If the bearing pressures for Class II Shale bedrock, as tabulated above, are adopted, spoon testing of 50% of all pad/strip footing will be required in conjunction with inspection of the base of all footings. We can complete the spoon testing, if required.

Special consideration will need to be given to any footings which are located either close to the crest of excavation cuts within the basement, or outside the basement shoring walls. Any footings within a distance of X from the crest of a cut face or basement retaining wall (where X is height of the cut face/basement wall) will require special consideration. In the case of rock cuts, a thorough inspection of the nearby rock face will be required, while footings near basement walls will most likely need to extend to below the bulk excavation level to avoid surcharging the basement retaining wall. In these cases, bearing pressures may need to be reduced or footings taken deeper to reduce the risk of instability or surcharge loading of walls or other structural elements.

4.5 On-Grade Floor Slab

The basement on-grade floor slabs will directly overlie bedrock and no particular subgrade preparation will be required.

Slab-on-grade construction is therefore considered appropriate. Underfloor drainage must however be provided. The underfloor drainage should connect with the wall drains, where appropriate, and direct groundwater seepage to a sump(s) for pumped disposal to a stormwater system. Joints in the on-grade floor slabs should incorporate dowels or keys.

4.6 Soil Aggression

Based on the soil chemistry test results, a 'Mild' exposure classification for concrete piles is applicable in accordance with Table 6.4.2 (C) in AS2159-2009.

4.7 Earthquake Design

In accordance with Table 4.1 of AS1170.4-2007, the site subsoil class is 'Class B_e – Rock'.

4.8 Additional Geotechnical Input Required

The following summarises the further geotechnical input which is required and which has been detailed in the preceding sections of this report:

- Finite element analysis of basement retaining walls (if required).
- Dilapidation surveys on nearby structures.
- Quantitative vibration monitoring during rock excavation.
- Proof-testing of anchors.
- Geotechnical inspection of bedrock cut faces.
- Seepage monitoring during excavation.
- Geotechnical footing inspections and spoon testing.

5 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 JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

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

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

A waste classification will need to be assigned to any soil excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), General Solid, Restricted Solid or Hazardous Waste. Analysis takes seven to 10 working days to complete, therefore, an adequate allowance should be included in the construction program unless testing is completed prior to construction. If contamination is encountered, then substantial further testing (and associated delays) should be expected. We strongly recommend that this issue is addressed prior to the commencement of excavation on site.

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.

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

TABLE A
MOISTURE CONTENT TEST REPORT

Client:	JK Geotechnics	**Ref No:**	30241ZN
Project:	Proposed Mixed Use Development	**Report:**	A
Location:	24-26 Railway Parade, Westmead, NSW	**Report Date:**	10/05/2017
		Page 1 of 1	

AS 1289	**TEST METHOD**	**2.1.1**
BOREHOLE NUMBER	**DEPTH m**	**MOISTURE CONTENT %**
1	1.20-1.50	8.1
1	3.50-4.00	6.2
2	2.00-2.50	7.1
3	1.00-1.50	6.4
3	4.00-4.10	5.4
4	2.50-3.00	4.8
4	5.50-6.00	6.2
5	2.50-3.00	7.4
5	4.50-5.00	4.2

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Macquarie Park, NSW 2113
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Facsimile: 02 9888 5001

SOIL TEST SERVICES

ABN 43 002 145 173

TABLE B
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Mixed Use Development
Location: 24-26 Railway Parade, Westmead, NSW

Ref No: 30341ZN
Report: B
Report Date: 10/05/2017

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
1	4.25-4.29	0.1	2
	4.33-4.38	0.5	10
	4.72-4.76	0.7	14
	5.43-5.47	1.2	24
	6.24-6.29	0.8	16
	6.72-6.76	1.1	22
	7.43-4.47	0.9	18
	8.25-8.29	0.8	16
	8.74-8.78	0.7	14
	9.47-9.51	0.5	10
	10.21-10.24	0.6	12
	10.74-10.78	0.7	14
	11.19-11.24	0.4	8
	12.31-12.35	0.6	12
	12.62-12.66	0.4	8
	13.50-13.54	0.5	10
	14.05-14.09	0.4	8
	14.70-14.74	0.4	8
	15.46-15.49	0.5	10
	16.26-13.30	0.4	8
	16.71-16.74	0.6	12
	17.50-17.54	2.1	42
	18.70-18.74	2.9	58
2	6.85-6.88	0.6	12
	7.11-7.15	0.5	10
	7.54-7.56	0.5	10

NOTES: See Page 4 of 4

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Mixed Use Development
Location: 24-26 Railway Parade, Westmead, NSW

Ref No: 30341ZN
Report: B
Report Date: 10/05/2017

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
2	8.46-8.49	1.0	20
	9.00-9.03	1.1	22
	9.81-9.85	1.2	24
	10.36-10.39	1.1	22
	11.10-11.13	0.4	8
	11.97-12.00	1.7	34
	12.33-12.36	1.0	20
	12.92-12.96	1.0	20
	13.12-13.15	0.5	10
	13.95-13.98	3.8	76
	14.28-14.31	1.5	30
	14.93-14.16	3.7	74
	15.31-15.35	2.1	42
	16.00-16.04	3.9	78
	16.46-16.49	2.4	48
3	6.11-6.13	1.1	22
	6.91-6.93	1.3	26
	7.21-7.24	0.6	12
	7.67-7.70	0.9	18
	8.27-8.30	0.9	18
	8.89-8.93	0.6	12
	9.42-9.45	0.4	8
	9.96-10.00	0.6	12
	11.22-11.25	0.6	12
	11.72-11.75	0.6	12
	12.38-12.41	0.6	12

NOTES: See Page 4 of 4

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SOIL TEST SERVICES

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TABLE B
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Mixed Use Development
Location: 24-26 Railway Parade, Westmead, NSW

Ref No: 30341ZN
Report: B
Report Date: 10/05/2017
Page 3 of 4

BOREHOLE NUMBER	DEPTH m	$I_{S (50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
3	12.96-12.98	2.1	42
	13.16-13.19	0.5	10
	13.70-13.73	0.7	14
	14.25-14.28	0.6	12
	14.81-14.84	0.8	16
	15.31-15.34	1.4	28
	15.92-15.95	3.1	62
	16.30-16.33	2.1	42
4	8.58-8.61	0.8	16
	9.31-9.36	1.2	24
	9.87-9.91	0.7	14
	10.59-10.62	0.6	12
	11.22-11.26	0.9	18
	11.72-11.76	0.9	18
	12.55-12.59	0.4	8
	13.15-13.18	0.4	8
	13.64-13.67	0.6	12
	14.56-14.59	0.8	16
	15.23-15.27	0.5	10
	15.66-15.70	0.5	10
	16.44-16.48	2.0	40
	17.09-17.12	5.2	104
5	5.97-6.00	0.6	12
	7.38-7.41	0.6	12
	7.96-8.00	0.7	14
	8.59-8.63	0.6	12

NOTES: See Page 4 of 4

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SOIL TEST SERVICES
ABN 43 002 145 173

TABLE B
POINT LOAD STRENGTH INDEX TEST REPORT

Client: JK Geotechnics
Project: Proposed Mixed Use Development
Location: 24-26 Railway Parade, Westmead, NSW

Ref No: 30341ZN
Report: B
Report Date: 10/05/2017
Page 4 of 4

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
5	9.01-9.04	1.3	26
	9.45-9.49	0.6	12
	10.23-10.27	0.7	14
	11.10-11.14	1.0	20
	11.75-11.80	0.4	8
	12.42-14.46	0.6	12
	13.13-13.17	1.2	24
	13.67-13.70	0.8	16
	14.55-14.59	0.4	8
	15.30-15.33	0.6	12
	15.75-15.78	1.1	22
	16.46-16.50	2.2	44
	17.23-17.27	2.0	40
	17.60-17.64	2.7	54

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the $I_{S(50)}$ has been rounded to the nearest 0.1MPa, or to one significant figure if less than 0.1MPa
5. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :
   U.C.S. = 20 $I_{S\,(50)}$

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~33.9 m
Date: 18/4/17 **Datum:** AHD
Plant Type: JK350 **Logged/Checked By:** A.C.K./N.E.S.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING			0		ASPHALTIC CONCRETE: 50mm.t				
					FILL: Silty clay, low plasticity, dark grey brown, trace of fine to medium grained igneous gravel.	MC<PL			
	N = 10 4,5,5	33	1	CH	SILTY CLAY: high plasticity, orange brown mottled light grey brown.	MC<PL	H	>600 >600 >600	RESIDUAL
		32	2		SHALE: grey brown, with L strength bands and iron indurated bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
		31	3			XW - DW	EL - VL		LOW RESISTANCE
		30	4		SHALE: dark grey brown.	DW	L - M		
		29, 28, 27	5, 6		REFER TO CORED BOREHOLE LOG				50mm DIAMETER PVC STANDPIPE PIEZOMETER INSTALLED TO 18.92m, MACHINE SLOTTED 6.92m TO 18.92m, CASING 0m TO 6.92m, 2mm SAND FILTER PACK 1.5m TO 18.92m, BENTONITE SEAL 0.35m TO 1.5m, BACKFILLED WITH SAND TO SURFACE AND COMPLETED WITH A CAST IRON GATIC COVER

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
1
2 / 4

CORED BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN | **Core Size:** NMLC | **R.L. Surface:** ~33.9 m
Date: 18/4/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK350 | **Bearing:** N/A | **Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific	General
					START CORING AT 4.21m						
ON COMPLETION OF CORING					SHALE: dark grey, with light grey laminae, bedded at 0°.	SW	L - M			(4.40m) XWS, 0°, 2 mm.t	
							M - H			(4.46m) XWS, 0°, 11 mm.t	
										(4.51m) XWS, 0°, 5 mm.t	
										(4.64m) XWS, 0°, 3 mm.t	
										(4.70m) XWS, 0°, 10 mm.t	
		29								(4.80m) XWS, 0°, 14 mm.t	
ON 21/4/17			5							(4.98m) XWS, 0°, 7 mm.t	
										(5.07m) XWS, 0°, 10 mm.t	
										(5.18m) XWS, 0°, 5 mm.t	
100% RETURN										(5.23m) J, 25°, P, S	
		28	6							(6.07m) XWS, 0°, 5 mm.t	
										(6.09m) XWS, 0°, 3 mm.t	
		27	7								
					CORE LOSS 0.04m						
ON 24/4/17					SHALE: dark grey, with light grey laminae, bedded at 0°.	SW	M - H			(7.32m) XWS, 0°, 2 mm.t	
							M				
		26	8							(7.92m) J, 85°, P, R	
										(7.97m) J, 50 - 90°, Un, R	
100% RETURN		25	9							(9.32m) J, 30°, P, S	
		24	10							(9.83m) XWS, 0°, 1 mm.t	
										(10.49m) J, 60°, P, S	
		23									

JK_LIB_CURRENT - V8.00.GLB Log J & K CORED BOREHOLE - MASTER 30341ZN WESTMEAD.GPJ <<DrawingFile>> 18/05/2017 14:28 Produced by gINT Professional, Developed by Datgel

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No.
1

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN | **Core Size:** NMLC | **R.L. Surface:** ~33.9 m
Date: 18/4/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK350 | **Bearing:** N/A | **Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS – DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific	General
100% RETURN		22, 21, 20, 19, 18, 17	12, 13, 14, 15, 16, 17		SHALE: dark grey, with light grey laminae, bedded at 0°. *(continued)*	SW	M			(11.37m) J, 80°, Un, R, IS (11.65m) XWS, 5°, 12 mm.t (11.75m) J, 40 - 90°, P, S (11.82m) XWS, 0°, 2 mm.t (11.89m) XWS, 0°, 6 mm.t (11.91m) XWS, 0°, 2 mm.t (11.92m) J, 30°, P, S (12.03m) J, 40°, P, R (12.10m) XWS, 5°, 2 mm.t (12.19m) J, 30°, P, S (12.50m) J, 40°, P, R (12.68m) J, 60°, P, S (12.71m) J, 40°, P, S (12.90m) J, 85°, P, S, IS (14.32m) J, 80°, P, R (14.93m) XWS, 0°, 130 mm.t (16.35m) J, 40°, P, S	
		16			SHALE: dark grey, with light grey laminae, bedded at 15-25°.		H			(17.45m) J, 65 - 90°, Un, R (17.84m) J, 80°, Un, R	

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN | **Core Size:** NMLC | **R.L. Surface:** ~33.9 m
Date: 18/4/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK350 | **Bearing:** N/A | **Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT SPACING (mm)	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
100% RETURN		15			SHALE: dark grey, with light grey laminae, bedded at 15-25°. *(continued)*	SW	H			(18.18m) J, 75°, Un, R	
		14, 13, 12, 11, 10, 9	19, 20, 21, 22, 23, 24		END OF BOREHOLE AT 18.92 m						


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JOB No. 30341ZN BH1 START CORING AT 4.21m
4
5
6
7
CL 0.04
8
9
10
11
12


JK Geotechnics
13
14
15
16
17
18
END OF BOREHOLE AT 18.92m

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
2

BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~31.8 m
Date: 19/4/17 **Datum:** AHD
Plant Type: JK350 **Logged/Checked By:** A.C.K./N.E.S.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING		0		CONCRETE: 200mm.t				6mm DIA. REINFORCEMENT, 170mm TOP COVER
	N > 16 8,16/ 100mm REFUSAL		CH	SILTY CLAY: high plasticity, light grey, red brown and orange brown.	MC~PL	(VSt - H)	240	RESIDUAL
				SHALE: grey brown, with iron indurated bands.	XW - DW	EL - VL		VERY LOW TO LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
		4		SHALE: dark grey brown.				VERY LOW RESISTANCE
		5		SHALE: dark grey.	SW	L - M		LOW TO MODERATE RESISTANCE
				REFER TO CORED BOREHOLE LOG				

RL (m AHD): 31, 30, 29, 28, 27, 26, 25
Depth (m): 1, 2, 3, 4, 5, 6

JK Geotechnics

GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No.
2

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN | **Core Size:** NMLC | **R.L. Surface:** ~31.8 m
Date: 19/4/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK350 | **Bearing:** N/A | **Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength
					START CORING AT 5.77m		
		26			CORE LOSS 0.10m		
100% RETURN			6		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	DW - SW	M
		25	7				
						FR	M - H
		24	8				
		23	9				
		22	10				
		21	11				
		20					

POINT LOAD STRENGTH INDEX $I_s(50)$: EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH

DEFECT SPACING (mm): 500, 300, 100, 50, 30, 10

DEFECT DETAILS — DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating.

Specific	General
(5.94m) FRAGMENTED ZONE, 0°, 120 mm.t	
(6.02m) XWS, 0°, 8 mm.t	
(6.05m) XWS, 0°, 10 mm.t	
(6.10m) Cr, 0°, 15 mm.t	
(6.13m) XWS, 0°, 4 mm.t	
(6.16m) XWS, 0°, 2 mm.t	
(6.23m) J, 35°, P, S	
(6.24m) XWS, 0°, 2 mm.t	
(6.30m) J, 30°, P, S	
(6.46m) FRAGMENTED ZONE, 0°, 30 mm.t	
(6.51m) J, 60°, St, R	
(6.54m) J, 45°, P, S, Clay	
(6.91m) XWS, 15°, 6 mm.t	
(7.34m) J, 70°, P, R	
(7.46m) J, 30°, P, S	
(7.49m) J, 80°, Un, S	
(7.74m) J, 70°, P, S	
(7.85m) J, 20°, P, S	
(7.89m) J, 20°, P, R	
(7.92m) J, 85°, P, S	
(8.30m) J, 70°, P, S, IS	
(8.60m) J, 40°, P, S	
(9.23m) HEALED J, 80°, P	
(9.60m) J, 70 - 90°, Un, R	
(10.61m) J, 65°, P, R	
(10.72m) J, 70 - 90°, Un, S	

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
2
3 / 3

CORED BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN **Core Size:** NMLC **R.L. Surface:** ~31.8 m
Date: 19/4/17 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK350 **Bearing:** N/A **Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	DEFECT DETAILS: DESCRIPTION — Type, inclination, thickness, planarity, roughness, coating. Specific / General
100% RETURN					SHALE: dark grey, with light grey laminae, bedded at 0-5°. *(continued)*	XW	EL	
						SW - FR	M - H	(12.48m) XWS, 5°, 5 mm.t
		19	13					(12.80m) XWS, 5°, 12 mm.t
								(13.36m) HEALED J, 50°, P
								(13.59m) FRAGMENTED ZONE, 10 - 30°
		18	14				H - VH	(13.76m) J, 40°, P, S
		17	15					
		16	16					(16.26m) J, 20°, P, S
		15	17		END OF BOREHOLE AT 16.78 m			
		14	18					
		13						

POINT LOAD STRENGTH INDEX $I_s(50)$: EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH
DEFECT SPACING (mm): 500, 300, 100, 50, 30, 10


JK Geotechnics
JOB No. 30341ZN BH2 START CORING AT 5.77m
CORE LOSS 0.1m
6
7
8
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13
14
15
16
17
END OF BOREHOLE AT 16.78m

JK Geotechnics
GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
3
1 / 3

BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~32.0 m
Date: 20/4/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./N.E.S.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING							0			TILES: 13mm.t over CONCRETE: 130mm.t				8mm DIA. REINFORCEMENT, 100mm TOP COVER
					N > 32 6,15,17/ 100mm REFUSAL				CH	SILTY CLAY: high plasticity, orange brown.	MC<PL	H	>600 >600 >600	RESIDUAL
						31	1		-	SHALE: dark grey brown, with iron indurated bands.	XW - DW	EL - VL		VERY LOW TO LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
						30	2							
						29	3							
ON COMPLETION OF CORING						28	4			SHALE: dark grey.	DW	M		LOW RESISTANCE
						27	5			REFER TO CORED BOREHOLE LOG				50mm DIAMETER PVC STANDPIPE PIEZOMETER INSTALLED TO 16.5m, MACHINE SLOTTED 4.5m TO 16.5m, CASING 0m TO 4.5m, 2mm SAND FILTER PACK 1.8m TO 16.5m, BENTONITE SEAL 0.1m TO 1.8m, BACKFILLED WITH SAND TO SURFACE AND COMPLETED WITH A CAST IRON GATIC COVER
						26	6							

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. 3

Client: DRILL PTY LTD

Project: PROPOSED MIXED USE DEVEOPMENT

Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN | **Core Size:** NMLC | **R.L. Surface:** ~32.0 m

Date: 20/4/17 | **Inclination:** VERTICAL | **Datum:** AHD

Plant Type: JK205 | **Bearing:** N/A | **Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components.)	Weathering	Strength	Defect Details – Description (Type, inclination, thickness, planarity, roughness, coating.)
				START CORING AT 4.41m			
				CORE LOSS 0.27m			
ON 24/4/17 (at ~5.0m)		27	5	SHALE: dark grey brown.	DW	M	(4.71m) FRAGMENTED ZONE, 0°, 20 mm.t (4.74m) XWS, 5°, 20 mm.t (4.76m) J, 80°, P, S, IS (4.78m) XWS, 0°, 3 mm.t (4.88m) J, 70°, P, S, IS (4.89m) J, 30°, P, S, IS (4.93m) XWS, 0°, 5 mm.t (5.06m) XWS, 0°, 80 mm.t (5.16m) XWS, 0°, 30 mm.t (5.19m) J, 65°, P, S (5.25m) FRAGMENTED ZONE, 0°, 35 mm.t (5.30m) J, 80°, P, R (5.33m) FRAGMENTED ZONE, 0°, 35 mm.t (5.42m) XWS, 0°, 90 mm.t (5.59m) FRAGMENTED ZONE, 0°, 30 mm.t
		26	6	SHALE: dark grey, with light grey laminae, bedded at 0-5°.		H	(5.65m) XWS, 0°, 4 mm.t (5.66m) XWS, 0°, 2 mm.t (5.77m) J, 60°, P, R (6.18m) J, 40°, P, R (6.44m) FRAGMENTED ZONE, 0°, 40 mm.t
				CORE LOSS 0.16m			
80% RETURN		25	7	SHALE: dark grey, with light grey laminae, bedded at 0-5°.	DW	H	(6.70m) FRAGMENTED ZONE, 0°, 170 mm.t (6.84m) J, 20°, P, S (6.89m) XWS, 0°, 2 mm.t
						M	(7.11m) XWS, 0°, 5 mm.t (7.27m) J, 40°, P, S (7.34m) XWS, 0°, 10 mm.t (7.36m) XWS, 0°, 1 mm.t (7.42m) XWS, 0°, 2 mm.t (7.46m) XWS, 0°, 6 mm.t (7.55m) XWS, 0°, 9 mm.t (7.59m) XWS, 0°, 4 mm.t (7.79m) XWS, 0 - 20°, 10 mm.t (7.88m) J, 80°, Un, R (7.92m) J, 40°, Un, S
		24	8		SW		(8.40m) J, 45°, P, R, IS (8.68m) J, 45°, P, R, IS
		23	9				
		22	10				(9.87m) HEALED J, 90°, P (10.33m) XWS, 0°, 6 mm.t

Point Load Strength Index $I_s(50)$: EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH

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

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. 3

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN **Core Size:** NMLC **R.L. Surface:** ~32.0 m
Date: 20/4/17 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK205 **Bearing:** N/A **Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT SPACING (mm)	DEFECT DETAILS – DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific / General
80% RETURN		20, 19, 18, 17, 16	12, 13, 14, 15, 16		SHALE: dark grey, with light grey laminae, bedded at 0-5°. *(continued)*	SW	M			(11.14m) XWS, 0°, 8 mm.t (12.83m) J, 70°, Un, R (13.40m) XWS, 0°, 20 mm.t
							H - VH			(15.02m) Jx2, 85°, P, S
		15	17		END OF BOREHOLE AT 16.50 m					


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JOB NO. 30341ZN BH3 START CORING AT 4.41m
4
CORE LOSS: 0.27m
5
6
CORE LOSS: 0.16
7
8
9
10
11
12
13
14
15
16
END OF BOREHOLE AT 16.50m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
4
1 / 4

BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~32.8 m
Date: 21/4/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./N.E.S.

Groundwater Record	Field Tests	RL (m AHD)	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING					TILES: 10mm.t over CONCRETE: 115mm.t				7mm DIA. REINFORCEMENT, 83mm & 87mm TOP COVER
				-	FILL: Silty clay, high plasticity, orange brown, with fine to medium grained sand.	MC>PL			
	N > 13 3,10,3/ 0mm REFUSAL	32		CH	SILTY CLAY: high plasticity, light grey mottled orange brown, trace of fine to medium grained ironstone gravel.	MC~PL	VSt	360 320	RESIDUAL
ON COMPLETION OF CORING		31	1 2		SHALE: grey brown, with iron indurated bands.	XW - DW	EL - VL		VERY LOW TO LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
		30 29	3 4		SHALE: dark grey borwn, with XW bands and iron inudrated bands.	DW	L - M		LOW RESISTANCE WITH VERY LOW BANDS
ON 24/4/17		28 27	5						
		26	6		SHALE: dark grey brown, with clay bands.				

SAMPLES: ES, U50, DB, DS

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
4
2 / 4

BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~32.8 m
Date: 21/4/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./N.E.S.

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
						25				SHALE: dark grey, with VL-L strength bands.	DW	M		MODERATE RESISTANCE WITH LOW BANDS
							8			SHALE: dark grey.	SW	M - H		MODERATE TO HIGH RESISTANCE
						24	9			REFER TO CORED BOREHOLE LOG				50mm DIAMETER PVC STANDPIPE PIEZOMETER INSTALLED TO 17.29m, MACHINE SLOTTED 50mm PVC STANDPIPE 5.29m TO 17.29m, CASING 0m TO 5.29m, 2mm SAND FILTER PACK 3.4m TO 17.29m, BENTONITE SEAL 0.1m TO 3.4m, BACKFILLED WITH SAND TO SURFACE AND COMPLETED WITH A CONCRETED GATIC COVER
						23	10							
						22	11							
						21	12							
						20	13							
						19								

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. 4

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN	**Core Size:** NMLC	**R.L. Surface:** ~32.8 m
Date: 21/4/17	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK205	**Bearing:** N/A	**Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS – DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
					START CORING AT 8.47m					
100% RETURN		24	9		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	FR	M - H			
		23	10				M			
		22								(10.50m) J, 85°, P, R
			11							(10.95m) J, 90°, P, R
										(11.38m) J, 70 - 80°, Un, R
										(11.63m) J, 65°, P, S
		21	12							
		20	13							(13.30m) CS, 0°, 22 mm.t
		19								(13.88m) XWS, 0°, 103 mm.t
			14							(14.04m) Cr, 0°, 5 mm.t
										(14.07m) FRAGMENTED ZONE, 0°, 12 mm.t
										(14.15m) XWS, 0°, 5 mm.t
										(14.24m) CS, 0°, 32 mm.t
										(14.28m) XWS, 0°, 6 mm.t
										(14.48m) J, 90°, Un, R
										(14.51m) XWS, 0°
		18								

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN | **Core Size:** NMLC | **R.L. Surface:** ~32.8 m
Date: 21/4/17 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK205 | **Bearing:** N/A | **Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS – DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific / General
100% RETURN		17, 16	16, 17		SHALE: dark grey, with light grey laminae, bedded at 0-5°. *(continued)*	FR	M H - VH			(15.08m) XWS, 0°, 12 mm.t (15.48m) Cr, 0°, 10 mm.t (16.20m) FRAGMENTED ZONE, 0°, 20 mm.t
		15, 14, 13, 12, 11	18, 19, 20, 21		END OF BOREHOLE AT 17.29 m					


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JOB No. 30341ZN BH4 START CORING AT 8.47m
8
9
10
11
12
13
14
15
16
17
END OF BOREHOLE AT 17.29m

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No.
5
1 / 3

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN **Method:** SPIRAL AUGER **R.L. Surface:** ~32.8 m
Date: 24/4/17 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** A.C.K./N.E.S.

Groundwater Record	Samples (ES / U50 / DB / DS)	Field Tests	RL (m AHD)	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
DRY ON COMPLETION OF AUGERING							TILES: 10mm.t over CONCRETE: 117mm.t				7mm, 66mm TOP COVER 8mm, 70mm TOP COVER
						CH	SILTY CLAY: high plasticity, light grey mottled orange brown.	MC~PL	(VSt - H)		RESIDUAL
	DS	N > 24 12,20,4/ 50mm REFUSAL	32	1			SHALE: grey brown, with iron indurated bands.	XW - DW	EL - VL		TOO FRIABLE FOR HP TESTING VERY LOW 'TC' BIT RESISTANCE WITH LOW BANDS
			31	2							
	DS		30	3			as above, but dark grey and brown.				
	DS		29	4			SHALE: dark grey.	DW	M		LOW RESISTANCE
ON COMPLETION OF CORING	DS		28	5							MODERATE TO HIGH RESISTANCE
			27	6			REFER TO CORED BOREHOLE LOG				
			26								

CORED BOREHOLE LOG

Borehole No.
5

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN	**Core Size:** NMLC	**R.L. Surface:** ~32.8 m
Date: 24/4/17	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK205	**Bearing:** N/A	**Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL -0.03, VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS – DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific	General
ON COMPLETION OF CORING					START CORING AT 5.62m						
		27, 26	6, 7		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	SW	M			(6.04m) Cr, 5°, 13 mm.t (6.08m) XWS, 5°, 4 mm.t (6.29m) J, 40°, P, S (6.65m) J, 80°, Un, S (6.76m) J, 35°, P, R (6.80m) J, 40°, P, S (6.90m) J, 85°, P, S	
					CORE LOSS 0.21m						
100% RETURN		25, 24, 23, 22	8, 9, 10		SHALE: dark grey, with light grey laminae, bedded at 0-5°.	SW	M - H			(7.26m) J, 60°, P, S (7.27m) HEALED J, 80°, Un (7.47m) Cr, 5°, 11 mm.t (7.53m) CS, 5°, 7 mm.t (7.80m) J, 60°, P, S (8.36m) J, 40°, Un, S (8.39m) J, 10 - 30°, Un, S (8.41m) J, 90°, P, R (9.16m) J, 40°, P, S (9.28m) HEALED J, 70°, Un (9.39m) J, 65°, P, R (9.67m) J, 70°, P, S (9.93m) J, 80°, Un, S (10.06m) J, 85 - 90°, Un, S (10.45m) J, 85°, P, S, CLAY INFILL	
						XW - DW	EL - VL				
		21	11			SW	M - H			(10.99m) J, 35°, P, R, IS	

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GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

Borehole No.
5

CORED BOREHOLE LOG

Client: DRILL PTY LTD
Project: PROPOSED MIXED USE DEVEOPMENT
Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Job No.: 30341ZN	**Core Size:** NMLC	**R.L. Surface:** ~32.8 m
Date: 24/4/17	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK205	**Bearing:** N/A	**Logged/Checked By:** A.C.K./N.E.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (500, 300, 100, 50, 30, 10)	DEFECT DETAILS DESCRIPTION (Type, inclination, thickness, planarity, roughness, coating.) Specific	General
100% RETURN		20, 19, 18, 17, 16, 15	13, 14, 15, 16, 17		SHALE: dark grey, with light grey laminae, bedded at 0-5°. *(continued)*	SW	M			(12.09m) J, 75°, P, R (12.55m) J, 75°, P, R (12.85m) J, 75 - 90°, Un, R (13.24m) J, 45°, P, R (13.43m) FRACTURED 0°, 20mm.t (14.08m) XWS, 15 - 40°, 75 mm.t (14.23m) J, 55°, P, R (14.32m) XWS, 30 - 40°, 30 mm.t (14.43m) J, 85°, P, R (14.67m) J, 80°, P, R	
						FR	H				
		15, 14	18		END OF BOREHOLE AT 17.76 m						

JK_LIB_CURRENT - V8.00.GLB Log J & K CORED BOREHOLE - MASTER 30341ZN WESTMEAD.GPJ <<DrawingFile>> 18/05/2017 14:29 Produced by gINT Professional, Developed by Datgel


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JOB No 30341ZN BH5 START CORING AT 5.62m
5
6
7
CORE LOSS: 0.21m
8
9
10
11
12
13
14
15
16
17
END OF BOREHOLE AT 17.76m

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

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

Title:	SITE LOCATION PLAN
Location:	24-26 RAILWAY PARADE WESTMEAD, NSW
Report No:	30341ZN
Figure No:	1

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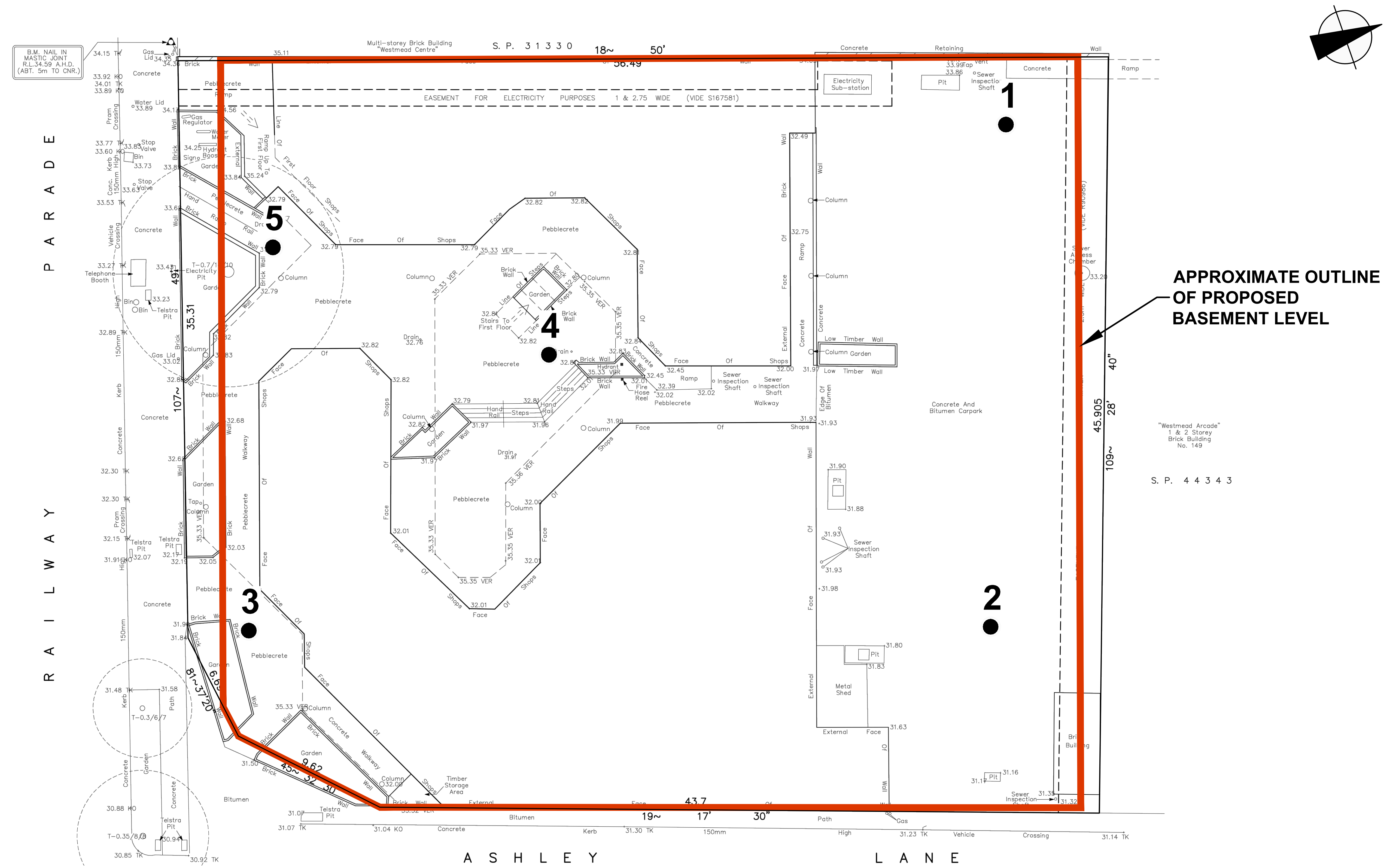
PLOT DATE: 28/04/2017 11:24:27 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30341ZN WESTMEAD\CAD\30341ZN.DWG



0 2.5 5 7.5 10 12.5 SCALE 1:250 @A3 METRES This plan should be read in conjunction with the JK Geotechnics report.	Title: **BOREHOLE LOCATION PLAN** Location: 24-26 RAILWAY PARADE WESTMEAD, NSW Report No: 30341ZN Figure No: 2 **JK Geotechnics**

PLOT DATE: 28/04/2017 11:23:56 AM DWG FILE: S:\6 GEOTECHNICAL JOBS\30000'S\30341ZN WESTMEAD\CAD\30341ZN.DWG

VIBRATION EMISSION DESIGN GOALS

German Standard DIN 4150 – Part 3: 1999 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 10Hz	10Hz to 50Hz	50Hz to 100Hz	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 100Hz, the higher values in the 50Hz to 100Hz column should be used.

REPORT EXPLANATION NOTES

INTRODUCTION

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

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

DESCRIPTION AND CLASSIFICATION METHODS

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

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

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

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

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

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

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

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

SAMPLING

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

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

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

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

INVESTIGATION METHODS

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

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

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

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

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

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

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

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

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

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

The test results are reported in the following form:

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

  N = 13
  4, 6, 7

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

  N>30
  15, 30/40mm

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

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

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

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

In the tests, a 35mm or 44mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm or 165mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

  The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between CPT and SPT values can be developed for both sands and clays but may be site specific.

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

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

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

Two relatively similar tests are used:

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

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

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

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

GROUNDWATER

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

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

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

FILL

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

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

LABORATORY TESTING

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

ENGINEERING REPORTS

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

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

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

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

SITE ANOMALIES

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

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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

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

REVIEW OF DESIGN

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

SITE INSPECTION

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

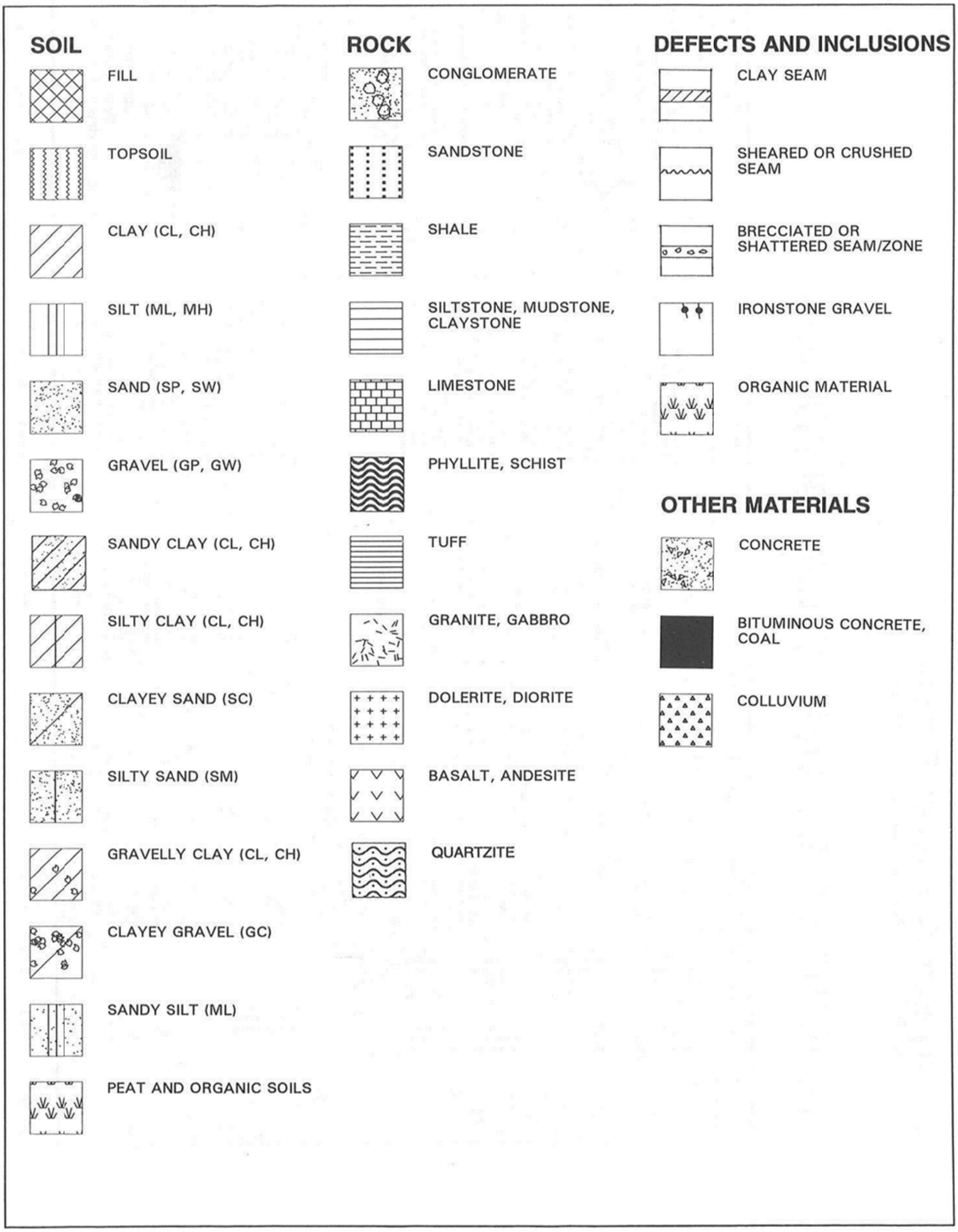
Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to

ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or

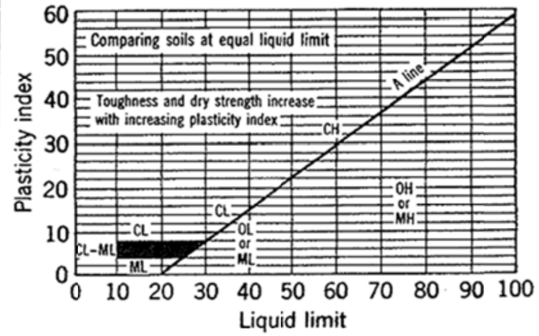
iii) full time engineering presence on site.

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS



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

Major divisions		Identification Procedures on Fraction Smaller than 380 μm Sieve Size: Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils More than half of material is *smaller* than 75 μm sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses. For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions. Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

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

LOG SYMBOLS

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

LOG SYMBOLS continued

ROCK MATERIAL WEATHERING CLASSIFICATION

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

ROCK STRENGTH

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

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

ABBREVIATIONS USED IN DEFECT DESCRIPTION

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

APPENDIX A

12 Ashley Street, Chatswood, NSW 2067
tel: +61 2 9910 6200

email: sydney@envirolab.com.au
envirolab.com.au

Envirolab Services Pty Ltd - Sydney | ABN 37 112 535 645

CERTIFICATE OF ANALYSIS 166179

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

Attention: Arthur Kourteis

Sample log in details:

Your Reference:	**30341ZN, Westmead**	
No. of samples:	6 soils	
Date samples received / completed instructions received	02/05/17	/ 02/05/17

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

Report Details:

Date results requested by: / Issue Date:	9/05/17	/ 8/05/17
Date of Preliminary Report:	Not Issued	

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

Results Approved By:

David Springer
General Manager

Misc Inorg - Soil						
Our Reference:	UNITS	166179-1	166179-2	166179-3	166179-4	166179-5
Your Reference	-------------	BH1	BH2	BH4	BH4	BH5
Depth	------------	0.5-0.95	0.75-1.0	0.5-0.7	2-2.5	0.5-0.85
Date Sampled		18/04/2017	19/04/2017	21/04/2017	21/04/2017	24/04/2017
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	04/05/2017	04/05/2017	04/05/2017	04/05/2017	04/05/2017
Date analysed	-	04/05/2017	04/05/2017	04/05/2017	04/05/2017	04/05/2017
pH 1:5 soil:water	pH Units	5.1	6.4	5.6	6.5	6.3
Chloride, Cl 1:5 soil:water	mg/kg	25	<10	10	<10	<10
Sulphate, SO4 1:5 soil:water	mg/kg	190	26	33	42	10
Resistivity in soil*	ohm m	79	420	180	230	630

Misc Inorg - Soil		
Our Reference:	UNITS	166179-6
Your Reference	-------------	BH1
Depth	------------	0.1-0.2
Date Sampled		18/04/2017
Type of sample		Soil
Date prepared	-	04/05/2017
Date analysed	-	04/05/2017
pH 1:5 soil:water	pH Units	8.7
Chloride, Cl 1:5 soil:water	mg/kg	<10
Sulphate, SO4 1:5 soil:water	mg/kg	45
Resistivity in soil*	ohm m	75

Method ID	Methodology Summary
Inorg-001	pH - Measured using pH meter and electrode in accordance with APHA latest edition, 4500-H+. Please note that the results for water analyses are indicative only, as analysis outside of the APHA storage times.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Alternatively determined by colourimetry/turbidity using Discrete Analyer.
Inorg-002	Conductivity and Salinity - measured using a conductivity cell at 25oC in accordance with APHA 22nd ED 2510 and Rayment & Lyons. Resistivity is calculated from Conductivity.

QUALITY CONTROL Misc Inorg - Soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			04/05/2017	166179-1	04/05/2017 || 04/05/2017	LCS-1	04/05/2017
Date analysed	-			04/05/2017	166179-1	04/05/2017 || 04/05/2017	LCS-1	04/05/2017
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	166179-1	5.1 || 5.1 || RPD: 0	LCS-1	102%
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	166179-1	25 || 26 || RPD: 4	LCS-1	94%
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	166179-1	190 || 210 || RPD: 10	LCS-1	107%
Resistivity in soil*	ohm m	1	Inorg-002	<1.0	166179-1	79 || 71 || RPD: 11	[NR]	[NR]

Report Comments:

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

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

Quality Control Definitions

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

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

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

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

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

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.
Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.
Spikes for Physical and Aggregate Tests are not applicable.
For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

SAMPLE AND CHAIN OF CUSTODY FORM

TO:		FROM:
Envirolab Services Pty Ltd 12 Ashley Street Chatswood NSW 2067 Phone: (02) 99106200 Fax: (02) 99106201 Attention: Aileen	J&K Job Number: 30341ZN Date Results Required: Standard akourtesis@... Contact: ~~afrost@jkgeotechnics.com.au~~ Please CC: nsmith@jkgeotechnics.com.au	JK Geotechnics Rear 115 Wicks Road Macquarie Park NSW 2113 Andrew Frost Phone: (02) 9888 5000 Fax: (02) 9888 5004

Project: Proposed Mixed Use Development

Location: 24-26 RAILWAY PARADE, WESTMEAD, NSW

Sampler: ~~Andrew Frost~~ ARTHUR KOURTESIS

Tests Required

Sample Preservation: None required

Date Sampled	Lab Ref:	Borehole/ Sample Number	Depth (m)	Sample Container	PID	Sample Description	pH	Sulfate	Chloride	EC	ECe	Resistivity	Conductivity				
18/4/17	1	BH1	.5-.95	Bag			X	X	X			X					
19/4/17	2	BH2	.75-1.0	Bag			X	X	X			X					
	~~3~~	~~BH3~~	~~.5-.7~~	~~Bag~~			~~X~~	~~X~~	~~X~~			~~X~~					
21/4/17	~~4~~ 3	BH4	.5-.7	Bag			X	X	X			X					
21/4/17	~~5~~ 4	BH ~~5~~ 4	2-2.5	Bag			X	X	X			X					
24/4/17	~~6~~ 5	BH5	.5-.85	Bag			X	X	X			X					
18/4/17	~~7~~ 6	BH1	0.1-0.2	Bag			X	X	X			X					
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Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 166179
Date Received: 2/5/17
Time Received: 1530
Received by: AL
Temp: Cool/Ambient
Cooling: Ice/Icepack
Security: Intact/Broken/None

Remarks (comments/detection limits required):

Relinquished By:	Date: ~~28/4/17~~ 1/5/17 Time: 4:00pm	Received By:	Relinquished By:	Date: 2/5/17 Time: 1530	Received By:
AK					A. Lie