REPORT TO

LORETO NORMANHURST

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED CAR PARKS AND THROUGH LINK

AT

91-93 PENNANT HILLS ROAD, NORMANHURST, NSW

Date: 17 December 2020

Ref: 31772L2rpt

JKGeotechnics

www.jkgeotechnics.com.au

T: +61 2 9888 5000

JK Geotechnics Pty Ltd

ABN 17 003 550 801

Report prepared by:

Linton Speechley
Principal | Geotechnical Engineer

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

DOCUMENT REVISION RECORD

Report Reference	Report Status	Report Date
31772L2rpt	Draft Report	14 December 2020
31772L2	Final	17 December 2020

This report (which includes all attachments and annexures) has been prepared by JK Geotechnics (JKG) for its Client, and is intended for the use only by that Client.

This Report has been prepared pursuant to a contract between JKG and its Client and is therefore subject to:

a) JKG's proposal in respect of the work covered by the Report;

b) The limitations defined in the Client's brief to JKG;

c) The terms of contract between JKG and the Client, including terms limiting the liability of JKG.

If the Client, or any person, provides a copy of this Report to any third party, such third party must not rely on this Report, except with the express written consent of JKG which, if given, will be deemed to be upon the same terms, conditions, restrictions and limitations as apply by virtue of (a), (b), and (c) above.

Any third party who seeks to rely on this Report without the express written consent of JKG does so entirely at their own risk and to the fullest extent permitted by law, JKG accepts no liability whatsoever, in respect of any loss or damage suffered by any such third party.

At the Company's discretion, JKG may send a paper copy of this report for confirmation. In the event of any discrepancy between paper and electronic versions, the paper version is to take precedence. The USER shall ascertain the accuracy and the suitability of this information for the purpose intended; reasonable effort is made at the time of assembling this information to ensure its integrity. The recipient is not authorised to modify the content of the information supplied without the prior written consent of JKG.

Table of Contents

ATTACHMENTS

1 INTRODUCTION

This report presents the results of a geotechnical investigation for proposed new car parks P3A, P4A and P1A along with a Through Link at Loreto Normanhurst. The location of the site is shown in Figure 1.

Based on the latest architectural drawings provided, we understand that the proposed works as part of this Stage 1 of the Loreto redevelopment will include;

- Two basement carparks (P1A and P4A) and a through link to the P1A carpark.
- Carpark P3A which involves adding a row of stacked carparking and a drop-off and pick-up zone to the existing on grade carpark. Additionally changes to vehicle circulation and the bus slip road are proposed as part of the Stage 1 works. A future basement carpark and all weather field is proposed in this location as part of the concept masterplan but does not form part of the Stage 1 application. This geotechnical report has been prepared to address the future basement carpark P3A as part of the concept masterplan, however subsurface information can be used for design of on grade carparking and other ancillary structures in the P3A investigation area.

The following summarises the proposed development at each carparking area that our geotechnical report has been prepared for.

P1A Carpark
The P1 carpark will include a basement carpark with a finished floor level at RL191.5 and the carpark will be overlain by tennis courts. Excavation to achieve the basement carparking level will range from less than 1m to a maximum of about 3m.

P3A Carpark
The P3A carpark will be located in the area of the existing playing field. No specific levels have been provided for the basement carpark, however it has been indicated that it will require about 3m of excavation to achieve the basement carparking level. An all weather playing field will be constructed over the top of the P3 carpark.

P4A Carpark
The P4A carpark will include a basement carpark with a finished floor level at RL187m, and the carpark will be overlain by basketball courts. Excavation to achieve the basement carparking level will be to a maximum of 5.5m at the western end.

Column loads for the above structures have been indicated to be in the order of 950kN.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions as a basis for comments and recommendations on excavation conditions, batter slopes, shoring, footings and design parameters for pavements.

JK Geotechnics carried out a previous investigation on the site for works which included the Boarding House Building and Early Learning Centre Building, as well as some development around the Mary Ward Building.

For specific details regarding those proposed developments, reference should be made to JK Geotechnics report Reference 31772Lrpt-rev2 dated 7 January 2019. No further comments on those particular developments are provided within this report.

This geotechnical investigation was carried out in conjunction with detailed Stage 2 site investigations by our environmental division, JK Environments (JKE). Reference should be made to the separate report by JKE, Ref: E31772PLrpt7, dated 11 December 2020.

2 INVESTIGATION PROCEDURE

The fieldwork for the investigation was carried out between 3 November and 6 November 2020 and comprised the drilling of twelve (12) boreholes (BH201 to BH212) using our track mounted JK205 and JK305 drilling rigs.

The borehole locations are shown on the attached Figure 2 and they were set out by taped measurements from existing site features shown on survey plans prepared by LTS Lockley (Reference No. 44200DT, Issue D, dated 17 October 2018). The surface reduced levels indicated on the attached borehole logs were interpolated from spot levels and contours shown on the survey plan and are therefore approximate only.

All boreholes were initially auger drilled using spiral auger techniques through the soils and some of the upper more weathered and lower strength rock. The rock was then core drilled to the borehole termination depth using rotary diamond coring techniques and an NMLC triple tube core barrel with water flush.

The apparent compaction of the fill and strength of the subsurface soils were assessed from the Standard Penetration Test (SPT) 'N' values augmented with the results of hand penetrometer tests on cohesive samples obtained from the SPT split tube sampler. Assessment of the rock strength in the augered portion of the boreholes was from observation of the drilling resistance when using a Tungsten Carbide (TC) bit on the augers, and inspection of the recovered rock cuttings, together with later correlation with the results of moisture content tests completed on rock chip samples. It should be noted that rock strengths assessed in this way are approximate, and variations of about one order of strength should not be unexpected

Where the rock was core drilled, the recovered rock core was placed in steel boxes and returned to our NATA registered laboratory where it was photographed and Point Load Strength Index (Is_{50}) testing was carried out. Using established correlations, the unconfined compressive strength (UCS) of the bedrock was estimated from the Is_{50} results. The Point Load Strength test results are summarised in the attached Table C.

Groundwater observations were made in the boreholes during and on completion of auger drilling. Groundwater levels at completion of coring have not been presented as water is used during the coring process and the water level in the borehole is likely to be artificially high. PVC groundwater monitoring standpipes with gatic covers were installed in five boreholes (BH201, BH204, BH207, BH210 and BH212) to allow for longer-term groundwater monitoring. Our geotechnical engineer returned to site on 10 December 2020 to measure the groundwater levels in these five boreholes.

The fieldwork was completed in the full-time presence of our geotechnical engineer (Ms Joanne Lagan) who set out the borehole locations, nominated the sampling and testing, and prepared the borehole logs. The borehole logs are attached with this report, together with a set of explanatory notes which provide further details of the investigation techniques adopted, their limitations and the logging terms and symbols used.

Selected soil and weathered rock samples were returned to STS, for testing to determine moisture content, Atterberg limits, linear shrinkage, standard compaction and four-day soaked California Bearing Ratio (CBR). The results of these tests are summarised in the attached Tables A and B. Copies of the photographs are provided with the borehole logs, and the Point Load Strength Index test results are summarised on the borehole logs and in Table C.

Additional samples of the soil and weathered siltstone were delivered to Envirolab Services Pty Ltd (Envirolab) for testing of soil pH, sulphate, chloride contents and soil resistivity. The results of these tests are provided in the Envirolab Services Certificate of Analysis 255667.

In conjunction with the geotechnical investigation, a contamination investigation was also carried out by JK Environments (JKE). Reference should be made to the JKE report (Reference E31772PLrpt7, dated December 2020) for further details.

3 RESULTS OF INVESTIGATION

3.1 Site Description

This report primarily covers four separate areas within the grounds of Loreto Normanhurst for the proposed carparks, these have been designated as car Park Site P3A, P4A and P1A and through link within the supplied masterplan drawings. Loreto Normanhurst is located within ridge and gully topography on a spur that extends southwards from the main east-west ridgeline proximately followed by Pennant Hills Road. Pennant Hills Road forms the northern boundary of the school. Surface levels across the school largely follow the undulations along the spur with a hillcrest situated roughly within the existing primary school carpark. From this point the hill slopes down towards the south at about 3°.

Car Park Site P3A

The site for the proposed carpark P3A covers the western portion of the main playing field (Sr Veronica Reid Oval), as well as the existing oval carpark. Surface levels across the playing field and the oval carpark appeared to be relatively level. Osborn Road forms the western boundary of the site, which grades to the south at about 3° to 4°. South of the site comprised a heavily vegetated area with medium to large trees, which also appeared to be sloping similarly to the adjacent Osborn Road. Single storey demountable buildings (Veronica Reid Buildings) founded at a similar level, as well as on a series of terraces occupied the adjoining area to the north of the site, sandstone block and concrete rendered retaining walls ranging from 1.0m to 1.5m high, support the concrete footpaths running adjacent to the demountable buildings, though some observation were obscured due to bushes and shrubs.

Car Park Site P4A
The site for the proposed carpark P4A comprised outdoor basketball/netball and tennis courts, which step down the site through a series of terraces. The difference in elevation between the eastern and western portions of the site is approximately 6.1m. The site generally slopes to the east at about 5°. The outdoor courts were supported by sandstone block and concrete masonry block retaining walls ranging from 1.0m to 1.5m high. The western boundary of the site was occupied by an asphaltic concrete (AC) surfaced access road, terraced garden beds, and medium to large trees. The concrete footpath along the northern boundary of the site grades to the east at approximately 5°, and appeared to have concrete stormwater drainage running underneath it. This concrete footpath was also supported by a brick retaining wall to its north, ranging from 1.5m to 2.1m high. Between the courts and the property boundary was a grass covered area which slopes at approximately 9° to the east and was occupied by a row of medium trees, and supported by a brick retaining wall up to about 0.6m high.

A two-storey brick building (Mary Ward Health and Wellness Centre) occupied the southern adjoining property, which appeared to be founded at a similar ground surface level to the lowest court (Court No.4), and was set back at approximately 2.0m from the edge of the nearest court.

Car park Site P1A
The site for the proposed carpark P1A comprised outdoor tennis court and maintenance sheds, which step down through the site to the east. The difference in elevation between the eastern and western portions of the site is approximately 3m. The site generally slopes down to the east at about 4°. The tennis court was supported by rendered retaining walls up to 1.2m high. The northern and eastern boundaries of the site was occupied by internal access roads, which slope to the east at 4° and are relatively level. The surrounding areas were occupied by grass covered lawns, garden beds, shrubs and medium to large sized trees.

Through Link
The site for the proposed through link comprised a single storey brick building (4 Mount Pleasant Avenue), and a brick shed, which generally occupied the central portion of the property, and has an eastern frontage onto Mount Pleasant Avenue. The site generally slopes down to the east at about 4°. The western portion of the property (rear yard) comprised grass lawn, and was supported by a 1.0m high brick retaining wall which is set back about 1.5m from the building.

A single level brick building occupied the neighbouring property to the south, which was set back at 2.0m from the common boundary. The surface level slopes to the east at approximately 7°. The ground levels over the central portion is generally lower by about 0.5m, with similar levels elsewhere. Concrete footpaths and a concrete strip driveway occupied the central rear portion and front northern portion, respectively.

3.2 Subsurface Conditions

The 1:100,000 Geological Series Sheet 9130 'Sydney' indicates that the site is underlain by Ashfield Shale comprising *"black to dark grey shale and laminite"*. Generally the investigations have encountered a profile of fill underlain by residual silty clay transitioning to weathered siltstone bedrock. The weathered siltstone is quite variable and contains numerous, clay seams, bedding, extremely weathered seams and jointing.

A summary of the strata encountered for each parking area is provided below, however for a detailed description at each location reference should be made to the attached borehole logs.

Car Parking Area P3A (BH201 to BH204 Inclusive)

Pavements and Fill

A 35mm thick asphaltic concrete pavement was encountered at the surface in BH201. Fill was encountered in each borehole and it was measured as being 0.3m deep in BH202 and BH204, 1.6m deep in BH201 and 2.8m in BH203. The deepest fill was located at the southern end of the proposed car park area. The fill generally comprised a silty clay of low or medium plasticity, although the upper fill in BH201 and the shallow fill in BH204 comprised silty sand. Where the fill was deepest in BH201 and BH203, and could be tested, it was assessed as being well compacted.

Residual Silty Clay

Residual silty clay was encountered below the fill in all boreholes except BH202. The residual silty clay was assessed as medium to high or high plasticity and of very stiff to hard strength in BH201 and BH204 and Stiff strength in BH203. The residual silty clay contained inclusions of ironstone gravel. No residual soils were encountered in BH202 as the fill directly overlies extremely weathered siltstone.

Weathered Siltstone Bedrock

Weathered siltstone bedrock of at least very low strength was encountered at depths of 2.5m, 0.8m, 4.4m and 2.0m in BH201 to BH204 respectively. In BH202, a 0.4m thickness of extremely weathered siltstone was encountered immediately below the fill. The bedrock generally increasing in strength and quality with depth, with siltstone of medium strength being encountered at depths ranging from about 5.3m to 6.4m. The exception being BH1, where poor quality siltstone continued to a depth of 5.7m, and in BH3 where the rock quality was poorer toward the base of the borehole. Some of the upper very low and low strength siltstone contained a significant proportion of defects, including numerous joints, clay seams and extremely weathered seams.

Groundwater

All the boreholes were dry on completion of augering, apart from some minor seepage at 3.0m toward the base of the fill in BH203. No groundwater level measurements were taken in the boreholes after coring, since water is introduced into the hole as part of the drilling process. Monitoring wells were installed in BH201 and BH204 after completion of coring. The groundwater levels in these monitoring wells were measured on 10 December 2020 to be at depths of 4.42m (RL175.18m) and 1.55m (RL179.85) in BH201 and BH204 respectively. No longer term groundwater monitoring has been carried out.

<u>Car Parking Area P4A</u> (BH210 to BH212 Inclusive)

Pavements and Fill

Asphaltic concrete pavements were encountered at the surface of BH210 and BH211. In BH210, a 15mm thick asphaltic concrete pavement was underlain by 125mm thickness of basecourse was encountered, while in BH211, a 20mm thick asphaltic concrete pavement was underlain by 90mm of basecourse. Surficial fill was only encountered in BH212 and it extended to a depth of 0.3m and comprised low plasticity silty clay.

Residual Silty Clay

Residual silty clay was encountered in all boreholes. The residual silty clays were assessed as medium to high or high plasticity and of very stiff to hard strength. The residual silty clay contained inclusions of ironstone gravel.

Weathered Siltstone Bedrock

Extremely weathered siltstone was first encountered at depths of 1.3m, 2.1m and 4.0m in BH210, BH211 and BH212 respectively. Siltstone of at least very low strength was then encountered at depths of 2.4m, 4.6m and 5.0m. In BH210, the rock strength did not increase to greater than low strength within the depth of the borehole, While in BH211 and BH212, siltstone of medium strength was encountered at depths of about 7.2m and 5.8m respectively.

Groundwater

All the boreholes were dry on completion of augering. No groundwater level measurements were taken in the boreholes after coring, since water is introduced into the hole as part of the drilling process. Monitoring wells were installed in BH210 and BH212 after completion of coring. The groundwater levels in these monitoring wells were measured on 10 December 2020 to be at depths of 5.52m (RL185.88m) and 2.51m (RL183.79) in BH210 and BH212 respectively. No longer term groundwater monitoring has been carried out.

<u>Car Parking Area P1A and Through Link</u> (BH205 to BH209 Inclusive)

Pavements and Fill

Asphaltic concrete pavements were encountered at the surface of BH207 and BH209. In BH207, a 50mm thick asphaltic concrete pavement was underlain by 150mm thickness of basecourse was encountered, while in BH209, a 15mm thick asphaltic concrete pavement was underlain by 85mm of basecourse. Fill was only encountered in BH205 and BH208. In BH205 the fill extended to a depth of 1.3m and comprised a silty clay which was assessed to be poorly compacted. Surficial fill was encountered in BH208 and it extended to 0.3m depth and comprised a silty clay.

Residual Silty Clay

Residual silty clay was encountered in all boreholes. The residual silty clays were assessed as medium to high or high plasticity and of very stiff to hard strength. The residual silty clay contained inclusions of ironstone gravel.

Weathered Siltstone Bedrock

Siltstone was first encountered at depths of 2.1m, 2.2m, 1.2m,2.5m and 2.5m in BH205 to BH209 respectively. On first rock contact the weathered shale was typically of at least very low strength with the exception of BH205 where it was only of extremely low strength. in BH210, BH211 and BH212 respectively. Siltstone of at least very low strength was then encountered at depths of 2.4m, 4.6m and 5.0m. In BH210, the rock strength did not increase to greater than low strength within the depth of the borehole, While in BH211 and BH212, siltstone of medium strength was encountered at depths of about 7.2m and 5.8m respectively.

Groundwater

All the boreholes were dry on completion of augering. No groundwater level measurements were taken in the boreholes after coring, since water is introduced into the hole as part of the drilling process. A monitoring well was installed in BH207 after completion of coring. The groundwater level in the monitoring well was measured on 10 December 2020 to be at depth of 7.48m (RL185.82m). No longer term groundwater monitoring has been carried out.

3.3 Laboratory Test Results

The moisture content test results were generally consistent with our field assessment of rock strength. The Atterberg Limit tests confirmed that the fill and residual clays range from medium to high plasticity and will therefore have a moderate to high potential for shrink-swell movements with changes in moisture content. The results of the point load strength index testing are summarised in the attached Table C and on the borehole logs.

Disturbed soil samples were sent to Envirolab for soil pH, soil sulphate, soil chloride content and resistivity testing. The following table summarises the results, but for specific details reference should be made to the attached Envirolab Certificate of Analysis 255667.

Sample Location	Depth (m)	Soil Description	Soil pH	Chloride (mg/kg)	Sulphate (mg/kg)	Resistivity (ohm.cm)
BH201	0.5-0.95	Silty Clay Fill	4.8	24	49	8,400
BH204	0.5-0.95	Silty Clay	4.5	87	120	6,600
BH206	0.5-0.95	Silty Clay	4.9	47	160	7,800
BH208	3.5-4.2	VL-L Siltstone	5.4	10	86	16,000
BH211	2.1-2.5	EW Siltstone	4.5	460	160	2,500
BH212	1.5-1.95	Silty Clay	4.5	240	140	3,800

Based on the table of results above, we consider that the soils and weathered siltstone would have an exposure classification of 'Moderate' for concrete structural elements and 'Non-Aggressive' for steel in accordance with Table 6.4.2(C) and Table 6.5.2(C) of AS2159-2009 'Piling Design and Installation.

The standard compaction and four day soaked CBR values for samples of residual silty clay and silty clay fill returned soaked CBR values ranging from 3% to 9% when surcharged with a 4.5kg load.

4 COMMENTS AND RECOMMENDATIONS

4.1 Excavation

The following recommendations should be read in conjunction with the latest version of 'Excavation Work – Code of Practise' by Safe Work Australia

Excavations for the various carparking structures will typically range from less than 1m to a maximum of about 5.5m at the western end of the P4A carpark.

Excavation will occur through fill, residual silty clays and weathered siltstone bedrock. Excavation through the fill, residual soils and extremely weathered siltstone should be readily excavated using conventional earthmoving equipment such as the buckets of tracked excavators. Ironstone bands and siltstone bands of low or greater strength within the extremely weathered siltstone may require ripping with tynes on tracked excavators.

Excavation through siltstone of low or higher strength will require the use of rock excavation techniques such as dozers with ripping tynes, hydraulic impact hammers, rock saws or rock grinders. Where hydraulic impact hammers are adopted there is the risk that transmitted vibrations may damage nearby movement sensitive structures or services. The most significant rock excavation will occur at the northern end of the P3A carpark and at the western end of the P4A carpark where there could up to about 2m of excavation through very low and low strength rock, including some medium strength bands.

During at least the initial stages of excavation using hydraulic impact hammers, quantitative vibration monitoring must be completed by the geotechnical engineers. Quantitative vibration monitoring should be carried out at the commencement of the use of hydraulic impact hammers, and then depending on the results, at the discretion and frequency as recommended by the geotechnical engineers. Vibration monitoring should be set up on structures in close proximity to the area of. Vibration monitoring should measure Peak Particle Velocities (PPV) and vibration frequency. If during excavation with hydraulic impact hammers, vibrations are found to be excessive or there is concern, then alternative lower vibration emitting equipment, such as rock saws, rock grinders or smaller hammers may need to be used. The use of a rotary grinder or rock sawing in conjunction with ripping or hydraulic hammers presents an alternative lower 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 attached vibration emission guidelines provide some advice on acceptable vibrations in this regard.

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

Based on the current groundwater monitoring, we expect the following in relation to groundwater seepage;

- For carpark P3A, groundwater levels will be above the lowest carpark excavation at the northern end of the basement carpark excavation. In that area groundwater was measured to be at depths of 4.42m (RL175.18m) and 1.55m (RL179.85) in BH201 and BH204 respectively.
- For carpark P1A, the groundwater level in the monitoring well was measured to be at a depth of 7.48m (RL185.82m) in BH207 which is below the proposed basement carparking level.
- For carpark P4A, the groundwater levels in these monitoring wells were measured to be at depths of 5.52m (RL185.88m) and 2.51m (RL183.79) in BH210 and BH212 respectively. Both of these levels are below the proposed carparking level.

Notwithstanding the above, it is quite likely that some groundwater seepage will be encountered during excavation, at the soil/rock interface, particularly during or immediately following periods of wet weather. Considering the relatively low permeability of the underlying siltstone bedrock, we expect that any groundwater seepage will be able to be controlled by conventional sump and pump techniques. Additional groundwater monitoring is recommended prior to any detailed design to assess groundwater levels further.

4.1.1 Temporary Batters

Temporary excavation batters may be feasible in some areas of the site where they can fit within the site boundaries or other site constraints. We provide the following general recommendations for temporary batters at this site.

- Temporary batters through the upper soils and extremely weathered and very low strength siltstone may be battered at not steeper than 1 Vertical (H) in 1.5 Horizontal (H). We consider this will be the case for most of the bulk excavation.
- Temporary batters through the underlying low and if encountered medium strength siltstone should be battered at not steeper than 1V in 1H. This batter slope is due to the numerous joints and defects within the siltstone.
- Steeper batters may be suitable, however the geotechnical engineers would be able to provide specific advice as and when they are exposed, as the batter slope will be governed primarily by the nature of any defects within the rock.
- We recommend that a horizontal berm of at least 1.5m width be formed for every 3m vertical height of batter.
- Surcharge loads should be kept well clear of the crest of batter slopes (at least 2H from the crest, where H is the vertical height of the batter in metres).
- Stormwater runoff should not be allowed to flow over the crest of temporary batters and should be directed and discharged in a manner which avoids concentrated flows and erosion within the batter slopes.
- Geotechnical inspections should be undertaken at not greater than 1.5m depth intervals to check for any adverse defects within the temporary batter slopes. If adverse defects are encountered, then temporary batters may need to be flattened or some stabilisation, such as rock bolts and shotcrete may be required.

Where temporary batters are formed, consideration needs to be given to the type of backfill to be used against the permanent basement walls. Uncompacted backfill placed up against basement walls will result in large settlements which can have adverse effects on structures, paving or landscaping supported above. The backfill placed against the permanent basement retaining walls should preferably comprise a uniform sized durable granular material which is surrounded in a geotextile fabric. A capping layer of at least 0.5m thickness of clayey site won material should be placed above the geofabric, to reduce water infiltration. A subsoil 'agg' drain surrounded by a geofabric filter sock should also be placed at the base and rear of the basement wall to collect seepage and discharge it to the stormwater system. This type of backfill has the advantage that only nominal compaction is required (such as by the use of a plate attached to the excavator). The alternative (although less preferred) is to use the site won material as backfill, however it will require careful control of moisture content, placement and compaction of material in thin layers, and density testing of each layer to ensure it is placed in a controlled manner as an engineered fill material. Placement and compaction of site won material at the rear of basement walls is difficult and time consuming due to the space limitations. Care should also be taken when compacting fill behind retaining walls, to ensure that compaction stresses do not exceed the design earth pressures. Advice during construction is recommended when the type of equipment proposed is known.

There are also cost implications of excavating and disposing of the additional soil and weathered siltstone from the batters, and importing large amounts of drainage material to backfill the permanent basement walls. The space required to form the temporary batters may also be problematic due to limited storage and construction space. Therefore it may be preferable to install a shoring system to avoid the excavation of the material in the batters and replacement with high quality material.

4.1.2 Permanent Batters

If permanent batters are proposed, then specific advice will be required from the geotechnical engineers following inspection of the temporary batters, however as a guide we consider that the following may be adopted for initial planning purposes.

- Permanent batters through the soils and extremely weathered and very low strength siltstone should be battered at not steeper than 1V in 2.5H.
- Permanent batters through the underlying low and if encountered medium strength siltstone should be battered at not steeper than 1V in 1.5H.
- Permanent batters will need to be protected by approved erosion protection, such as shotcrete facing. If flatter batters (say 1V in 3H) within the upper soils are adopted then erosion control may include revegetation.

4.2 Shoring Systems

Where temporary batter slopes are not preferred or cannot fit within the boundary constraints, we recommend that properly designed insitu shoring systems be constructed and installed prior to commencement of excavation.

Given the subsurface conditions encountered, we consider that anchored soldier pile walls with shotcrete infill panels are probably most suitable for this site, although where movements are a concern we recommend an anchored contiguous piled wall be adopted to provide a stiffer shoring system. During the detailed design stage of the works and prior to commencement of shoring wall construction and excavation, we recommend that a few test pits be excavated next to any nearby adjoining structures to assess their footing type and depth. These details will need to be taken into account in the design.

Bored piles will be suitable for the piles, however some seepage will likely occur into bored piles if they are left open for any extended periods of time and this will require pumping of water and thorough cleaning of the base (including removal of any softened material) prior to pouring or more likely the need to pour using tremie techniques.

Piles for the shoring system should be socketed at least 1.0m below the bulk excavation level, including allowances for nearby lift pits, footing and services excavations. Greater embedment may be required for lateral stability of the shoring system. Deeper shoring systems may need to penetrate higher strength siltstone bedrock which will require the use of large capacity piling rigs. Even with large capacity piling rigs, productivity may be very slow. We recommend that further advice from piling contractors be obtained on the suitability of their equipment to cost effectively penetrate through the required strength of rock.

Temporary lateral support of the shoring system will need to be provided by anchors or internal propping. During excavation, reinforced shotcrete panels should be sprayed progressively with the excavation to support the soil and weathered rock between the piles, such that there is no more than 1.5m of vertical face of material exposed at any one time. It will be necessary to install strip drains with a non-woven geotextile filter fabric behind each panel of shotcrete to dissipate the pore pressures behind the shotcrete. We recommend strip drain be placed at minimum 1.5m centres. Where contiguous piled walls are adopted, we recommend that weep holes be placed through the walls at horizontal and vertical spacing's of not greater than 1.5m. The weep holes should include 30mm diameter PVC pipes with a non-woven geotextile filter fabric on the end. We have assumed that the permanent support of the shoring system will be provided by bracing or propping from the floor slabs in the long term.

Where temporary batter slopes are adopted, conventional concrete block retaining walls can be constructed.

An alternative shoring option may be the use of soil nailed walls. While further specific design and construction staging would need to be provided once details are known, soil nail walls are likely to include soil nails drilled at 1.5m horizontal and vertical spacings, with the soil nails installed to a similar length to the height of the excavation. However a specific soil nail design would be required.

4.2.1 Insitu Shoring Systems – Design Parameters

The following characteristic parameters may be adopted for shoring wall design. Where soldier pile walls are constructed, inspection of the soil and rock faces between soldier piles should be completed by a geotechnical engineer at not greater than 1.5m depth intervals to check for significant adverse defects.

- Where minor movements of the shoring wall are tolerable, we recommend a trapezoidal lateral earth pressure distribution of 6H (where H is the depth of excavation in metres). The 6H should apply over the central 75% of the distribution with the earth pressure tapering to zero at the crest and bulk excavation level
- Where adjoining structures or movement sensitive services are within a horizontal distance of 2H from the shoring wall, we recommend that the magnitude of the trapezoidal lateral earth pressure be increased to 8H to reduce the risk of adverse deflections.
- Within siltstones there is always a risk that large continuous defects will be encountered. Therefore although geotechnical inspections at 1.5m depth intervals are recommended, in addition, we also recommend that the structural shoring design be checked for the presence of a 45° sliding wedge of rock with a friction angle of 25° and with soil surcharge above. If such defects are encountered during geotechnical inspections, then additional and or higher capacity anchors may need to be installed.
- Measures should be taken to provide permanent and effective drainage of the ground immediately behind the shoring walls. As discussed above, strip drain protected by non-woven geotextile filter fabric should be used behind the shotcrete panels of soldier pile walls. PVC weep holes should be adopted through contiguous piled walls. The drainage should be connected into the basement drainage. Although the shoring walls will be provided with rear drainage in the form of strip drains or weep holes, this drainage will essentially only be effective in reducing water pressures from immediately behind the shotcrete facing. Hydrostatic pressures can build up behind wedges of rock some distance back from the wall. Therefore we recommend that hydrostatic pressures based on the groundwater level should still be assumed to apply to the shoring wall design. These hydrostatic pressures are additional to the earth pressure recommendations above. Out of balance hydrostatic pressures will occur during construction and these need to be considered as part of the shoring wall design.
- All surcharge loads affecting the walls (e.g. nearby footings, construction loads and traffic etc) are additional to the earth pressure recommendations above and should be included in the design.
- Anchors should be bonded a minimum of 3m into siltstone of at least very low strength or siltstone of at least low strength for which we consider that a maximum allowable bond stress of 100kPa or 150kPa may be adopted respectively. The anchor bond length should commence beyond a line drawn up at 45° from the bulk excavation level.
- All anchors should be proof loaded to 1.3 times their design working load and then locked off at about 85% of the working load under the direction of an experienced engineer or construction superintendent, independent of the anchor contractor. Lift off tests should be completed on all anchors about 4 days after lock off to confirm that anchors are holding their load.
- Piles embedded below bulk excavation level into weathered siltstone of very low strength or low strength may be designed for a uniform passive resistance of 150kPa and 250kPa respectively. The upper 0.5m of the rock socket should be ignored in the passive resistance calculations to account for some disturbance and jointing within the upper siltstone from the excavation processes.

- Shoring wall designs should include an assessment of wall movements during all stages of the excavation and anchoring construction stages. The wall designer should review the wall movements and assess whether such movements will adversely affect any nearby adjoining structures and services. If movements are assessed to be adverse to adjoining structures then consideration will need to be given to underpinning.

4.2.2 In situ Shoring Wall Parameters for Detailed Computer Based Design

Where detailed computer based shoring wall designs are to be undertaken, we provide the following table of parameters. Such designs should be undertaken by engineers familiar with the geology and the implication of jointing and defects within the underlying bedrock. The following table provides our parameters for the rock mass (i.e. it takes into account some strata bound jointing only). All designs must also be checked for the possibility of large continuous defects within the siltstone. Designs must check all stages of excavation, and anchoring to confirm that the shoring wall has adequate factors of safety during all stages of its construction.

Material Type	Unit Weight (kN/m^3)	Effective Friction Angle (°)	Effective Cohesion (kPa)	Elastic Modulus (MPa)
Fill	19	26	2	5
Residual Very Stiff or Hard Silty Clays	20	30	2	20
XW Siltstone (Class 5)	21	30	5	50
Very Low to Low strength Siltstone	23	30	15	300

As discussed above, the shoring designs should also be checked for the potential of a 45° sliding wedge of rock with a friction angle of 25°, daylighting from the excavated rock face just above each stage of excavation and above the final bulk excavation level.

4.2.3 Permanent Basement Walls and Landscaping Walls

Where temporary batter slopes are adopted and permanent basement walls constructed within the excavation, we recommend that the following characteristic parameters may be adopted for shoring wall design. The following parameters are on the basis of either a properly placed and compacted engineered backfill or backfill comprising a uniform sized durable granular material which is surrounded in a geotextile fabric as discussed in Section 5.2.1 above.

- For cantilever walls where some movement can be tolerated we recommend a triangular lateral earth pressure distribution using an 'active' earth pressure coefficient (Ka) of 0.35.
- For cantilever walls which will be propped by floor slabs or where movements are to be reduced, we recommend a triangular lateral earth pressure distribution using an 'at rest' earth pressure coefficient (Ko) of 0.6.

- A bulk unit weight of 20kN/m^3 may be used for the backfill.
- All surcharge loads affecting the walls (e.g. nearby footings, construction loads and traffic etc) are additional to the earth pressure recommendations above and should be included in the design.

Measures must be taken to provide permanent and effective drainage of the ground immediately behind the basement walls. We recommend the use of a free draining durable aggregate (such as 20mm size blue metal) with 'agg' pipe surrounded by a geotextile at the base and connected to the stormwater drainage system.

4.3 Earthworks

The following earthworks recommendations will be suitable for construction of the Through link. Specific details of the Through link have not been provided, however we expect that it will generally be constructed at or close to existing surface levels. Once details are developed we recommend that they be provided to us so that the following comments and recommendations can be reviewed and amended if necessary. The nearest boreholes to the through link are BH205 and the previous BH10. BH10 encountered a shallow (0.3m thick) surficial fill layer underlain by very stiff to hard residual clays. However BH205 encountered 1.3m of poorly compacted fill. It is not clear the extent of the poorly compacted fill and therefore at the initial stages of construction we recommend a few test pits be excavated to assess the extent and depth of the is fill layer in more detail. The lowest risk option for pavements in this area would be to filly remove the poorly compacted fill down to the underlying very stiff residual soils. However other options may be feasible such as partial removal where further geotechnical investigations and inspections show that this is a feasible option.

For all new pavement areas subgrade preparation should initially comprise the stripping of all topsoil, root affected soils and any uncontrolled (or poorly compacted) fill. The topsoils and root affected soils are unsuitable for re-use as engineered fill but may be used for landscaping purposes. If topsoil/root affected soils are not to be re-used these should be stockpiled separately for disposal.

The uncontrolled fill may be able to be re-used as an engineered fill provided it does not contain any obvious deleterious materials or particles greater than a nominal 70mm diameter. We note however that some drying of the fill may be required before it is suitable for use as an engineered fill.

Following stripping, the exposed subgrade should be proof rolled with 8 passes of a minimum 10 tonne smooth drum roller to detect any soft or heaving areas. The proof rolling should be carried out in the presence of a geotechnical engineer or experienced earthworks technician. The boreholes have generally indicated that the residual silty clays are of very stiff or hard strength, although the moisture content of the residual soils is often close to or greater than the plastic limit and therefore some areas of heaving subgrade may occur during proof rolling. Where heaving subgrade occurs it should be locally removed to a competent base and replaced with engineered fill. If there is a significant thickness of heaving subgrade then further advice should be obtained from the geotechnical engineers, however it is likely that a bridging layer and geogrid reinforcement may be required. The subgrade should be well graded to promote runoff and reduce the risk of water ponding on the surface. If the subgrade becomes wet it may become untrafficable.

Preferably engineered fill should comprise a good quality granular material, such as crushed siltstone or sandstone. All engineered fill should be compacted in horizontal layers with a maximum 200mm loose thickness to at least 98% of Standard Maximum Dry Density (SMDD).

While not preferred, the existing residual clays and the excavated and approved existing site won fill materials may also be used as engineered fill, provided they are compacted to between 98% and 102% of Standard Maximum Dry Density (SMDD) and to within ±2% of Standard Optimum Moisture Content (SOMC). If the clayey soils are to be adopted for use as an engineered fill the following needs to be carefully considered.

(i) Some of the clays have moisture contents greater than the plastic limit and therefore they may require drying out prior to their use as engineered fill, and

(ii) Where reactive silty clays are used as an engineered fill, they will undergo greater shrink swell movements with changes in moisture content than the insitu reactive clays. Therefore consideration needs to be given to the affect that greater shrink-swell movements will have on the performance of structures founded above.

Density testing should be regularly carried out on any engineered fill. Regular density testing in accordance with Level 1 requirements of AS3798-2007 'Guidelines on Earthworks for Commercial and Residential Developments' are recommended. Any of the existing weathered rock excavated from the site would be suitable for use as an engineered fill. However the weathered siltstones will likely degrade during fill placement and compaction and may well become closer to a silty clay when placed and compacted. Therefore these materials would also then have a relatively low soaked CBR value for pavement design purposes.

Soil may need to be removed from site during earthworks operations or pile drilling. A contamination assessment has been carried out by Environmental Investigation Services (EIS). Reference should be made to their report (Reference E29845KP dated February 2017) for further advice.

4.4 Footing Design

Based on the borehole results, we consider that the bedrock encountered in the current boreholes is either Class 5 or Class 4 in accordance with Pells et al 1998. for the full depth of the boreholes. The following table provides the approximate depths and reduced levels to Class 5 and Class 4 siltstone at each borehole location.

Borehole Number (Surface Reduced level mAHD)	Depth to Class 5 Siltstone (Reduced level at top of Class 5 Siltstone mAHD)	Depth to Class 4 Siltstone (Reduced level at top of Class 4 Siltstone mAHD)
BH201 (179.6m)	2.5m (177.1)	2.5m (177.1)
BH202 (181.3m)	0.3m (181.0)	0.8m (180.5)
BH203 (179.5m)	4.2m (175.3)	4.2m (175.3)
BH204 (181.4m)	2.0m (179.4)	2.0m (179.4)
BH205 (186.9m)	2.2m (184.7)	n/a
BH206 (192.3m)	2.2m (190.1)	4.4m (187.9)
BH207 (193.3m)	1.2m (192.1)	1.2m (192.1)

BH208 (193.6m)	2.5m (191.1)	2.5m (191.1)
BH209 (192.2m)	2.5m (189.7)	3.2m (189.7)
BH210 (191.4m)	2.4m (189.0)	2.4m (189.0)
BH211 (192.4m)	2.1m (190.3)	4.6m (187.8)
BH212 (186.3m)	4.0m (182.3)	5.0m (181.3)

The following table presents our recommendations on maximum allowable end bearing pressures, ultimate end bearing pressures, maximum allowable skin friction values and ultimate skin friction values for the various rock. The skin friction values are for compressive loads. For tension loads the skin friction values should be halved.

Summary Table of Maximum Allowable and Ultimate End Bearing Pressures and Skin Friction Values

Rock Class	Maximum Allowable End Bearing Pressure (kPa)	Ultimate End Bearing Pressure (kPa)	Maximum Allowable Skin Friction (kPa)	Ultimate Skin Friction (kPa)
Class 5 Siltstone	700	1,500	40	70
Class 4 Siltstone	1,000	3,000	75	150

Based on the results of the investigations and the expected column loads, we recommend for uniformity of support to new structures that all new building footings be uniformly founded on the underlying Class 4 siltstone bedrock. Pad/strip footings will be feasible where Class 4 siltstone is exposed at bulk excavation level or is at a relatively shallow depth below bulk excavation level, while piled footings will be required where the Class 4 siltstone is greater than about 1.5m below bulk excavation levels.

Class 4 siltstone bedrock is expected to be encountered at bulk excavation level;

- At the northern end of the P3A basement carpark,
- At the north-western corner of the P1A basement carpark, and
- Within the western portion of the P4A basement carpark.

Pad Footing Recommendations

Where bulk excavations expose at least Class 4 weathered siltstone, shallow pad/strip footings founded on weathered siltstone would be feasible. Pad/strip footings may be designed on the basis of the recommended end bearing pressures outlined in the table above provided they are founded on and with a minimum embedment of at least 0.3m into the appropriate class of rock.

Water should be prevented from ponding in the base of footing excavations as this will lead to softening of the base. Any water softened founding material as well as any 'fall in' must be removed from the base of footings prior to pouring concrete.

All footing excavations should be visually inspected and tested by the geotechnical engineer to confirm that a suitable founding stratum is being achieved.

Pile Footing Recommendations

Where Class 4 siltstone is encountered more than about 1.5m below bulk excavation level, then pile footings will be required. We recommend that all piles be founded on and with a minimum embedment of 0.3m into the appropriate quality of rock. In addition to the maximum allowable and ultimate end bearing pressures, piles can also be designed for skin friction.

Where ultimate end bearing and skin friction values are adopted, then the ultimate values recommended in the table above must be reduced by an appropriate geotechnical reduction factor. The geotechnical reduction factor should be based on the risk assessment procedure set out in Table 4.3.2 (A) of AS2159-2009, but should not be greater than 0.5, unless the risk factors producing a higher geotechnical reduction factor can be fully justified. Consideration should also be given to the pile testing requirements when determining a suitable geotechnical strength reduction factor.

In order to achieve the recommended skin friction values nominated in the table above, it is essential that the rock sockets be cleaned of any clay smear and suitably roughened using a side wall grooving tool, and that they be at least as rough as Roughness Class R2. We note that an R2 roughness is equivalent to grooves 1mm to 4mm deep and grooves 2mm wide, which are spaced at 50mm to 200mm down the socket length. It will be the responsibility of the piling contractor to ensure that he has the appropriate equipment and methodology to satisfy this roughness criteria.

Where allowable bearing pressures and skin friction values are adopted, settlement of piles will typically be less than 1% of the pile diameter at the toe of the pile. However where ultimate end bearing and skin friction values are adopted, settlements will be greater and therefore once column loads are known, some detailed settlement analysis of piles is recommended to check that predicted settlements are within acceptable limits.

We recommend that the geotechnical engineers inspect piles during drilling to confirm the above recommended bearing pressures and skin frictions are being achieved. We consider that only a selection of piles will need to be inspected by the geotechnical engineers, unless there is a contractual requirement for all piles to be signed off by the geotechnical engineers, in which case all piles will need to eb inspected. It is important to note that the geotechnical engineers can only 'sign off' on piles which they have inspected.

Prior to pouring concrete, piles will need to be dewatered, cleaned of all loose debris from the base, inspected and approved by the geotechnical engineers. Piles will need to be poured as soon as possible after drilling, but at least on the day of drilling. If piles are left open overnight they must be redrilled prior to pouring concrete to remove any softened or other debris from the base of the pile.

4.5 Basement Slabs

Following bulk excavation at each of the car parking structures, variable subgrade conditions are expected to be encountered. In each case we expect that some siltstone bedrock will be encountered over at least part of the subgrade while either residual silty clays or silty clay fill (southern end of P3 carpark) will be encountered in other areas.

Options for support of basement slabs include;

- Constructing the basement slabs as slabs on grade, or
- Designing the basement slabs as fully suspended slabs where the subgrade comprises residual soils or silty clay fill.

Where weathered siltstone is encountered at subgrade level, no specific subgrade treatment will be required and basement slabs can be supported directly on the weathered siltstone subgrade provided a granular separation layer (such as DGB20 or other approved granular subbase) is provided as recommended for concrete pavements below.

Where the residual silty clays are encountered at subgrade level, and slabs on grade are proposed, we recommend that the subgrade be prepared in accordance with the recommendations outlined in Section 4.3 above. In this case the basement slabs should be separated from the structural footings and columns to allow relative movement (i.e. designed as floating slabs). If suspended basement slabs are to be adopted, slabs will need to be founded on piers supported on the underlying Class 4 siltstone as recommended above. Suspended slabs will need to eb underlain by void formers of at least 100mm thickness to reduce the risk of swelling soils 'jacking' the slabs off the piles.

Fill is expected to be encountered at the southern end of the P3 carpark. While the fill has been assessed as well compacted, we have no details of its placement or compaction, therefore it must be assumed to be uncontrolled. We consider that the options in this area are either to;

1. Design the basement slab as a fully suspended slab,
2. Excavate the fill and replace it with engineered fill, or
3. Carry out additional testing of the fill to confirm that it is suitable to support the basement slab loads. This could include further boreholes or a series and/or a series of DCP tests once the subgrade has been exposed.

If the additional testing confirms that the fill is suitable to support the slab on grade then the subgrade should be prepared in accordance with the requirements of Section 4.3 above. If the testing shows the existing fill is not suitable then either the fill will need to be excavated and replaced with engineered fill or the basement slab designed as a suspended slab on piers. If a suspended slab is adopted void formers will need to be provided below the slab as discussed above.

Drainage will also need to be incorporated into the subbase layer. Drainage will need to be provided below the basement slab either as a grid of subsoil drains or a gravel blanket. The drainage will need to be connected to a permanent fail safe pump out system which is fitted with automatic level control pumps to avoid flooding, or alternatively drainage may be able to be discharged using gravity means.

The extent of basement drainage will depend on the seepage volumes. As a guide the weathered siltstone may have a horizontal permeability in the order of $1x10^{-7}$m/sec, however we recommend that some further assessment of groundwater levels (including some pump out tests) be carried out to provide further assessment of seepage inflows. Assuming seepage volumes are within the acceptable authority limits, the basement will be able to be designed as a permanently drained structure.

4.6 Pavements

Following satisfactory preparation of the subgrade (as detailed in Section 4.3 above), new pavements will need to be designed on the basis of the specific subgrade material. Where pavements are supported on the underlying residual silty clays then they may be able to be designed on the basis of a soaked CBR of 3%.

Flexible pavements should be underlain by a good quality base-course layer comprising crushed rock to RTA QA specification 3051 (2010) unbound base material, or equivalent good quality and durable fine crushed rock compacted to at least 100% of Standard Maximum Dry Density (SMDD).

Concrete pavements should also be underlain by a subbase layer of at least 100mm thickness comprising DGB20 compacted to at least 100% of SMDD. This will reduce the risk of pumping of fines where clayey subgrades are encountered. Concrete pavements should be isolated from the structural columns to allow relative movement.

Consideration could be given to the use of subsoil drains along the high side of pavements. The subsoil drains should extend to a depth of at least 0.3m below the subgrade level and the drains should have adequate falls to reduce ponding in the drains.

4.7 Earthquake Classification

The following parameters can be adopted for earthquake design in accordance with AS1170.4-2007 'Structural Design Actions, Part 4: Earthquake Actions in Australia':

- Hazard factor (Z) = 0.08
- Site Subsoil Class = Class Ce

4.8 Further Geotechnical Input

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

- Further groundwater monitoring to assess groundwater levels,
- Excavation of some test pits to expose the footings of the adjoining structures.
- Vibration Monitoring during use of hydraulic impact hammers.
- Proof rolling of the subgrade during earthworks operations.
- Inspection of the basement bulk excavation conditions to confirm suitable subgrade conditions for support of basement slabs.
- Footing inspections.
- Proof load testing of anchors.

5 GENERAL COMMENTS

The recommendations presented in this report include specific issues to be addressed during the construction phase of the project. As an example, special treatment of soft spots may be required as a result of their discovery during proof-rolling, etc. In the event that any of the construction phase recommendations presented in this report are not implemented, the general recommendations may become inapplicable and JK Geotechnics accept no responsibility whatsoever for the performance of the structure where recommendations are not implemented in full and properly tested, inspected and documented.

The long term successful performance of floor slabs and pavements is dependent on the satisfactory completion of the earthworks. In order to achieve this, the quality assurance program should not be limited to routine compaction density testing only. Other critical factors associated with the earthworks may include subgrade preparation, selection of fill materials, control of moisture content and drainage, etc. The satisfactory control and assessment of these items may require judgment from an experienced engineer. Such judgment often cannot be made by a technician who may not have formal engineering qualifications and experience. In order to identify potential problems, we recommend that a pre-construction meeting be held so that all parties involved understand the earthworks requirements and potential difficulties. This meeting should clearly define the lines of communication and responsibility.

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

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

A waste classification is required for any soil and/or bedrock excavated from the site prior to offsite disposal. Subject to the appropriate testing, material can be classified as Virgin Excavated Natural Material (VENM), Excavated Natural Material (ENM), General Solid, Restricted Solid or Hazardous Waste. Analysis can take up to seven to ten 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) could be expected. We strongly recommend that this requirement 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, ATTERBERG LIMIT AND LINEAR SHRINKAGE TEST REPORT

Client:	JK Geotechnics	**Ref No:**	31772L2
Project:	Proposed Carparks P3A, P4A, P1A & Through Link	**Report:**	A
Location:	Loreto Normanhurst School, Normanhurst, NSW	**Report Date:**	11/12/2020
		Page 1 of 1	

AS 1289	TEST METHOD	2.1.1	3.1.2	3.2.1	3.3.1	3.4.1
BOREHOLE NUMBER	**DEPTH m**	**MOISTURE CONTENT %**	**LIQUID LIMIT %**	**PLASTIC LIMIT %**	**PLASTICITY INDEX %**	**LINEAR SHRINKAGE %**
201	2.60 - 2.80	10.2	-	-	-	-
202	0.50 - 0.75	9.8	28	18	10	4.0
202	2.00 - 2.50	5.8	-	-	-	-
203	1.50 - 1.95	23.2	46	23	23	8.5
203	5.30 - 5.60	17.1	-	-	-	-
204	2.00 - 2.20	7.9	-	-	-	-
207	1.50 - 1.95	7.8	-	-	-	-
208	2.50 - 2.80	9.2	-	-	-	-
209	0.50 - 0.95	24.1	49	20	29	10.5
209	3.50 - 4.20	11.1	-	-	-	-
210	0.50 - 0.95	29.9	73	25	48	15.0
210	3.50 - 4.50	10.0	-	-	-	-
211	3.00 - 4.00	10.8	-	-	-	-
212	5.00 - 5.50	9.8	-	-	-	-

Notes:
- The test sample for liquid and plastic limit was air-dried & dry-sieved
- The linear shrinkage mould was 125mm
- Refer to appropriate notes for soil descriptions
- Date of receipt of sample: 04/12/2020.
- Sampled and supplied by client. Samples tested as received.

NATA

NATA Accredited Laboratory Number:1327

Accredited for compliance with ISO/IEC 17025 - Testing.
This document shall not be reproduced except
In full without approval of the laboratory. Results relate only to
the items tested or sampled.

11/12/2020
Authorised Signature / Date
(D. Treweek)

115 Wicks Road
Macquarie Park, NSW 2113
Telephone: 02 9888 5000
Facsimile: 02 9888 5001

SOIL TEST SERVICES

TABLE B
FOUR DAY SOAKED CALIFORNIA BEARING RATIO TEST REPORT

Client: JK Geotechnics
Project: Proposed Carparks P3A, P4A, P1A & Through Link
Location: Loreto Normanhurst School, Normanhurst, NSW

Ref No: 31772L2
Report: B
Report Date: 9/12/2020

BOREHOLE NUMBER		BH 201	BH 205	BH 207	BH 212
DEPTH (m)		0.40 - 1.40	1.30 - 2.00	0.40 - 1.20	0.40 - 1.20
Surcharge (kg)		4.5	4.5	4.5	4.5
Maximum Dry Density (t/m^3)		1.65 STD	1.53 STD	1.80 STD	1.55 STD
Optimum Moisture Content (%)		21.4	26.5	14.9	25.4
Moulded Dry Density (t/m^3)		1.62	1.49	1.76	1.51
Sample Density Ratio (%)		98	98	98	98
Sample Moisture Ratio (%)		96	98	101	98
Moisture Contents					
Insitu (%)		19.8	32.0	11.5	27.0
Moulded (%)		20.6	26.0	15.0	24.9
After soaking and After Test, Top 30mm(%)		24.0	33.2	21.5	29.8
	Remaining Depth (%)	21.9	29.1	19.7	25.7
Material Retained on 19mm Sieve (%)		0	0	0	0
Swell (%)		1.0	3.0	1.5	2.0
C.B.R. value:	@2.5mm penetration	9			3.0
	@5.0mm penetration		3.0	6	

NOTES: Sampled and supplied by client. Samples tested as received.
- Refer to appropriate Borehole logs for soil descriptions
- Test Methods : AS 1289 6.1.1, 5.1.1 & 2.1.1.
- Date of receipt of sample: 04/12/2020.

NATA

NATA Accredited Laboratory Number:1327

Accredited for compliance with ISO/IEC 17025 - Testing.
This document shall not be reproduced except in full without approval of the laboratory. Results relate only to the items tested or sampled.

09/12/2020
Authorised Signature / Date
(D. Treweek)

TABLE C
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	LORETO NORMANHURST	**Ref No:**	31772L2
Project:	PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK	**Report:**	C
Location:	LORETO NORMANHURST SCHOOL, NORMANHURST, NSW	**Report Date:**	9/11/20

BOREHOLE NUMBER	DEPTH (m)	$I_{S\,(50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
201	4.32 - 4.34	0.6	12	A
	4.82 - 4.85	0.1	2	A
	5.34 - 5.36	0.1	2	A
	5.88 - 5.90	0.7	14	A
	6.32 - 6.34	0.7	14	A
	6.68 - 6.70	0.4	8	A
	7.15 - 7.18	0.7	14	A
	7.77 - 7.79	0.8	16	A
	8.22 - 8.25	0.6	12	A
	8.80 - 8.82	1.2	24	A
	9.11 - 9.13	0.9	18	A
	9.49 - 9.52	1.5	30	A
202	3.81 - 3.84	0.2	4	A
	4.11 - 4.15	0.7	14	A
	4.78 - 4.80	0.2	4	A
	5.37 - 5.39	0.3	6	A
	5.93 - 5.96	0.5	10	A
	6.08 - 6.10	0.7	14	A
	6.75 - 6.77	0.6	12	A
	7.05 - 7.07	0.1	2	A
	7.93 - 7.95	0.3	6	A
	8.12 - 8.15	3	60	A
	8.42 - 8.45	0.4	8	A
203	6.49 - 6.53	0.2	4	A
	7.66 - 7.68	0.4	8	A

NOTE: SEE PAGE 4

TABLE C
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	LORETO NORMANHURST	**Ref No:**	31772L2
Project:	PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK	**Report:**	C
Location:	LORETO NORMANHURST SCHOOL, NORMANHURST, NSW	**Report Date:**	9/11/20

BOREHOLE NUMBER	DEPTH (m)	$I_{S(50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
203	8.17 - 8.20	0.2	4	A
	9.70 - 9.73	0.3	6	A
	10.20 - 10.23	0.8	16	A
204	3.26 - 3.28	0.03	1	A
	4.26 - 4.28	0.1	2	A
	4.67 - 4.69	0.2	4	A
	5.12 - 5.14	0.3	6	A
	5.55 - 5.58	0.3	6	A
	6.43 - 6.45	0.4	8	A
	6.85 - 6.88	0.1	2	A
	7.11 - 7.14	0.5	10	A
	7.63 - 7.65	0.6	12	A
	8.12 - 8.15	0.6	12	A
	8.68 - 8.70	0.3	6	A
	9.20 - 9.22	0.4	8	A
	9.83 - 9.85	0.6	12	A
	10.08 - 10.11	1.2	24	A
206	5.85 - 5.88	0.2	4	A
	6.05 - 6.08	0.3	6	A
	6.56 - 6.58	0.08	2	A
	6.91 - 6.94	0.08	2	A
	7.31 - 7.33	0.05	1	A
	7.86 - 7.89	0.08	2	A
	8.06 - 8.09	0.09	2	A
	8.51 - 8.53	0.2	4	A

NOTE: SEE PAGE 4

TABLE C
POINT LOAD STRENGTH INDEX TEST REPORT

Client: LORETO NORMANHURST | **Ref No:** 31772L2

Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK | **Report:** C

Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW | **Report Date:** 9/11/20

BOREHOLE NUMBER	DEPTH (m)	$I_{S(50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
206	8.97 - 8.99	0.1	2	A
207	2.89 - 2.92	0.1	2	A
	3.70 - 3.73	0.06	1	A
	6.31 - 6.33	0.2	4	A
	6.40 - 6.43	0.2	4	A
	6.95 - 6.97	0.2	4	A
	7.16 - 7.17	0.1	2	A
	7.42 - 7.45	0.3	6	A
	7.97 - 7.99	0.3	6	A
	8.17 - 8.20	0.5	10	A
	8.72 - 8.74	0.3	6	A
	9.21 - 9.23	0.4	8	A
208	5.88 - 5.90	0.2	4	A
	7.00 - 7.02	0.5	10	A
	8.02 - 8.04	0.4	8	A
	8.83 - 8.86	0.3	6	A
	9.08 - 9.12	0.4	8	A
209	6.20 - 6.23	0.5	10	A
	6.78 - 6.81	0.2	4	A
	7.18 - 7.20	0.6	12	A
	7.87 - 7.89	0.6	12	A
	8.05 - 8.07	1	20	A
	8.76 - 8.79	0.8	16	A
210	6.06 - 6.08	0.1	2	A
	6.63 - 6.66	0.03	1	A

NOTE: SEE PAGE 4

TABLE C
POINT LOAD STRENGTH INDEX TEST REPORT

Client:	LORETO NORMANHURST	**Ref No:**	31772L2
Project:	PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK	**Report:**	C
Location:	LORETO NORMANHURST SCHOOL, NORMANHURST, NSW	**Report Date:**	9/11/20
		Page 4 of 4	

BOREHOLE NUMBER	DEPTH (m)	$I_{S(50)}$ (MPa)	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)	TEST DIRECTION
210	8.21 - 8.24	0.1	2	A
	8.76 - 8.79	0.2	4	A
211	7.17 - 7.18	0.2	4	A
	7.79 - 7.82	0.4	8	A
	8.23 - 8.26	0.6	12	A
	8.74 - 8.76	0.9	18	A
	9.11 - 9.14	0.8	16	A
212	6.27 - 6.29	0.4	8	A
	6.87 - 6.90	0.4	8	A
	7.31 - 7.33	0.2	4	A
	7.74 - 7.76	0.4	8	A
	8.14 - 8.16	0.3	6	A
	8.94 - 8.96	0.6	12	A

NOTES

1. In the above table, testing was completed in test direction A for the axial direction, D for the diametral direction, B for the block test and L for the lump test.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RMS T223.
4. For reporting purposes, the IS(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 based on the correlation provided in AS1726:2017 'Geotechnical Site Investigations' and rounded off to the nearest whole number: U.C.S. = 20 IS(50).

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 255667

Client Details

Client	JK Geotechnics
Attention	Joanne Lagan
Address	PO Box 976, North Ryde BC, NSW, 1670

Sample Details

Your Reference	**Proposed Carparks P3A, P4A and P1A**
Number of Samples	6 Soil
Date samples received	13/11/2020
Date completed instructions received	13/11/2020

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.

Report Details

Date results requested by	20/11/2020
Date of Issue	17/12/2020
Reissue Details	This report replaces R00 created on 20/11/2020 due to: Project ID Amended (Client Request)

NATA Accreditation Number 2901. This document shall not be reproduced except in full.

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

Results Approved By
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Misc Inorg - Soil						
Our Reference		255667-1	255667-2	255667-3	255667-4	255667-5
Your Reference	UNITS	201	204	206	208	211
Depth		0.5-0.95	0.5-0.95	0.5-0.95	3.5-4.2	2.1-2.5
Date Sampled		09/11/2020	09/11/2020	09/11/2020	09/11/2020	09/11/2020
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	16/11/2020	16/11/2020	16/11/2020	16/11/2020	16/11/2020
Date analysed	-	16/11/2020	16/11/2020	16/11/2020	16/11/2020	16/11/2020
pH 1:5 soil:water	pH Units	4.8	4.5	4.9	5.4	4.5
Chloride, Cl 1:5 soil:water	mg/kg	24	87	47	10	460
Sulphate, SO4 1:5 soil:water	mg/kg	49	120	160	86	160
Resistivity in soil*	ohm m	84	66	78	160	25

Misc Inorg - Soil		
Our Reference		255667-6
Your Reference	UNITS	212
Depth		1.5-1.95
Date Sampled		09/11/2020
Type of sample		Soil
Date prepared	-	16/11/2020
Date analysed	-	16/11/2020
pH 1:5 soil:water	pH Units	4.5
Chloride, Cl 1:5 soil:water	mg/kg	240
Sulphate, SO4 1:5 soil:water	mg/kg	140
Resistivity in soil*	ohm m	38

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-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 (non NATA). Resistivity (calculated) may not correlate with results otherwise obtained using Resistivity-Current method, depending on the nature of the soil being analysed.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.

QUALITY CONTROL: Misc Inorg - Soil					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	[NT]
Date prepared	-			16/11/2020	[NT]	[NT]	[NT]	[NT]	16/11/2020	[NT]
Date analysed	-			16/11/2020	[NT]	[NT]	[NT]	[NT]	16/11/2020	[NT]
pH 1:5 soil:water	pH Units		Inorg-001	[NT]	[NT]	[NT]	[NT]	[NT]	102	[NT]
Chloride, Cl 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	92	[NT]
Sulphate, SO4 1:5 soil:water	mg/kg	10	Inorg-081	<10	[NT]	[NT]	[NT]	[NT]	94	[NT]
Resistivity in soil*	ohm m	1	Inorg-002	<1	[NT]	[NT]	[NT]	[NT]	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

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.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

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: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-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.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

JKGeotechnics

BOREHOLE LOG

Borehole No.
201

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~179.6 m
Date: 4/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.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		-	ASPHALTIC CONCRETE: 35mm.t	D			APPEARS WELL COMPACTED
							FILL: Silty sand, fine grained, light brown, with fine to coarse grained igneous, ironstone gravel, trace of wood fragments and clay fines.				
		N = 11 5,5,6	179				FILL: Silty clay, medium to high plasticity, brown and grey, trace of fine to coarse grained ironstone and siltstone gravel.	w~PL		590 >600 >600	
				1							
		N = 13 5,5,8	178			CH	Silty CLAY: high plasticity, red brown and grey brown, trace of fine grained ironstone gravel.	w>PL	VSt - Hd	390 450 580	RESIDUAL
				2							
			177			-	SILTSTONE: grey and brown, with occasional ironstone bands.	DW	VL - L		ASHFIELD SHALE VERY LOW TO LOW 'TC' BIT RESISTANCE WITH MODERATE BANDS
				3					L		
			176								
				4							
			175				REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 9.57m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.97m TO 9.57m. CASING 3.97m TO 0.08m. 2mm SAND FILTER PACK 3.2m TO 9.57m. BENTONITE SEAL 0.15m TO 3.2m. COMPLETED WITH A CONCRETED GATIC COVER.
				5							
			174								
				6							
			173								

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
201
2 / 2

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2	**Core Size:** NMLC	**R.L. Surface:** ~179.6 m
Date: 4/11/20	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK305	**Bearing:** N/A	**Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DETAILS: SPACING (mm) 600 200 60 20	DEFECT DETAILS: DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) Specific	General	Formation
					START CORING AT 4.29m							
90% RETURN		175 174 173 172 171 170	5 6 7 8 9		SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-15°.	HW MW SW	VL - L M M - H	0.60 0.10 0.10 0.70 0.70 0.40 0.70 0.80 0.60 1.2 0.90 1.5		(4.38m) CS, 5°, 35 mm.t (4.47m) CS, 5°, 20 mm.t (4.59m) XWS, 5°, 15 mm.t (4.63m) XWS, 5°, 20 mm.t (4.76m) XWS, 0°, 55 mm.t (4.86m) CS, 5°, 40 mm.t (4.90m) J, 80°, P, R, Fe Sn (4.96m) CS, 5°, 20 mm.t (5.05m) XWS, 0°, 10 mm.t (5.18m) Be, 0°, P, R, Fe Sn (5.60m) XWS, 0 - 30°, 20 mm.t (5.63m) J, 30°, P, R, Fe Sn (5.87m) CS, 5°, 10 mm.t (6.42m) XWS, 0°, 20 mm.t (6.62m) XWS, 0°, 60 mm.t (6.89m) XWS, 0°, 40 mm.t (7.00m) XWS, 0°, 40 mm.t (7.12m) Cr, 5°, 35 mm.t (7.30m) J, 60°, Ir, R, Fe Sn (7.47m) Be, 5°, P, R, Fe Sn (7.51m) Be, 5°, P, R, Fe Sn (7.57m) XWS, 5°, 15 mm.t (7.65m) XWS, 5°, 10 mm.t (7.84m) Be, 5°, P, R, Fe Sn (7.92m) Be, 10°, P, R, Fe Sn (8.02m) XWS, 5°, 30 mm.t (8.06m) XWS, 10°, 15 mm.t (8.10m) Be, 10°, P, R, Fe Sn (8.28m) XWS, 5°, 10 mm.t (8.87m) XWS, 5°, 15 mm.t (9.04m) CS, 60°, 2 mm.t (9.19m) Be, 0°, P, R, Fe Sn (9.26m) XWS, 5°, 10 mm.t		Ashfield Shale
		169	10		END OF BOREHOLE AT 9.62 m							

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 31772L2
Borehole No: BH201
Depth: 4.29 - 9.62m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH201 START CORING AT 4.29m
4
5
6
7
8
9
END OF BH201 AT 9.62m

JKGeotechnics

BOREHOLE LOG

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~181.3 m
Date: 3/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.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			181				FILL: Silty clay, low plasticity, dark brown, trace of earthenware and wood fragments, roots and root fibres.	w<PL			MULCH AND LEAF COVER
		N > 15 8,15/ 100mm REFUSAL				-	Extremely Weathered siltstone: silty CLAY, medium plasticity, grey and brown.	XW	Hd		ASHFIELD SHALE TOO FRIABLE FOR HP TESTING
			180	1			SILTSTONE: grey and brown.	DW	VL - L		VERY LOW TO LOW 'TC' BIT RESISTANCE
			179	2							
			178	3			REFER TO CORED BOREHOLE LOG				
			177	4							
			176	5							
			175	6							

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
202

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Core Size:** NMLC **R.L. Surface:** ~181.3 m
Date: 3/11/20 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK305 **Bearing:** N/A **Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	SPACING (mm) (600, 200, 60, 20)	Formation
		179			START CORING AT 2.84m					
90% RETURN		178	3		NO CORE 0.86m					
		177	4		SILTSTONE: grey, with light brown and orange brown laminae, bedded at 0-20°.	HW	L - M	0.20, 0.70, 0.20		Ashfield Shale
		176, 175, 174	5, 6, 7			SW	M	0.30, 0.50, 0.70, 0.60, 0.10	600, 200, 60, 20	
		173	8		SILTSTONE: grey and brown.			0.30, 3.0, 0.40		
					END OF BOREHOLE AT 8.65 m				600, 200, 60, 20	

DEFECT DETAILS

DESCRIPTION
Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness

Specific General

- (3.75m) Fragmented, 0 - 5°, 40 mm.t
- (3.81m) Jh, 30°, C, Fe Sn
- (3.85m) Be, 20°, P, R, Fe Sn
- (3.88m) Fragmented, 0 - 10°, 25 mm.t
- (3.96m) J, 30°, P, R, Fe Sn
- (4.00m) Fragmented, 0 - 10°, 120 mm.t
- (4.20m) Fragmented, 0 - 20°, 130 mm.t
- (4.28m) J, 40°, C, R, Fe Sn
- (4.35m) Be, 10°, P, R, Fe Sn
- (4.37m) Be x 2, 20°, P, R, Fe Sn
- (4.42-4.71m) Fragmented, 0 - 20°
- (4.72m) Bex 2, 10°, P, R, Fe Sn
- (4.87m) Fragmented, 0 - 5°, 50 mm.t, and J, 40°, P, Fe, Sn
- (5.00m) Cr, 0 - 10°, 50 mm.t
- (5.16m) CS, 5°, 100 mm.t
- (5.24m) Cr, 0 - 60°, 50 mm.t, and J, 60°, J, R, Fe, Sn
- (5.40m) J, 80 - 90°, P, R, Fe Sn
- (5.53m) J, 35 - 90°, P, R, Fe Sn
- (5.62m) J, 75°, P, R, Fe Sn
- (5.67m) Be, 10°, P, R, Fe Sn
- (5.69m) CS, 5°, 5 mm.t
- (5.74m) XWS, 10°, 15 mm.t
- (5.79m) XWS, 75°, 5 mm.t
- (5.82m) XWS, 15°, 10 mm.t
- (5.90m) XWS, 10°, 6 mm.t
- (5.92m) Be, 5°, P, R, Fe Sn
- (5.97m) Cr, 5°, 15 mm.t
- (6.01m) Be x 2, 10°, P, R, Fe Sn
- (6.11m) XWS, 10°, 5 mm.t
- (6.15m) Be, 5°, P, R, Fe Sn
- (6.20m) Be, 10°, P, R, Fe Sn
- (6.26m) Cr, 0 - 5°, 30 mm.t
- (6.30m) Be, 20°, C, R, Fe Sn
- (6.39m) Cr, 10°, 30 mm.t
- (6.53m) J, 30°, P, R, Fe Sn
- (6.55m) XWS, 10°, 15 mm.t
- (6.76m) XWS, 5°, 20 mm.t
- (6.79m) XWS, 10°, 3 mm.t
- (6.83m) XWS, 10°, 5 mm.t
- (6.89m) XWS, 20°, 5 mm.t
- (6.93m) XWS, 20°, 25 mm.t
- (6.97m) Cr, 10°, 15 mm.t
- (7.03m) Be, 20°, P, R, Fe Sn
- (7.06-7.52m) Fragmented, 6 - 10°
- (7.32m) J, 80°, P, R, Fe Sn
- (7.67m) Be, 10°, P, R, Fe Sn
- (7.73m) J, 30°, P, R, Fe Sn
- (7.89m) Cr, 0 - 5°, 50 mm.t
- (8.10m) Be, 10°, P, R, Fe Sn
- (8.42m) Be, 5°, P, R, Fe Sn
- (8.55m) Be, 5°, P, R, Fe Sn

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 31772L2
Borehole No: BH202
Depth: 2.84m - 8.65m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH202 START CORING AT 2.84m
3
NO CORE 0.86m
4
5
6
7
8
END OF BH202 AT 8.65m

JKGeotechnics

BOREHOLE LOG

Borehole No. **203**

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~179.5 m
Date: 3/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.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		FILL: Silty clay, low plasticity, dark brown and orange brown, trace of fine to coarse grained igneous and ironstone gravel, fine to medium grained sand, roots and root fibres.	w<PL			GRASS COVER
	N = 9 7,5,4			FILL: Silty clay, medium to high plasticity, light grey, orange brown and red brown, trace of fine to medium grained igneous, ironstone and siltstone gravel.	w~PL		370 400 230	APPEARS WELL COMPACTED
	N = 9 3,5,4						340 320 330	
				FILL: Silty clay, high plasticity, grey brown, trace of fine to medium grained ironstone and ash.	w>PL		170 170 160	HP READING ON REMOULDED SAMPLE
	N = 11 4,5,6		CH	Silty CLAY: high plasticity, light grey mottled red brown.	w>PL	St	160 180 190	RESIDUAL
			-	SILTSTONE: brown and grey.	DW	VL - L		ASHFIELD SHALE VERY LOW 'TC' BIT RESISTANCE
						L - M		LOW TO MODERATE RESISTANCE
				REFER TO CORED BOREHOLE LOG				

Depth (m) scale: 1, 2, 3, 4, 5, 6. RL (m AHD) scale: 179, 178, 177, 176, 175, 174, 173.

SAMPLES: ES, U50, DB, DS. Graphic Log.

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
203

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2	**Core Size:** NMLC	**R.L. Surface:** ~179.5 m
Date: 3/11/20	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK305	**Bearing:** N/A	**Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	DEFECT DETAILS: SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS: DESCRIPTION – Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness (Specific / General)	Formation
		174			START CORING AT 5.78m						
			6		NO CORE 0.57m						
90% RETURN		173			SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-20°.	MW	L - M	0.20		(6.40m) Cr, 0 - 5°, 50 mm.t (6.47m) Be, 0°, P, R, Fe Sn (6.54m) Cr, 0°, 40 mm.t (6.69m) CS, 5°, 15 mm.t (6.75m) Cr, 10°, 20 mm.t (6.84-6.93m) Be x 7, 0 - 10°, P, R, Fe Sn (6.95m) CS, 5°, 45 mm.t	Ashfield Shale
			7							(7.06m) Cr, 0 - 5°, 100 mm.t (7.12-7.30m) Be x 6, 0 - 5°, P, R, Fe Sn (7.33m) XWS, 0°, 20 mm.t (7.45m) Cr, 0 - 5°, 120 mm.t	
		172						0.40		(7.75m) Cr, 0 - 5°, 85 mm.t (7.84m) CS, 5°, 8 mm.t (7.96m) Cr, 0 - 5°, 190 mm.t	
			8					0.20	60 20	(8.10m) XWS, 0 - 5°, 60 mm.t (8.36m) J, 90°, P, R, Fe Sn (8.48m) Cr, 0°, 150 mm.t	
		171								(8.66m) XWS, 0°, 10 mm.t (8.77m) Cr, 0 - 5°, 110 mm.t (8.90m) CS, 5°, 60 mm.t	
			9							(9.13m) XWS, 10°, 5 mm.t (9.20m) CS, 0 - 10°, 50 mm.t (9.27m) Cr, 0 - 5°, 50 mm.t (9.33-9.41m) Be x 7, 0 - 10°, P, R, Fe Sn	
		170						0.30		(9.76m) Be, 20°, Ir, R, Fe Sn (9.83m) Be, 0°, P, R, Fe Sn (9.85m) Jh, 90°, P, Fe Sn (9.90m) Jh, 40°, C, Fe Sn (9.91m) Be, 5°, P, R, Fe Sn (9.92m) J, 30°, C, R, Fe Sn	
			10					0.80		(10.07m) J, 40°, P, R, Fe Sn (10.12m) Be, 5°, P, R, Fe Sn	
		169			END OF BOREHOLE AT 10.26 m						
			11								
		168							600 200 60 20		

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 31772L2
Borehole No: BH203
Depth: 5.78m - 10.26m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH203 START CORING AT 5.78m
NO CORE
6
0.57m
7
8
9
10
END OF BH203 AT 10.26m

JKGeotechnics

BOREHOLE LOG

Borehole No. 204

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~181.4 m
Date: 3/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.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							FILL: Silty sand, fine to medium grained brown, trace of fine to coarse grained igneous gravel	M			GRASS COVER
		N = 21 7,8,13	181			CI-CH	Silty CLAY: medium to high plasticity, light grey, red brown and orange brown, trace of fine to medium grained ironstone gravel.	w>PL	Hd	530 >600 >600	RESIDUAL
ON 10/12/20		N = 42 10,18,24	180	1			as above. but with extremely weathered siltstone seams.	w~PL		580 >600 >600	
			179	2			SILTSTONE: grey and brown.	DW	L L - M		ASHFIELD SHALE LOW 'TC' BIT RESISTANCE LOW RESISTANCE WITH MODERATE BANDS
			178 177 176 175	3 4 5 6			REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 10.1m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.1m TO 10.1m. CASING 0.1m TO 3.1m. 2mm SAND FILTER PACK 2.5m TO 10.1m. BENTONITE SEAL 0.4m TO 2.5m. BACKFILLED WITH SAND TO THE SURFACE. COMPLETED WITH A CONCRETED GATIC COVER.

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
204

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2	**Core Size:** NMLC	**R.L. Surface:** ~181.4 m
Date: 3/11/20	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK305	**Bearing:** N/A	**Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT DETAILS: SPACING (mm) 600 200 60 20	Formation
		179			START CORING AT 2.86m					
90% RETURN		178, 177, 176, 175	3, 4, 5, 6		SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-10°.	HW	L	0.030, 0.10, 0.20, 0.30, 0.30		Ashfield Shale
		174, 173	7, 8			MW	M	0.40, 0.10, 0.50, 0.60, 0.60, 0.30		

DEFECT DETAILS – DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) – Specific / General

- (2.88m) Be, 10°, P, R, Fe Sn
- (2.91m) Be, 10°, P, R, Fe Sn
- (3.01m) Cr, 0°, 20
- (3.12m) Be, 0°, P, R, Fe Sn
- (3.19m) XWS, 10°, 6 mm.t
- (3.24m) Be, 5°, P, R, Fe Sn
- (3.35m) XWS, 5°, 10 mm.t
- (3.49m) Cr, 0°, 70 mm.t
- (3.64m) Bex 9, 0 - 5°, P, R, Fe Sn
- (3.57-3.82m) Be, 0°, P, R, Fe Sn
- (3.95m) Be, 5°, P, R, Fe Sn
- (3.97m) XWS, 5°, 10 mm.t
- (4.00m) Be x 4, 0 - 5°, P, R, Fe Sn
- (4.09m) Jh, 30°, P, S Sn
- (4.00-4.24m) J, 30°, P, R, Fe Sn
- (4.17m) Cr, 0°, 30 mm.t
- (4.36m) CS, 0°, 5 mm.t
- (4.40m) Jh, 30°, C, Fe Sn
- (4.46m) Cr, 0°, 25 mm.t
- (4.70m) Jh, 50°, P, Fe Sn
- (4.73m) Jh, 40°, P, C, Fe Sn
- (4.79m) CS, 10°, 5 mm.t
- (4.94m) J, 60°, C, R, Fe Sn
- (5.04m) Be, 0°, P, R, Fe Sn
- (5.32m) Be, 10°, P, R, Fe Sn
- (5.36m) Be, 10°, P, R, Fe Sn
- (5.41m) Be, 0°, P, R, Fe Sn
- (5.60m) J, 30°, C, R, Fe Sn
- (5.61m) Be, 20°, Ir, R, Fe Sn
- (5.66m) Be, 20°, Ir, R, Fe Sn
- (5.73m) Cr, 5°, 60 mm.t
- (5.84m) Be, 5°, P, R, Fe Sn
- (5.86m) J, 30°, P, R, Cn
- (5.91m) CS, 5°, 8 mm.t
- (6.07m) Sheared Zone, 60°, 150 mm.t
- (6.17m) J, 70°, P, R, Fe Sn
- (6.24m) XWS, 10°, 10 mm.t
- (6.31m) Be, 10°, P, R, Fe Sn
- (6.40m) J, 70°, P, R, Fe Sn
- (6.47m) Be, 5°, P, R, Fe Sn
- (6.70m) XWS, 10°, 5 mm.t
- (6.75m) J, 70°, P, R, Fe Sn
- (6.82m) J, 70°, P, R, Fe Sn
- (6.89m) Jh, 60°, P, Fe Sn
- (7.03m) Cr, 20°, 40 mm.t
- (7.13m) J, 30°, P, R, Fe Sn
- (7.22m) XWS, 10°, 8 mm.t
- (7.24m) XWS, 10°, 8 mm.t
- (7.30m) J, 40°, C, R, Cn
- (7.31m) Be, 5°, P, R, Fe Sn
- (7.37m) J x 2, 40°, P, R, Fe Sn
- (7.40m) J, 40°, C, R, Fe Sn
- (7.44m) Be, 10°, P, R, Fe Sn
- (7.47m) Be, 10°, P, R, Fe Sn
- (7.70m) J, 50°, P, R, Clay FILLED, 1 mm.t
- (7.90m) J, 60°, C, R, Fe Sn
- (8.00m) J, 40°, P, R, XWS FILLED, 1 mm.t
- (8.08m) XWS, 5°, 3 mm.t
- (8.19m) CS, 15°, 4 mm.t
- (8.26m) J, 40°, Cn
- (8.30m) Be, 10°, P, R, XWS FILLED, 3 mm.t
- (8.32m) Be, 10°, P, R, XWS FILLED, 2 mm.t
- (8.47m) Be, 5°, P, R, Fe Sn
- (8.67m) Be, 0°, P, R, Fe Sn
- (8.70-8.87m) Be x 6, 0 - 20°, P, R, Fe Sn

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
204

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Core Size:** NMLC **R.L. Surface:** ~181.4 m
Date: 3/11/20 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK305 **Bearing:** N/A **Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	DEFECT SPACING (mm) (600, 200, 60, 20)	DEFECT DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness (Specific / General)	Formation
90% RETURN		172	10		SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-10°. *(continued)*	MW	M	0.40 0.60 1.2		(9.03m) CS, 0 - 20°, 75 mm.t (9.06-9.16m) J x 3, 30°, P, R, Fe Sn (9.28m) J, 40°, P, R, Cn (9.35m) CS, 0°, 20 mm.t (9.38m) CS, 0°, 5 mm.t (9.55m) CS, 0°, 70 mm.t (9.61m) XWS, 0°, 10 mm.t (9.69m) Cr, 0°, 35 mm.t (9.77m) CS, 5°, 10 mm.t (10.03m) Jh x 2, 35°, P, Fe Sn	Ashfield Shale
		171 170 169 168 167 166	11 12 13 14 15		END OF BOREHOLE AT 10.23 m						

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 31772L2
Borehole No: BH204
Depth: 2.86m - 10.23m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH204 START CORING AT 2.86m
3
4
5
6
7
8
9
10
END OF BH204 AT 10.23m

JKGeotechnics

BOREHOLE LOG

Borehole No.
205
1 / 1

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~186.9 m
Date: 2/11/20 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** J.L./L.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			0		FILL: Silty clay, low plasticity, dark brown, trace of fine to medium grained igneous and ironstone gravel, trace of roots and root fibres.	w~PL			GRASS COVER
	N = 2 1,1,1	186	1		FILL: Silty clay, medium plasticity, dark brown and orange brown, trace of fine to medium grained igneous and ironstone gravel, ash and earthernware fragments.			190 190 200	APPEARS POORLY COMPACTED
	N = 13 3,6,7	185		CH	Silty CLAY: high plasticity, light grey mottled red brown and orange brown, trace of fine to medium grained ironstone gravel.	w>PL	VSt - Hd	260 550 >600	RESIDUAL
		184	2	-	Extremely Weathered siltstone: silty CLAY, medium plasticity, light grey, with occasional ironstone bands.	XW	Hd		ASHFIELD SHALE VERY LOW 'TC' BIT RESISTANCE
			3		END OF BOREHOLE AT 3.00 m				
		183	4						
		182	5						
		181	6						
		180							

Samples: ES, U50, DB, DS

JKGeotechnics

BOREHOLE LOG

Borehole No.
206

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~192.3 m
Date: 6/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.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 – 0.15		ASPHALTIC CONCRETE and ROADBASE: 150mm.t				
	N = 10 4,5,5	0.15 – 1.5	CI-CH	Silty CLAY: medium to high plasticity, orange brown and light grey, trace of fine to medium grained ironstone gravel.	w>PL	VSt	300 300 270	RESIDUAL
	N = 23 7,10,13	1.5 – 2.2	CI	as above, but medium plasticity, with occasional extremely weathered siltstone seams.	w~PL	Hd	>600 >600 >600	
		2.2 – 4.4	-	SILTSTONE: grey and brown, with occasional ironstone and clay bands.	DW	VL		ASHFIELD SHALE VERY LOW 'TC' BIT RESISTANCE
		4.4 – 5.85				VL - L		VERY LOW STRENGTH WITH LOW STRENGTH BANDS
		5.85		REFER TO CORED BOREHOLE LOG				

RL (m AHD): 192, 191, 190, 189, 188, 187, 186
Depth (m): 1, 2, 3, 4, 5, 6

SAMPLES: ES, U50, DB, DS

JKGeotechnics

CORED BOREHOLE LOG

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2	**Core Size:** NMLC	**R.L. Surface:** ~192.3 m
Date: 6/11/20	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK305	**Bearing:** N/A	**Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	DEFECT DETAILS: SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS: DESCRIPTION — Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness (Specific / General)	Formation
		187			START CORING AT 5.85m						
90% RETURN		186, 185, 184	6, 7, 8, 9		SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-10°.	HW	VL - L	0.20, 0.30, 0.080, 0.080, 0.050, 0.080, 0.090, 0.20, 0.10		(5.95m) Cr, 0 - 50°, Cn (6.12m) Be, 0°, Cn (6.26m) Be, 0°, Cn (6.27m) XWS, 0°, Cn (6.36m) XWS, 0°, Cn (6.47m) XWS, 0°, Cn (6.54m) XWS, 0°, Cn (6.61m) XWS, 0°, Cn (6.67m) XWS, 0°, Cn (6.91m) Be, 0 - 5°, Cn (7.17m) XWS, 0°, Cn (7.25m) XWS, 0°, Cn (7.38m) XWS, 0°, Cn (7.45m) Cr, 0°, Cn (7.53m) Cr, 0°, Cn (7.57m) J, 40°, Cn (7.61m) J, 40°, Cn (7.74m) Cr, 0 - 10°, Cn (7.95m) J, 80°, Cn (8.14m) XWS, 5°, Cn (8.20m) Be x 2, 10°, Cn (8.26m) XWS, 5°, Cn (8.32m) CS, 5°, Cn (8.38m) XWS, 5°, Cn (8.45m) CS, 5°, Cn (8.48m) CS, 5°, Cn (8.49m) XWS, 5°, Cn (8.55m) Be, 5°, Cn (8.68m) Be, 0°, Cn	Ashfield Shale
		183, 182, 181	10, 11		END OF BOREHOLE AT 9.07 m						

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 31772L2
Borehole No: BH206
Depth: 5.85m – 9.07m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH206 START CORING AT 5.85m
6
7
8
9
END OF BH206 AT 9.07m

JKGeotechnics

BOREHOLE LOG

Borehole No.
207

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~193.3 m
Date: 6/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.S.

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel Density	Hand Penetrometer Readings (kPa)	Remarks
		0–0.15		ASPHALTIC CONCRETE: 150mm.t				
	N = 31 6,12,19	0.15–1.2	CI-CH	Silty CLAY: medium to high plasticity, light grey and orange brown, with ironstone bands.	w~PL	Hd	>600 >600 >600	RESIDUAL
		1.2–2.8	-	SILTSTONE: grey and orange brown, with occasional clay bands.	DW	VL - L		ASHFIELD SHALE VERY LOW TO LOW 'TC' BIT RESISTANCE
		2.8–		REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 9.01m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 3.01m TO 9.01m. CASING 0.09m TO 3.01m. 2mm SAND FILTER PACK 1.9m TO 9.01m. BENTONITE SEAL 0.6m TO 1.9m. BACKFILLED WITH SAND TO THE SURFACE. COMPLETED WITH A CONCRETED GATIC COVER.

RL (m AHD) scale: 193, 192, 191, 190, 189, 188, 187. Depth (m) scale: 1, 2, 3, 4, 5, 6.

CORED BOREHOLE LOG

Borehole No.
207

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 | **Core Size:** NMLC | **R.L. Surface:** ~193.3 m
Date: 6/11/20 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK305 | **Bearing:** N/A | **Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	DEFECT DETAILS – SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS – DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness (Specific / General)	Formation
		191			START CORING AT 2.78m						
90% RETURN		190, 189	3, 4		SILTSTONE: grey and orange brown laminae, bedded at 0-20°.	HW	VL	0.10, 0.060		(2.82m) Cr, 0°, 55 mm.t (2.86m) CS, 0°, 20 mm.t (2.89m) Be, 5°, P, R, Fe Sn (2.97m) CS, 0 - 5°, 120 mm.t (3.12m) CS, 0 - 20°, 45 mm.t (3.23m) CS, 0°, 10 mm.t (3.27m) CS, 0 - 10°, 45 mm.t (3.33m) CS, 0°, 15 mm.t (3.36m) CS, 20°, 10 mm.t (3.43m) Be, 20°, P, R, Fe Sn (3.49m) XWS, 20°, 20 mm.t (3.53m) CS, 20°, 15 mm.t (3.59m) Be, 10°, P, R, Fe Sn (3.65m) CS, 0 - 10°, 25 mm.t (3.73m) CS, 10°, 5 mm.t (3.80m) Jh, 60 - 80°, C, Fe Sn (3.87m) CS, 10°, 10 mm.t (3.97m) CS, 10°, 35 mm.t (4.05m) CS, 0°, 40 mm.t (4.11m) CS, 20°, 5 mm.t (4.17-4.56m) XWS, 0 - 10° (4.59m) Cr, 0 - 10°, 55 mm.t	Ashfield Shale
		188	5		Silty CLAY: medium to high plasticity, grey and brown, with iron indurated seams.	RS	Hd			(4.78m) HP: 400, 480, >600 kPa (4.79m) Cr, 0 - 5°, 60 mm.t	
ON 10/12/20		187, 186, 185	6, 7, 8		SILTSTONE: grey and orange brown laminae.	HW / MW	L / L - M	0.20, 0.20, 0.20, 0.10, 0.30, 0.30, 0.50, 0.30		(5.44m) Cr, 0°, 40 mm.t (5.60-6.20m) Fragmented, 0 - 20° (6.56m) Be, 5°, P, R, Fe Sn (6.66m) Be, 0°, P, R, Fe Sn (6.71m) XWS, 0°, 6 mm.t (6.81m) XWS, 5°, 8 mm.t (7.10m) Cr, 0°, Cn, 35 mm.t (7.20m) XWS, 0°, 8 mm.t (7.27m) Cr, 0°, 60 mm.t (7.40m) Jh, 80 - 90°, C, Fe Sn (7.62m) XWS, 5°, 15 mm.t (7.77m) XWS, 5°, 15 mm.t (7.90m) XWS, 5°, 25 mm.t (8.00m) XWS, 0°, 20 mm.t (8.21m) Be, 0°, P, R, Fe Sn (8.26m) Be, 0°, P, R, Fe Sn (8.37m) XWS, 0°, 130 mm.t (8.47m) XWS, 0°, 10 mm.t (8.51m) XWS, 0°, 10 mm.t (8.74m) XWS, 0°, 10 mm.t (8.83m) Cr, 0°, 20 mm.t (8.93m) Cr, 0°, 30 mm.t	Ashfield Shale

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

JKGeotechnics

CORED BOREHOLE LOG

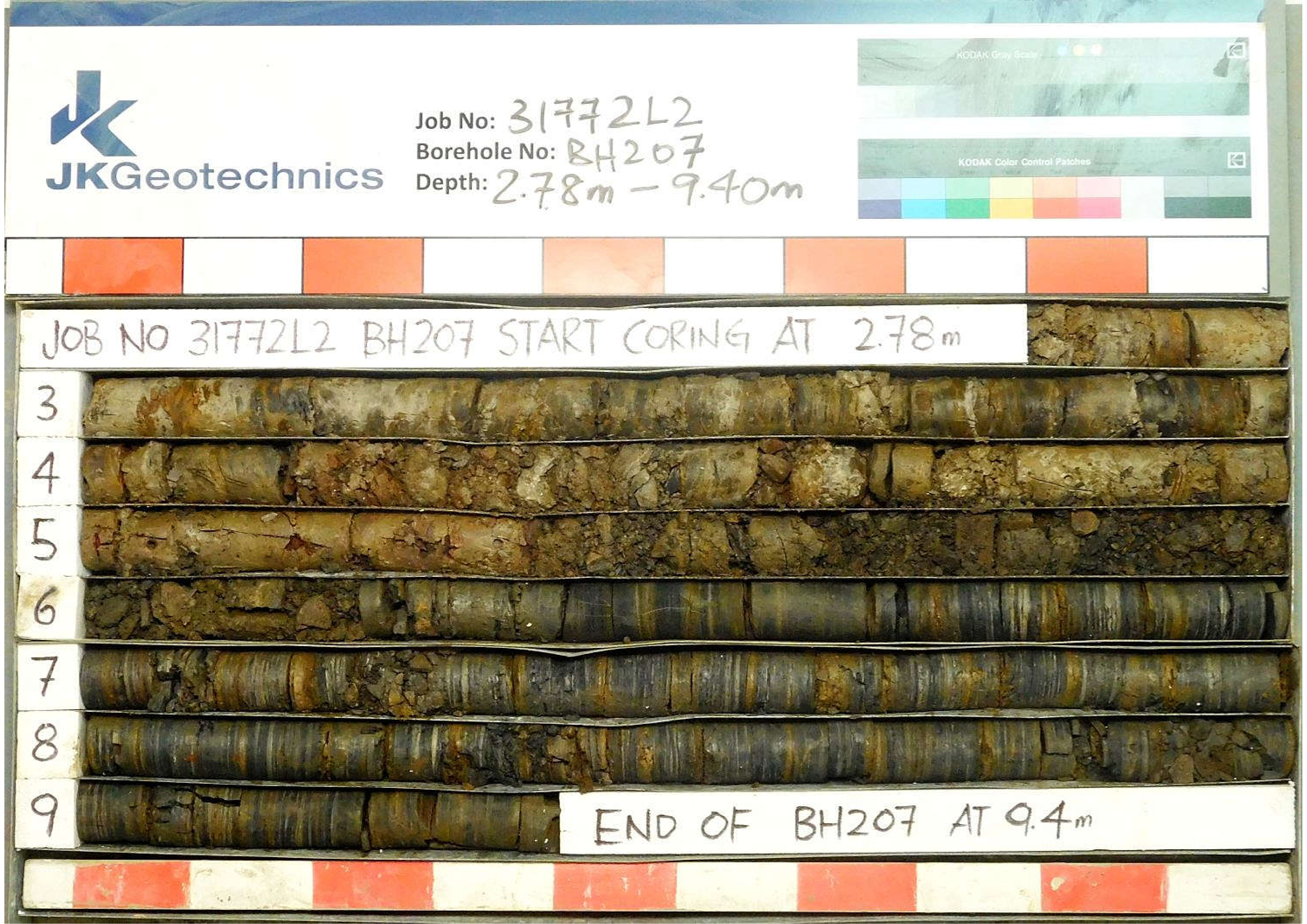
Borehole No.
207

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Core Size:** NMLC **R.L. Surface:** ~193.3 m
Date: 6/11/20 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK305 **Bearing:** N/A **Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	DEFECT SPACING (mm) (600, 200, 60, 20)	DEFECT DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness — Specific / General	Formation
		184			SILTSTONE: grey and orange brown laminae. *(continued)*	MW	L - M	0.40		(8.97m) J, 35°, Ir, R, Fe Sn (9.05m) XWS, 5°, 12 mm.t (9.30m) J, 70°, P, t, Fe Sn	
		183	10		END OF BOREHOLE AT 9.40 m						
		182	11								
		181	12								
		180	13								
		179	14								
		178	15								

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 31772L2
Borehole No: BH207
Depth: 2.78m – 9.40m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH207 START CORING AT 2.78m
3
4
5
6
7
8
9
END OF BH207 AT 9.4m

JKGeotechnics

BOREHOLE LOG

Borehole No.
208

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~193.6 m
Date: 5/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.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		FILL: Silty clay, low plasticity, dark brown, trace of fine to medium grained ironstone and igneous gravel, roots and root fibres.	w<PL			GRASS COVER
	N = 8 3,4,4	193		CH	Silty CLAY: high plasticity, light grey and orange brown, trace of fine to medium grained ironstone gravel.	w>PL	VSt	340 330 300	RESIDUAL
	N = 24 8,9,15	192	1				Hd	490 520 >600	
			2		as above, but with occasional ironstone bands.				
		191		-	SILTSTONE: grey and brown, with occasional ironstone bands.	DW	VL - L		ASHFIELD SHALE VERY LOW TO LOW 'TC' BIT RESISTANCE
		190	3, 4						
		189			REFER TO CORED BOREHOLE LOG				
		188, 187	5, 6						

JKGeotechnics

CORED BOREHOLE LOG

Borehole No. 208

2 / 2

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 | **Core Size:** NMLC | **R.L. Surface:** ~193.6 m
Date: 5/11/20 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK305 | **Bearing:** N/A | **Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Core Description (Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components)	Weathering	Strength	Point Load Strength Index $I_s(50)$	Defect Details – Description (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness)	Formation
				START CORING AT 4.45m					
90% RETURN		189		SILTSTONE: grey, with orange brown laminae, bedded sub-horizontally.	HW	VL			Ashfield Shale
			5	Silty CLAY: high plasticity, light grey, with iron indurated bands.		VSt - Hd		(4.58-5.23m) HP: 340, 340, 300, 470, 400 kPa	
		188		SILTSTONE: grey, with orange brown laminae, bedded at 0-10°.	HW	VL		(5.24m) Be, 20°, P, R, Fe Sn; (5.44m) J, 60 - 90°, C, R, Fe Sn; (5.60m) Clayey band, 0 - 20°, 190 mm.t; (5.74m) Fragmented, 0 - 10°, 20 mm.t; (5.82m) Cr, 0 - 10°, 55 mm.t	
		187	6			L - M	0.20	(6.00m) J, 60°, Ir, R, Fe Sn, Cr, 230mm.t; (6.35m) J, 70°, Ir, R, Fe Sn; (6.46m) J, 75°, St, R, Fe Sn; (6.55m) Be, 20°, P, R, Fe Sn; (6.58m) CS, 5°, 30 mm.t; (6.66m) Cr, 5°, 90 mm.t; (6.84m) J, 70°, Ir, R, Fe Sn	
		186	7		MW	M	0.50	(7.15m) XWS, 50°, 5 mm.t; (7.28m) XWS, 10°, 2 mm.t; (7.52m) Be, 5°, C, R, Fe Sn; (7.81m) Cr, 0 - 5°, 30 mm.t	
		185	8				0.40	(8.10m) Jh, 70°, P, Fe Sn; (8.14m) XWS, 5°, 5 mm.t; (8.21m) Jh, 70°, P, Fe Sn; (8.25m) XWS, 20°, 8 mm.t; (8.30m) Jh, 40 - 60°, P, Fe Sn; (8.64m) CS, 5°, 2 mm.t	
			9				0.30; 0.40	(8.89m) Be, 0 - 10°, P, R, Fe Sn; (9.15m) Be, 0°, P, R, Fe Sn	
		184		END OF BOREHOLE AT 9.21 m					
		183	10						

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

JK 9.02.4 LIB.GLB Log JK CORED BOREHOLE - MASTER 31772L2 NORMANHURST.GPJ <<DrawingFile>> 17/12/2020 11:33 10.01.00.01 Datgel Lab and In Situ Tool - DGD | Lib: JK 9.02.4 2019-05-31 Prj: JK 9.01.0 2018-03-20


JKGeotechnics
Job No: 31772L2
Borehole No: BH208
Depth: 4.45m - 9.21m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH208 START CORING AT 4.45m
4
5
6
7
8
9
END OF BH208 AT 9.21m

JKGeotechnics

BOREHOLE LOG

Borehole No.
209

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~192.2 m
Date: 5/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.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			192	0			ASPHALTIC CONCRETE: 85mm.t				
						CH	Silty CLAY: high plasticity, light grey and orange brown, trace of fine to medium grained ironstone gravel.	w<PL	VSt		RESIDUAL
		N = 8 3,3,5								260 260 200	
			191	1							
		N = 28 8,11,17							Hd	>600 >600 >600	
			190	2			as above, but with ironstone bands.	w~PL			
						-	SILTSTONE: grey and brown.	DW	VL		ASHFIELD SHALE VERY LOW 'TC' BIT RESISTANCE
			189	3					L		LOW RESISTANCE
			188	4							
			187	5							
ON 10/12/20											
			186	6			REFER TO CORED BOREHOLE LOG				

JKGeotechnics

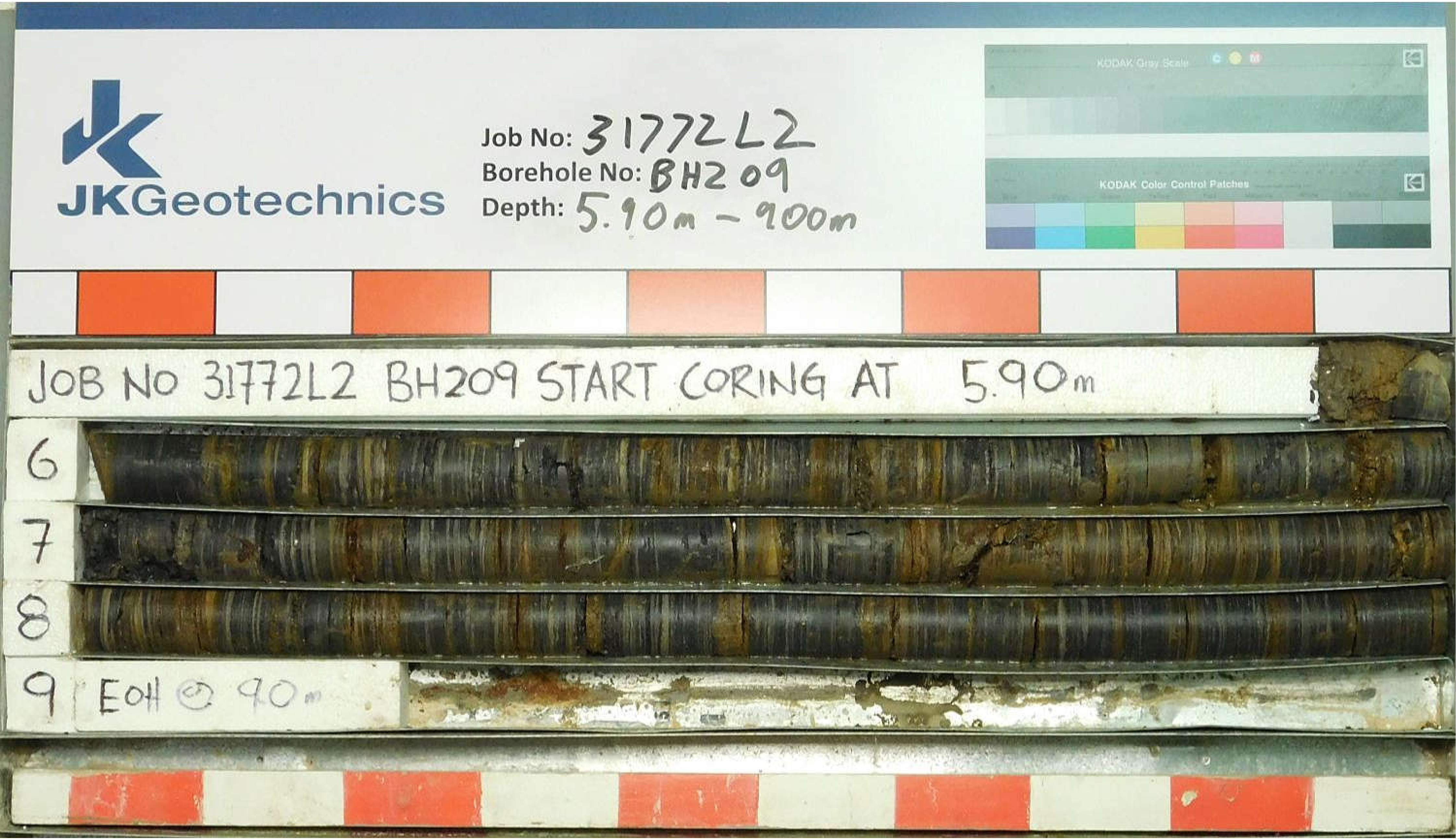
CORED BOREHOLE LOG

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2	**Core Size:** NMLC	**R.L. Surface:** ~192.2 m
Date: 5/11/20	**Inclination:** VERTICAL	**Datum:** AHD
Plant Type: JK305	**Bearing:** N/A	**Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	DEFECT DETAILS: SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS: DESCRIPTION (Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness) Specific / General	Formation
ON 10/12/20		187			START CORING AT 5.90m						
90% RETURN		186, 185, 184	6, 7, 8		SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-10°.	MW	L - M (to ~7.1 m); M	0.50, 0.20, 0.60, 0.60, 1.0, 0.80		(5.95m) J, 50°, P, R, Fe Sn (6.09m) CS, 5°, 5 mm.t (6.10m) CS, 5°, 4 mm.t (6.23m) CS, 10°, 3 mm.t (6.26m) CS, 0°, 4 mm.t (6.34m) J, 70°, St, R, Fe Sn (6.45m) Be, 0°, P, R, Fe Sn (6.60m) XWS, 0°, 3 mm.t (6.65m) XWS, 0°, 15 mm.t (6.74m) Be, 0°, P, R, Fe Sn (6.82m) Cr, 0°, 10 mm.t (6.93m) XWS, 0°, 10 mm.t (7.01m) Cr, 0°, 10 mm.t (7.13m) Be, 0°, P, R, Cn (7.20m) Be, 0°, P, R, Fe Sn (7.30m) Be, 0°, P, R, Fe Sn (7.50m) Be, 0°, P, R, Fe Sn (7.53m) J, 30°, P, R, Fe Sn (7.60m) Be, 0°, P, R, Fe Sn (7.67m) J, 40 - 70°, C, R, Fe Sn (7.96m) CS, 0°, 6 mm.t (8.07m) XWS, 0°, 10 mm.t (8.13m) XWS, 0°, 6 mm.t (8.15m) Be, 0°, P, R, Fe Sn (8.19m) XWS, 0°, 3 mm.t (8.22m) XWS, 0°, 10 mm.t (8.26m) XWS, 0°, 2 mm.t (8.31m) XWS, 0°, 5 mm.t (8.36m) XWS, 0°, 8 mm.t (8.46m) XWS, 0°, 20 mm.t (8.56m) XWS, 0°, 8 mm.t (8.58m) XWS, 40°, 5 mm.t (8.64m) XWS, 0°, 3 mm.t	Ashfield Shale
		183, 182, 181	9, 10, 11		END OF BOREHOLE AT 9.00 m						

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 3177LL2
Borehole No: BH209
Depth: 5.90m – 900m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 3177L2 BH209 START CORING AT 5.90m
6
7
8
9
EOH @ 9.0m

JKGeotechnics

BOREHOLE LOG

Borehole No.
210

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~191.4 m
Date: 2/11/20 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** J.L./L.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		ASPHALTIC CONCRETE: 15mm.t and ROADBASE: 125mm.t				
	N = 11 3,4,7		CH	Silty CLAY: high plasticity, orange brown and red brown mottled light grey, with occasional iron indurated bands.	w>PL	VSt - Hd	520 430 360	RESIDUAL
	N = 50 7,20,30	~1.3	-	Extremely Weathered siltstone: silty CLAY, medium plasticity, grey mottled orange brown, with occasional ironstone bands.	XW	Hd	>600 >600 >600	ASHFIELD SHALE
		~2.4		SILTSTONE: grey and brown, with occasional ironstone bands and clay seams.	DW	VL - L		VERY LOW TO LOW 'TC' BIT RESISTANCE
ON 10/12/20		~5.9		REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 9.48m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 5.48m TO 9.48m. CASING 0.1m TO 5.48m. 2mm SAND FILTER PACK 4.4m TO 9.48m. BENTONITE SEAL 0.2m TO 4.4m. BACKFILLED WITH SAND TO THE SURFACE. COMPLETED WITH A CONCRETED GATIC COVER.

RL (m AHD) scale: 191, 190, 189, 188, 187, 186, 185. Depth (m) scale: 1, 2, 3, 4, 5, 6. Samples columns: ES, U50, DB, DS.

JKGeotechnics

CORED BOREHOLE LOG

Borehole No. 210

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Core Size:** NMLC **R.L. Surface:** ~191.4 m
Date: 2/11/20 **Inclination:** VERTICAL **Datum:** AHD
Plant Type: JK205 **Bearing:** N/A **Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS – DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness – Specific	General	Formation
ON 10/12/20		186			START CORING AT 5.90m							
90% RETURN			6		SILTSTONE: grey and orange brown laminae, bedded at 0-20°.	HW	VL - L	0.10		(6.05m) Be, 20°, P, R, Fe Sn (6.06m) Jh, 80°, Fe Sn (6.11m) XWS, 20°, 60 mm.t (6.17m) Jh, 70°, Fe Sn (6.18m) Be, 20°, P, R, Fe Sn (6.27m) Be, 10°, P, R, Fe Sn		Ashfield Shale
		185						0.030		(6.38m) CS, 20°, 1 mm.t (6.44m) CS, 20°, 40 mm.t (6.52m) Cr, 20°, 20 mm.t (6.59m) J, 75°, P, R, Fe Sn		
			7				L			(6.73m) J, 80°, P, R, Fe Sn (6.78m) Be, 20°, P, R, Fe Sn (6.82m) CS, 20°, 10 mm.t (6.86m) Be, 20°, P, R, Fe Sn (7.10m) Cr, 0°, 40 mm.t (7.22m) Cr, 0 - 20°, 100 mm.t		
		184								(7.33m) Be, 10°, P, R, Fe Sn (7.46m) Cr, 5°, 70 mm.t (7.58m) Cr, 5°, 100 mm.t (7.64-7.78m) Be x 5, 0 - 20°, P, R, Fe Sn (7.83m) Be, 5°, P, R, Fe Sn (7.93m) Be, 20°, P, R, Fe Sn		
			8							(8.03m) CS, 20°, 5 mm.t		
		183						0.10	60 20	(8.23m) Be, 15°, P, R, Fe Sn (8.33m) Be, 20°, P, R, Fe Sn (8.43m) Be, 15°, P, R, Fe Sn (8.61m) Be, 15°, P, R, Fe Sn		
								0.20		(8.75m) Be, 20°, P, R, Fe Sn (8.79m) Be, 5°, P, R, Fe Sn (8.86m) Jh, 20°, Fe Sn (8.93m) Jh, 40°, Fe Sn (8.95m) Jh, 40°, Fe Sn		
			9		END OF BOREHOLE AT 9.00 m							
		182										
			10									
		181										
			11									
		180							600 200 60 20			

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS

JKGeotechnics
Job No: 31772L2
Borehole No: BH210
Depth: 5.90m - 9.0m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH210 START CORING AT 5.90m
6
7
8
END OF BH210 AT 9.00m

JKGeotechnics

BOREHOLE LOG

Borehole No.
211

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~192.4 m
Date: 2/11/20 **Datum:** AHD
Plant Type: JK205 **Logged/Checked By:** J.L./L.S.

Groundwater Record	Samples (ES, U50, DB, DS)	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: 20mm.t and ROADBASE: 90mm.t	D			
			192		CI-CH	Silty CLAY: medium to high plasticity, red brown and orange brown, trace of fine to medium grained ironstone gravel, and root fibres.	w>PL	Hd		RESIDUAL
		N = 10 4,4,6							460 540 420	
				1		as above, but mottled grey.				
			191		CH	Silty CLAY: high plasticity, light grey mottled red brown and orange brown.				
		N = 28 5,11,17							>600 >600 >600	
			190	2	-	Extremely Weathered siltstone: silty CLAY, medium plasticity, light grey and orange brown, with occasional ironstone bands.	XW	Hd		ASHFIELD SHALE VERY LOW 'TC' BIT RESISTANCE
			189	3						
			188	4		SILTSTONE: grey brown and red brown.	DW	VL - L		VERY LOW TO LOW RESISTANCE
			187	5						
			186	6		REFER TO CORED BOREHOLE LOG				

JKGeotechnics

CORED BOREHOLE LOG

Borehole No.
211

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 | **Core Size:** NMLC | **R.L. Surface:** ~192.4 m
Date: 2/11/20 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK205 | **Bearing:** N/A | **Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$	DEFECT DETAILS – DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness (Specific)	Formation
		187			START CORING AT 5.47m					
90% RETURN		186, 185	6, 7		SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-15°.	HW	VL - L	0.20	(5.49m) CS, 10°, 5 mm.t (5.52m) CS, 5°, 8 mm.t (5.54m) J, 30°, St, R, Fe Sn (5.59m) XWS, 0 - 20°, 40 mm.t (5.61m) CS, 10°, 5 mm.t (5.66m) CS, 5°, 5 mm.t (5.80m) J, 80°, P, R, Clay FILLED, 2 mm.t (5.94m) CS, 0°, 8 mm.t (6.02m) CS, 0°, 10 mm.t (6.05m) J, 50°, St, R, Fe Sn (6.11m) CS, 0°, 20 mm.t (6.49m) J, 40°, P, Fe Sn (6.51m) Be, 5°, P, R, Fe Sn (6.61m) Cr, 0°, 110 mm.t (6.66m) CS, 5°, 10 mm.t (6.79m) Cr, 5°, 50 mm.t (7.03m) Cr, 0°, 20 mm.t (7.09m) CS, 0°, 30 mm.t	Ashfield Shale
						MW	M	0.40	(7.33m) Cr, 5°, 30 mm.t (7.47m) Be, 5°, P, R, Fe Sn (7.55m) Be, 10°, P, R, Fe Sn (7.60m) Be, 5°, P, R, Fe Sn (7.87m) Be, 0°, P, R, Fe Sn	
			8		NO CORE 0.19m					
		184, 183	9		SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-15°.	MW	M	0.60, 0.90, 0.80	(8.13m) CS, 0°, 20 mm.t (8.32m) Be, 5°, P, R, Fe Sn (8.36m) Cr, 0°, 20 mm.t (8.47m) Cr, 0°, 20 mm.t (8.64m) Cr, 0 - 10°, 100 mm.t (8.84m) Cr, 0°, 35 mm.t (8.90m) XWS, 5°, 15 mm.t (8.95m) XWS, 5°, 3 mm.t (9.06m) Be, 10°, P, R, Fe Sn (9.16m) Be, 5°, P, R, Fe Sn (9.25m) J, 30°, C, R, Fe Sn (9.29m) Be, 5°, P, R, Fe Sn (9.35m) Be, 15°, P, R, Fe Sn (9.48m) J, 60°, Ir, R, Fe Sn	
		182, 181	10, 11		END OF BOREHOLE AT 9.54 m					

Point load scale: VL -0.1, L -0.3, M -1, H -3, VH -10, EH. Spacing (mm): 600, 200, 60, 20.

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JK
JKGeotechnics
Job No: 31772L2
Borehole No: BH211
Depth: 5.47m – 9.54m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH211 START CORING AT 5.47m
5
6
7
NO CORE
8
0.19m
9
END OF BH211 AT 9.54m

JKGeotechnics

BOREHOLE LOG

Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 **Method:** SPIRAL AUGER **R.L. Surface:** ~186.3 m
Date: 4/11/20 **Datum:** AHD
Plant Type: JK305 **Logged/Checked By:** J.L./L.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		FILL: Silty clay, low plasticity, dark brown, trace of fine grained igneous, roots and root fibres.	w<PL			GRASS COVER
	N = 10 4,5,5	186		CH	Silty CLAY: high plasticity, grey, light grey and orange brown, trace of fine to medium grained ironstone gravel.	w>PL	VSt	330 350 310	RESIDUAL
	N = 20 6,7,13	185	1		Silty CLAY: high plasticity, light grey mottled orange brown.		Hd	460 >600 >600	
ON 10/12/20	N = 26 7,10,16	184, 183	2, 3		as above, but with occasional extremely weathered siltstone seams.			>600 >600 >600	
		182	4	-	Extremely Weathered siltstone: silty CLAY, medium plasticity, light grey, with occasional ironstone bands.	XW	Hd		ASHFIELD SHALE VERY LOW 'TC' BIT RESISTANCE
		181	5		SILTSTONE: grey and brown.	DW	L		LOW RESISTANCE
		180	6		REFER TO CORED BOREHOLE LOG				GROUNDWATER MONITORING WELL INSTALLED TO 8.97m. CLASS 18 MACHINE SLOTTED 50mm DIA. PVC STANDPIPE 4.97m TO 8.97m. CASING 0.1m TO 4.97m. 2mm SAND FILTER PACK 4.2m TO 8.97m. BENTONITE SEAL 1.6m TO 4.2m. BACKFILLED WITH SAND TO THE SURFACE. COMPLETED WITH A CONCRETED GATIC COVER.

JKGeotechnics

CORED BOREHOLE LOG

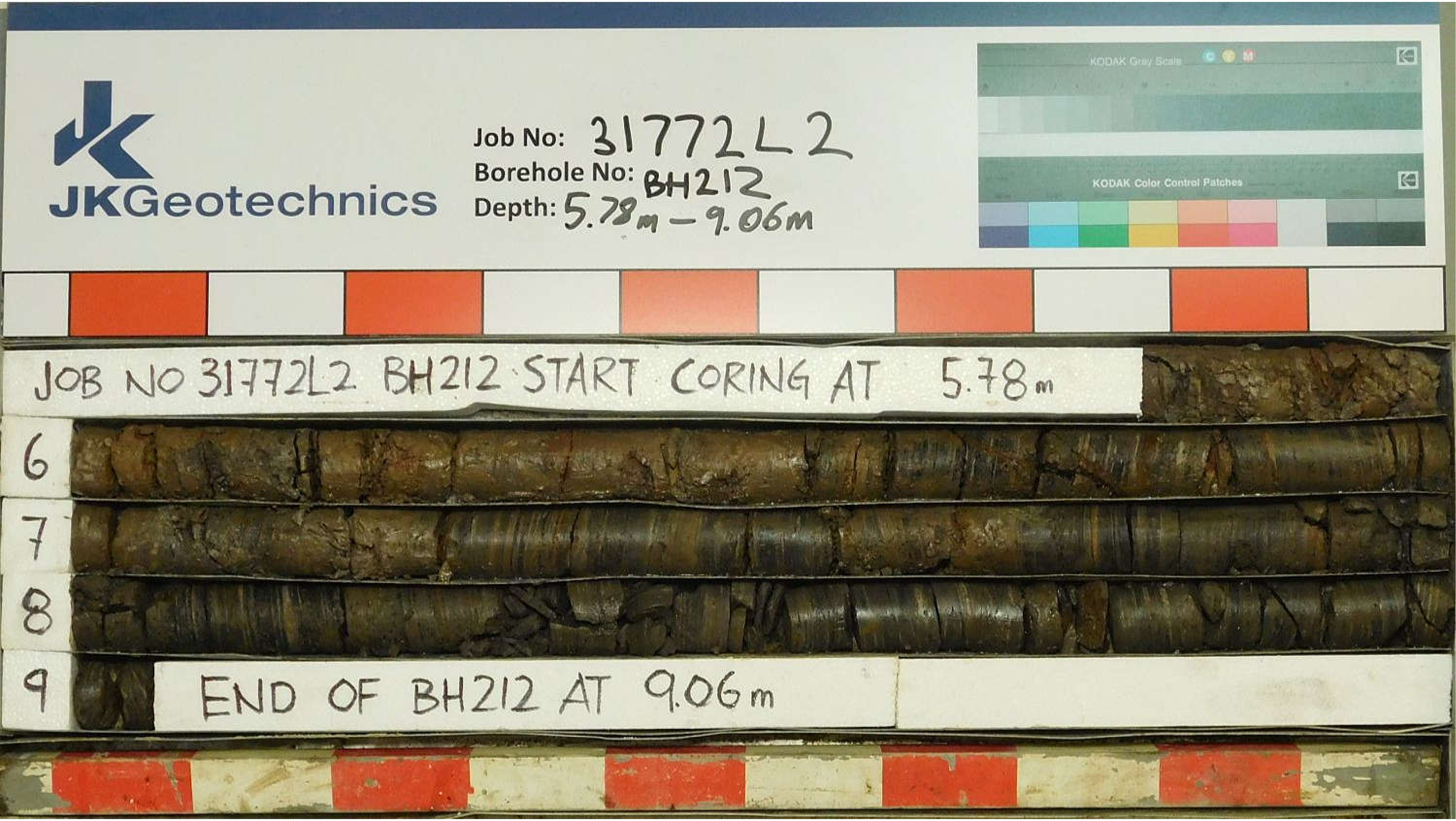
Borehole No.
212

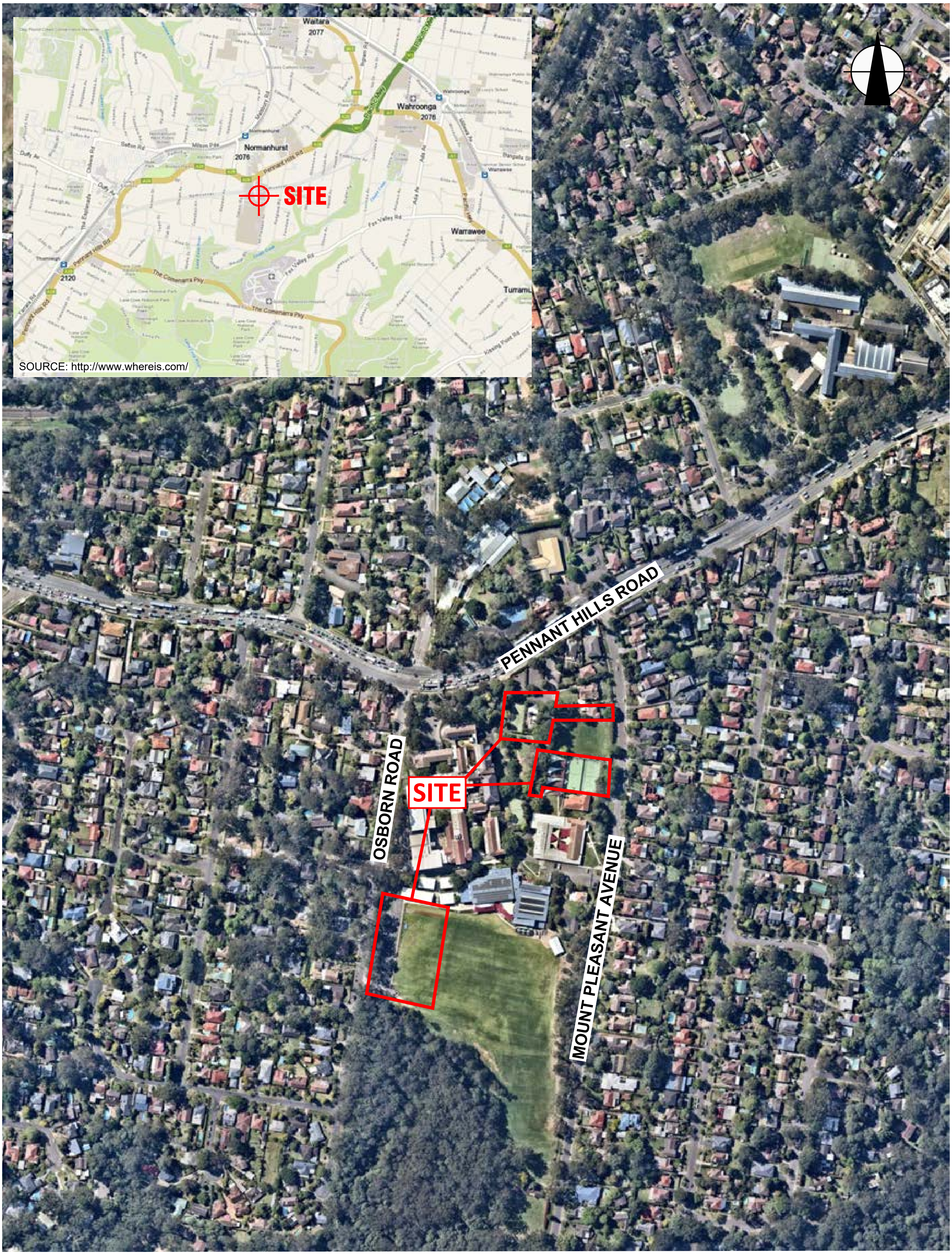
Client: LORETO NORMANHURST
Project: PROPOSED CARPARKS P3A, P4A, P1A & THROUGH LINK
Location: LORETO NORMANHURST SCHOOL, NORMANHURST, NSW

Job No.: 31772L2 | **Core Size:** NMLC | **R.L. Surface:** ~186.3 m
Date: 4/11/20 | **Inclination:** VERTICAL | **Datum:** AHD
Plant Type: JK305 | **Bearing:** N/A | **Logged/Checked By:** J.L./L.S.

Water Loss\Level	Barrel Lift	RL (m AHD)	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, texture and fabric, features, inclusions and minor components	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (VL -0.1, L -0.3, M -1, H -3, VH -10, EH)	SPACING (mm) (600, 200, 60, 20)	DEFECT DETAILS – DESCRIPTION: Type, orientation, defect shape and roughness, defect coatings and seams, openness and thickness – Specific	General	Formation
		181			START CORING AT 5.78m							
90% RETURN		180	6		SILTSTONE: grey, with light grey and orange brown laminae, bedded at 0-20°.	HW	M	0.40		(5.90m) XWS, 0°, 200 mm.t (6.09m) XWS, 10°, 10 mm.t (6.14m) CS, 10°, 15 mm.t (6.20m) XWS, 5°, 15 mm.t (6.40m) CS, 10°, 10 mm.t (6.46m) XWS, 10°, 20 mm.t (6.52m) XWS, 10°, 12 mm.t (6.71m) J, 60 - 90°, C, R, Fe Sn (6.82m) Be, 10°, P, R, Fe Sn		
		179	7					0.40 0.20		(7.09m) XWS, 30°, 20 mm.t (7.19m) CS, 5°, 15 mm.t (7.20m) J, 40°, C, R, Fe Sn		
						MW		0.40		(7.55m) Be, 5°, P, R, Fe Sn (7.65m) CS, 10°		
		178	8					0.30		(7.90m) Be, 5°, P, R, Fe Sn (8.00m) J, 90°, P, R, Fe Sn		
			9					0.60		(8.49m) Fractured, 0 - 5°, Ir, R, Fe Sn, 40 mm.t (8.57m) J, 70°, Ir, R, Fe Sn (8.73m) Highly Fractured, 0 - 5°, Cn, 40 mm.t (8.87m) J, 35°, Ir, R, Fe Sn (8.90m) Be, 5°, Ir, R, Fe Sn (8.98m) J, 40°, C, R, Fe Sn (9.03m) Be, 20°, P, R, Fe Sn		
		177			END OF BOREHOLE AT 9.06 m							
		176	10									
		175	11									

FRACTURES NOT MARKED ARE CONSIDERED TO BE DRILLING AND HANDLING BREAKS


JKGeotechnics
Job No: 31772L2
Borehole No: BH212
Depth: 5.78m – 9.06m
KODAK Gray Scale
KODAK Color Control Patches
JOB NO 31772L2 BH212 START CORING AT 5.78m
6
7
8
9
END OF BH212 AT 9.06m



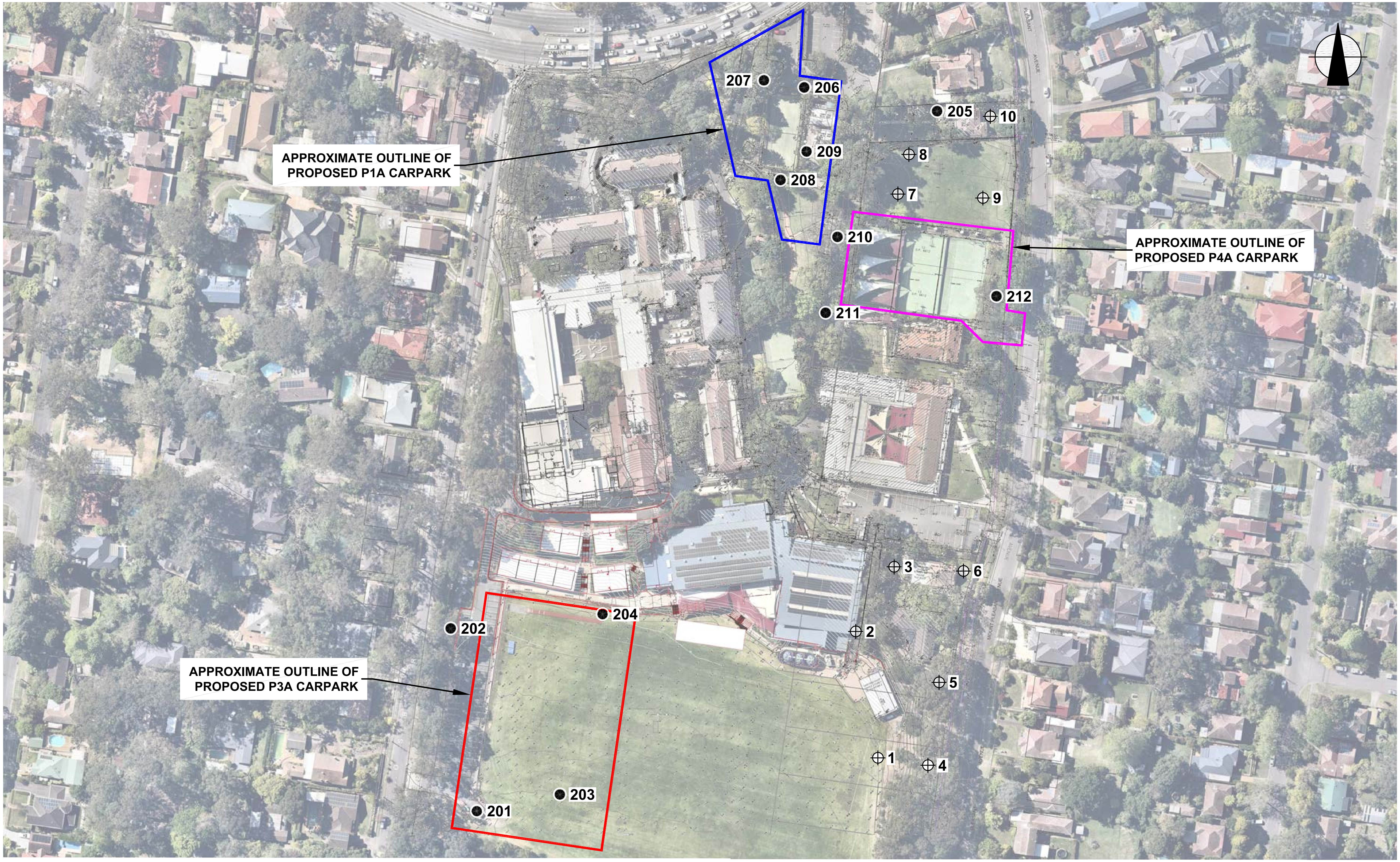
AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

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

Title:	**SITE LOCATION PLAN**
Location:	LORETO NORMANHURST, 91-93 PENNANT HILLS ROAD, NORMANHURST, NSW
Report No: 31772L2	Figure No: 1

JKGeotechnics

PLOT DATE: 29/10/2020 4:19:28 PM DWG FILE: Y:\31000'S\31772L NORMANHURST\CAD\2020\31772L2.DWG



● BH201 TO BH212 ARE FROM OUR CURRENT INVESTIGATION.

⊕ BH1 TO BH10 ARE PREVIOUS BOREHOLES DRILLED AUGUST/SEPTEMBER 2018.
REFER TO REPORT Ref: 31772Lrpt, Revision 2 DATED 7 JANUARY 2019.

AERIAL IMAGE SOURCE: MAPS.AU.NEARMAP.COM

0 15 30 45 60 75

SCALE 1:1500 @A3 METRES

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

Title: **BOREHOLE LOCATION PLAN**

Location: LORETO NORMANHURST, 91-93 PENNANT HILLS ROAD, NORMANHURST, NSW

Report No: 31772L2

Figure No: 2

JKGeotechnics

PLOT DATE: 17/12/2020 11:17:05 AM DWG FILE: Y:\31000'S\31772L NORMANHURST\CAD\2020\31772L2.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 1726:2017 *'Geotechnical Site Investigations'*. 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 soil classification table qualified by the grading of other particles present (eg. sandy clay) as set out below:

Soil Classification	Particle Size
Clay	< 0.002mm
Silt	0.002 to 0.075mm
Sand	0.075 to 2.36mm
Gravel	2.36 to 63mm
Cobbles	63 to 200mm
Boulders	> 200mm

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 (VL)	< 4
Loose (L)	4 to 10
Medium dense (MD)	10 to 30
Dense (D)	30 to 50
Very Dense (VD)	> 50

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

Classification	Unconfined Compressive Strength (kPa)	Indicative Undrained Shear Strength (kPa)
Very Soft (VS)	≤ 25	≤ 12
Soft (S)	> 25 and ≤ 50	> 12 and ≤ 25
Firm (F)	> 50 and ≤ 100	> 25 and ≤ 50
Stiff (St)	> 100 and ≤ 200	> 50 and ≤ 100
Very Stiff (VSt)	> 200 and ≤ 400	> 100 and ≤ 200
Hard (Hd)	> 400	> 200
Friable (Fr)	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 fissile mudstone, with a weakness parallel to bedding. Rocks with alternating inter-laminations of different grain size (eg. siltstone/claystone and siltstone/fine grained sandstone) is referred to as 'laminite'.

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 shrink-swell behaviour, 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 methods except test pits, hand auger drilling and portable Dynamic Cone Penetrometers require the use of a mechanical rig which is commonly mounted on a truck chassis or track base.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils and 'weaker' bedrock 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 a large 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. Refusal of the hand auger can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, 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 limited 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 cuttings. 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 assessed 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. 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, NMLC or HQ triple tube core barrels, which give a core of about 50mm and 61mm diameter, respectively, 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 NO CORE. The location of NO CORE recovery is determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the bottom 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 1289.6.3.1–2004 (R2016) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – Standard Penetration Test (SPT)'*.

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 63.5kg 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.

A modification to the SPT 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.

Cone Penetrometer Testing (CPT) and Interpretation: The cone penetrometer is sometimes referred to as a Dutch Cone. The test is described in Australian Standard 1289.6.5.1–1999 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Static Cone Penetration Resistance of a Soil – Field Test using a Mechanical and Electrical Cone or Friction-Cone Penetrometer'*.

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. The CPT does not provide soil sample recovery.

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. There are two scales presented for the cone resistance. The lower scale has a range of 0 to 5MPa and the main scale has a range of 0 to 50MPa. For cone resistance values less than 5MPa, the plot will appear on both scales.
- 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.

There are limitations when using the CPT in that it may not penetrate obstructions within any fill, thick layers of hard clay and very dense sand, gravel and weathered bedrock. Normally a 'dummy' cone is pushed through fill to protect the equipment. No information is recorded by the 'dummy' probe.

Flat Dilatometer Test: The flat dilatometer (DMT), also known as the Marchetti Dilometer comprises a stainless steel blade having a flat, circular steel membrane mounted flush on one side.

The blade is connected to a control unit at ground surface by a pneumatic-electrical tube running through the insertion rods. A gas tank, connected to the control unit by a pneumatic cable, supplies the gas pressure required to expand the membrane. The control unit is equipped with a pressure regulator, pressure gauges, an audio-visual signal and vent valves.

The blade is advanced into the ground using our CPT rig or one of our drilling rigs, and can be driven into the ground using an SPT hammer. As soon as the blade is in place, the membrane is inflated, and the pressure required to lift the membrane (approximately 0.1mm) is recorded. The pressure then required to lift the centre of the membrane by an additional 1mm is recorded. The membrane is then deflated before pushing to the next depth increment, usually 200mm down. The pressure readings are corrected for membrane stiffness.

The DMT is used to measure material index (I_D), horizontal stress index (K_D), and dilatometer modulus (E_D). Using established correlations, the DMT results can also be used to assess the 'at rest' earth pressure coefficient (K_o), over-consolidation ratio (OCR), undrained shear strength (C_u), friction angle (ϕ), coefficient of consolidation (C_h), coefficient of permeability (K_h), unit weight (γ), and vertical drained constrained modulus (M).

The seismic dilatometer (SDMT) is the combination of the DMT with an add-on seismic module for the measurement of shear wave velocity (V_s). Using established correlations, the SDMT results can also be used to assess the small strain modulus (G_o).

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a 16mm diameter rod with a 20mm diameter cone end with a 9kg hammer dropping 510mm. The test is described in Australian Standard 1289.6.3.2–1997 (R2013) *'Methods of Testing Soils for Engineering Purposes, Soil Strength and Consolidation Tests – Determination of the Penetration Resistance of a Soil – 9kg Dynamic Cone Penetrometer Test'*.

The results are used to assess the relative compaction of fill, the relative density of granular soils, and the strength of cohesive soils. Using established correlations, the DCP test results can also be used to assess California Bearing Ratio (CBR).

Refusal of the DCP can occur on a variety of materials such as obstructions within any fill, tree roots, hard clay, gravel or ironstone, cobbles and boulders, and does not necessarily indicate rock level.

Vane Shear Test: The vane shear test is used to measure the undrained shear strength (C_u) of typically very soft to firm fine grained cohesive soils. The vane shear is normally performed in the bottom of a borehole, but can be completed from surface level, the bottom and sides of test pits, and on recovered undisturbed tube samples (when using a hand vane).

The vane comprises four rectangular blades arranged in the form of a cross on the end of a thin rod, which is coupled to the bottom of a drill rod string when used in a borehole. The size of the vane is dependent on the strength of the fine grained cohesive soils; that is, larger vanes are normally used for very low strength soils. For borehole testing, the size of the vane can be limited by the size of the casing that is used.

For testing inside a borehole, a device is used at the top of the casing, which suspends the vane and rods so that they do not sink under self-weight into the 'soft' soils beyond the depth at which the test is to be carried out. A calibrated torque head is used to rotate the rods and vane and to measure the resistance of the vane to rotation.

With the vane in position, torque is applied to cause rotation of the vane at a constant rate. A rate of 6° per minute is the common rotation rate. Rotation is continued until the soil is sheared and the maximum torque has been recorded. This value is then used to calculate the undrained shear strength. The vane is then rotated rapidly a number of times and the operation repeated until a constant torque reading is obtained. This torque value is used to calculate the remoulded shear strength. Where appropriate, friction on the vane rods is measured and taken into account in the shear strength calculation.

LOGS

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

The terms and symbols used in preparation of the logs are defined in the following pages.

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 reliable water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after the groundwater level has stabilised 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 assess 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 Soils for Engineering Purposes'* or appropriate NSW Government Roads & Maritime Services (RMS) test methods. 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.

Reasonable 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.
- Details of the development that the Company could not reasonably be expected to anticipate.

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 rather than at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

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. Licence to use the documents may be revoked without notice if the Client is in breach of any obligation 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 an experienced geotechnical engineer/engineering geologist.

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 and appropriate footing or pile founding depths, or

iii) full time engineering presence on site.

SYMBOL LEGENDS

SOIL

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

ROCK

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

OTHER MATERIALS

- BRICKS OR PAVERS
- CONCRETE
- ASPHALTIC CONCRETE

CLASSIFICATION OF COARSE AND FINE GRAINED SOILS

Major Divisions		Group Symbol	Typical Names	Field Classification of Sand and Gravel	Laboratory Classification	
Coarse grained soil (more than 65% of soil excluding oversize fraction is greater than 0.075mm)	GRAVEL (more than half of coarse fraction is larger than 2.36mm	GW	Gravel and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 4$ $1 < C_c < 3$
		GP	Gravel and gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		GM	Gravel-silt mixtures and gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	Fines behave as silt
		GC	Gravel-clay mixtures and gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	Fines behave as clay
	SAND (more than half of coarse fraction is smaller than 2.36mm)	SW	Sand and gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	$C_u > 6$ $1 < C_c < 3$
		SP	Sand and gravel-sand mixtures, little or no fines	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength	≤ 5% fines	Fails to comply with above
		SM	Sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength	≥ 12% fines, fines are silty	N/A
		SC	Sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength	≥ 12% fines, fines are clayey	

Major Divisions		Group Symbol	Typical Names	Field Classification of Silt and Clay			Laboratory Classification
				Dry Strength	Dilatancy	Toughness	% < 0.075mm
ine grained soils (more than 35% of soil excluding oversize fraction is less than 0.075mm)	SILT and CLAY (low to medium plasticity)	ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or silt with low plasticity	None to low	Slow to rapid	Low	Below A line
		CL, CI	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay	Medium to high	None to slow	Medium	Above A line
		OL	Organic silt	Low to medium	Slow	Low	Below A line
	SILT and CLAY (high plasticity)	MH	Inorganic silt	Low to medium	None to slow	Low to medium	Below A line
		CH	Inorganic clay of high plasticity	High to very high	None	High	Above A line
		OH	Organic clay of medium to high plasticity, organic silt	Medium to high	None to very slow	Low to medium	Below A line
	Highly organic soil	Pt	Peat, highly organic soil	–	–	–	–

Laboratory Classification Criteria

A well graded coarse grained soil is one for which the coefficient of uniformity $Cu > 4$ and the coefficient of curvature $1 < C_c < 3$. Otherwise, the soil is poorly graded. These coefficients are given by:

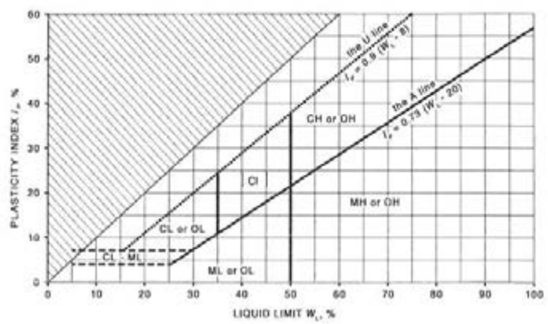
$$C_U = \frac{D_{60}}{D_{10}} \quad \text{and} \quad C_C = \frac{(D_{30})^2}{D_{10}\,D_{60}}$$

Where D_{10}, D_{30} and D_{60} are those grain sizes for which 10%, 30% and 60% of the soil grains, respectively, are smaller.

NOTES:

1. For a coarse grained soil with a fines content between 5% and 12%, the soil is given a dual classification comprising the two group symbols separated by a dash; for example, for a poorly graded gravel with between 5% and 12% silt fines, the classification is GP-GM.
2. Where the grading is determined from laboratory tests, it is defined by coefficients of curvature (C_c) and uniformity (C_u) derived from the particle size distribution curve.
3. Clay soils with liquid limits > 35% and ≤ 50% may be classified as being of medium plasticity.
4. The U line on the Modified Casagrande Chart is an approximate upper bound for most natural soils.

Modified Casagrande Chart for Classifying Silts and Clays according to their Behaviour



JKGeotechnics

LOG SYMBOLS

Log Column	Symbol	Definition
Groundwater Record	 C 	Standing water level. Time delay following completion of drilling/excavation may be shown. Extent of borehole/test pit collapse shortly after drilling/excavation. Groundwater seepage into borehole or test pit noted during drilling or excavation.
Samples	ES U50 DB DS ASB ASS SAL	Sample taken over depth indicated, for environmental analysis. Undisturbed 50mm diameter tube sample taken over depth indicated. Bulk disturbed sample taken over depth indicated. Small disturbed bag sample taken over depth indicated. Soil sample taken over depth indicated, for asbestos analysis. Soil sample taken over depth indicated, for acid sulfate soil analysis. 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. 'Refusal' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	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° solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25 PID = 100	Vane shear reading in kPa of undrained shear strength. Photoionisation detector reading in ppm (soil sample headspace test).
Moisture Condition (Fine Grained Soils)	w > PL w ≈ PL w < PL w ≈ LL w > LL	Moisture content estimated to be greater than plastic limit. Moisture content estimated to be approximately equal to plastic limit. Moisture content estimated to be less than plastic limit. Moisture content estimated to be near liquid limit. Moisture content estimated to be wet of liquid limit.
(Coarse Grained Soils)	D M W	DRY – runs freely through fingers. MOIST – does not run freely but no free water visible on soil surface. WET – free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS S F St VSt Hd Fr ( )	VERY SOFT – unconfined compressive strength ≤ 25kPa. SOFT – unconfined compressive strength > 25kPa and ≤ 50kPa. FIRM – unconfined compressive strength > 50kPa and ≤ 100kPa. STIFF – unconfined compressive strength > 100kPa and ≤ 200kPa. VERY STIFF – unconfined compressive strength > 200kPa and ≤ 400kPa. HARD – unconfined compressive strength > 400kPa. FRIABLE – strength not attainable, soil crumbles. Bracketed symbol indicates estimated consistency based on tactile examination or other assessment.
Density Index/ Relative Density (Cohesionless Soils)	 VL L MD D VD ( )	**Density Index (I_D) Range (%)** / **SPT 'N' Value Range (Blows/300mm)** VERY LOOSE ≤ 15 / 0 – 4 LOOSE > 15 and ≤ 35 / 4 – 10 MEDIUM DENSE > 35 and ≤ 65 / 10 – 30 DENSE > 65 and ≤ 85 / 30 – 50 VERY DENSE > 85 / > 50 Bracketed symbol indicates estimated density based on ease of drilling or other assessment.
Hand Penetrometer Readings	300 250	Measures reading in kPa of unconfined compressive strength. Numbers indicate individual test results on representative undisturbed material unless noted otherwise.

Log Column	Symbol	Definition
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Twin pronged tungsten carbide bit.
	T_{60}	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.
	Soil Origin	The geological origin of the soil can generally be described as: RESIDUAL – soil formed directly from insitu weathering of the underlying rock. No visible structure or fabric of the parent rock. EXTREMELY WEATHERED – soil formed directly from insitu weathering of the underlying rock. Material is of soil strength but retains the structure and/or fabric of the parent rock. ALLUVIAL – soil deposited by creeks and rivers. ESTUARINE – soil deposited in coastal estuaries, including sediments caused by inflowing creeks and rivers, and tidal currents. MARINE – soil deposited in a marine environment. AEOLIAN – soil carried and deposited by wind. COLLUVIAL – soil and rock debris transported downslope by gravity, with or without the assistance of flowing water. Colluvium is usually a thick deposit formed from a landslide. The description 'slopewash' is used for thinner surficial deposits. LITTORAL – beach deposited soil.

Classification of Material Weathering

Term		Abbreviation		Definition
Residual Soil		RS		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely Weathered		XW		Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible.
Highly Weathered	Distinctly Weathered (Note 1)	HW	DW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately Weathered		MW		The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly Weathered		SW		Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh		FR		Rock shows no sign of decomposition of individual minerals or colour changes.

NOTE 1: The term 'Distinctly Weathered' is used where it is not practicable to distinguish between 'Highly Weathered' and 'Moderately Weathered' rock. 'Distinctly Weathered' is defined as follows: *'Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores'*. There is some change in rock strength.

Rock Material Strength Classification

			Guide to Strength	
Term	**Abbreviation**	**Uniaxial Compressive Strength (MPa)**	**Point Load Strength Index $Is_{(50)}$ (MPa)**	**Field Assessment**
Very Low Strength	VL	0.6 to 2	0.03 to 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	L	2 to 6	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium Strength	M	6 to 20	0.3 to 1	Scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	H	20 to 60	1 to 3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High Strength	VH	60 to 200	3 to 10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High Strength	EH	> 200	> 10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Abbreviations Used in Defect Description

Cored Borehole Log Column		Symbol Abbreviation	Description
Point Load Strength Index		• 0.6	Axial point load strength index test result (MPa)
		x 0.6	Diametral point load strength index test result (MPa)
Defect Details	– Type	Be	Parting – bedding or cleavage
		CS	Clay seam
		Cr	Crushed/sheared seam or zone
		J	Joint
		Jh	Healed joint
		Ji	Incipient joint
		XWS	Extremely weathered seam
	– Orientation	Degrees	Defect orientation is measured relative to normal to the core axis (ie. relative to the horizontal for a vertical borehole)
	– Shape	P	Planar
		C	Curved
		Un	Undulating
		St	Stepped
		Ir	Irregular
	– Roughness	Vr	Very rough
		R	Rough
		S	Smooth
		Po	Polished
		Sl	Slickensided
	– Infill Material	Ca	Calcite
		Cb	Carbonaceous
		Clay	Clay
		Fe	Iron
		Qz	Quartz
		Py	Pyrite
	– Coatings	Cn	Clean
		Sn	Stained – no visible coating, surface is discoloured
		Vn	Veneer – visible, too thin to measure, may be patchy
		Ct	Coating ≤ 1mm thick
		Filled	Coating > 1mm thick
	– Thickness	mm.t	Defect thickness measured in millimetres