



**REPORT**

**TO**

**THORNTON NORTH PENRITH PTY LTD**

**ON**

**PRELIMINARY GEOTECHNICAL INVESTIGATION**

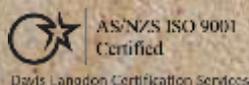
**FOR**

**PROPOSED RESIDENTIAL DEVELOPMENT**

**AT**

**LOT 3007 THORTON DEVELOPMENT, LORD  
SHEFFIELD CIRCUIT, PENRITH, NSW**

**16 September 2014**  
**Ref: 27694ZNrpt Rev1**



Davis Langdon Certification Services

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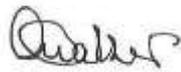
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Date: 16 September 2014  
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## **TABLE OF CONTENTS**

|              |  |           |
|--------------|--|-----------|
| <b>1</b>     | <b>INTRODUCTION</b>                          | <b>1</b>  |
| <b>2</b>     | <b>INVESTIGATION PROCEDURE</b>               | <b>1</b>  |
| <b>3</b>     | <b>RESULTS OF INVESTIGATION</b>              | <b>2</b>  |
| <b>3.1</b>   | <b>Site Description</b>                      | <b>2</b>  |
| <b>3.2</b>   | <b>Subsurface Conditions</b>                 | <b>3</b>  |
| <b>3.3</b>   | <b>Laboratory Test Results</b>               | <b>4</b>  |
| <b>4</b>     | <b>COMMENTS AND RECOMMENDATIONS</b>          | <b>5</b>  |
| <b>4.1</b>   | <b>Excavation</b>                            | <b>5</b>  |
| <b>4.1.1</b> | <b>Excavation Conditions</b>                 | <b>5</b>  |
| <b>4.1.2</b> | <b>Seepage</b>                               | <b>5</b>  |
| <b>4.2</b>   | <b>Retention</b>                             | <b>5</b>  |
| <b>4.2.3</b> | <b>Retention Options</b>                     | <b>5</b>  |
| <b>4.2.4</b> | <b>Retaining Wall Design Parameters</b>      | <b>6</b>  |
| <b>4.3</b>   | <b>Footings</b>                              | <b>8</b>  |
| <b>4.4</b>   | <b>Basement On-Grade Floor Slab</b>          | <b>9</b>  |
| <b>4.5</b>   | <b>Soil Aggressivity</b>                     | <b>9</b>  |
| <b>4.6</b>   | <b>Additional Geotechnical Work Required</b> | <b>10</b> |
| <b>5</b>     | <b>GENERAL COMMENTS</b>                      | <b>10</b> |

**STS TABLE A: POINT LOAD STRENGTH INDEX TEST REPORT**

**BOREHOLE LOGS 1 TO 5 INCLUSIVE, INCLUDING COLOUR CORE PHOTOGRAPH**

**FIGURE 1: BOREHOLE LOCATION PLAN**

**FIGURE 2: GRAPHICAL BOREHOLE SUMMARY**

**REPORT EXPLANATION NOTES**

**APPENDIX A: ENVIROLAB SERVICES CERTIFICATE OF ANALYSIS NO: 115736**



## **1 INTRODUCTION**

This report presents the results of a preliminary geotechnical investigation for the proposed residential development at Lot 3007, Thornton Development, Lord Sheffield Circuit, Penrith, NSW. The investigation was commissioned by Mr Frank Katsanevas of St Hilliers on behalf of Thornton North Penrith Pty Ltd by email dated 22 August 2014. The investigation was completed generally in accordance with our proposal Ref: 'P39186ZN' dated 21 August 2014, our subsequent email dated 3 September 2014, and our further discussion on 4 September 2014.

This report confirms and amplifies the preliminary information provided by email dated 11 September 2014.

From the email from Mr Robert Facioni of Structural Design Solutions (NSW) [SDS] dated 21 August 2014, we understand the proposed development will comprise a 9 storey residential apartment building over a single level of basement carparking, however, consideration is being given to 2 levels of basement carparking. The proposed basement will extend to, or close to, the site boundaries. Maximum column loads on the order of 6,000kN have been estimated by SDS.

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

## **2 INVESTIGATION PROCEDURE**

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

Initially, four boreholes, BH1 to BH4, were drilled to refusal at depths between 5.8m (BH3) and 7.4m (BH1) using spiral augering and rotary washboring techniques with our truck mounted JK500 drill rig. One additional borehole, BH5, was initially drilled to a depth of 12.78m using spiral augering and 'tubex' down hole hammering techniques using our truck mounted JK500 drill rig. BH5 was subsequently extended to a depth of 15.65m using rotary diamond coring techniques with water flush.



The strength of the alluvial silts and clays and relative density of the alluvial sands and gravels were assessed from the results of Standard Penetration tests (SPTs) and SPT Solid Cone tests completed in the boreholes along with hand penetrometer tests on recovered cohesive soil samples. The strength of the bedrock was assessed from tactile examination of recovered rock core and subsequent laboratory point load strength index ( $I_{s(50)}$ ) tests. The results of the point load strength index tests are presented on the attached Soil Test Services Pty Ltd (STS) Table A and are plotted on the borehole logs. A colour core photograph is also attached with the borehole logs.

50mm diameter PVC standpipe piezometers were installed in BH1, BH3 and BH5 to allow for the ongoing measurement of groundwater levels and these were monitoring whilst we were on site. No longer term groundwater monitoring was completed.

The borehole locations, as shown on the attached Borehole Location Plan (Figure 1) were set out by taped measurements from inferred site boundaries.

Our geotechnical engineer, David Schwarzer, was on site full time during the fieldwork and set out the borehole locations, directed the electromagnetic scanning, nominated the sampling and testing, and prepared logs of the encountered subsurface profile. The borehole logs are attached to this report along with a set of Report Explanation Notes which describe the investigation techniques adopted and define the logging terms and symbols used.

Selected samples were submitted to Envirolab Services Pty Ltd, a NATA registered laboratory, for aggressivity testing (soil pH, sulfate content, chloride content, electrical conductivity and resistivity). The results of the testing are summarised in the attached Envirolab Certificate of Analysis No. 115736, attached as Appendix A of this report. Contamination testing was outside the scope of our investigation.

### **3 RESULTS OF INVESTIGATION**

#### **3.1 Site Description**

The site is located in relatively level topography and the site itself was near level.

The proposed Lord Sheffield Circuit formed the north-western site boundary and northern corner of the site, and had been boxed out at the time of our investigation.



At the time of the fieldwork, the site was vacant with a number of small stockpiles scattered across the site. The stockpiles were a maximum of about 2m high.

Vacant sites, including that for a proposed road, were located to the north-west, south-east and south-west of the site. An at-grade asphaltic concrete surfaced carpark was located to the north-east of the site.

### **3.2 Subsurface Conditions**

The 1:100,000 Geological Map of Penrith indicates the site is underlain by Quaternary alluvial soils of the Cranebrook Formation.

The boreholes disclosed a subsurface profile comprising surficial fill over alluvial sands, silts and clays, then alluvial gravels, with interbedded sandstone and shale bedrock at depth. For details of the encountered subsurface profile, reference should be made to the attached borehole logs. A summary of the encountered conditions is presented below. Figure 2 presents a Graphical Borehole Summary.

**Fill**, comprising silty clay and silty gravelly clay of low to medium plasticity was encountered in all 5 boreholes to depths between 0.05m (BH3 and BH4) and 0.5m (BH2 and BH5).

**Alluvial Sands, Silts and Clays** were encountered from immediately beneath the fill and extended to depths between 5.0m (BH3) and 6.45m (BH1) below existing levels. The clays ranged from low to high plasticity and were of very stiff to hard strength. The silts were of low plasticity and of hard strength. The sands were medium dense, with the basal 0.5m of the sand profile in some boreholes were interbedded with alluvial gravels.

**Alluvial Gravels** were encountered beneath the alluvial sands, silts and clays in all 5 boreholes. The alluvial gravels were assessed as being medium dense or dense, and borehole refusal occurred within the gravel profile in all but one of the boreholes after only limited penetration. BH1 to BH4 inclusive were terminated at depths between 5.8m (BH3) and 7.4m (BH1). In BH5, the alluvial gravel profile extended to a depth of 12.5m.

**Interbedded Shale and Sandstone Bedrock** was encountered from immediately beneath the alluvial gravel profile in BH5 and extended to the 15.65m borehole termination depth. The interbedded shale and sandstone was initially of low strength, increasing to high strength with depth. A number of defects were encountered over the upper portion of the bedrock profile, with



no defects below 15m depth. The core loss zones likely represent thicker extremely weathered or clay seams within the better quality bedrock profile.

**Groundwater:** Boreholes BH1 to BH4 were 'dry' during and on completion of augering and BH3 remained 'dry' 6 days after the completion of drilling. On completion of washboring, standing water was measured in BH1 at 4.2m depth, falling to 5.4m after 18 hours then to 6.6m after 7 days.

In BH5, groundwater seepage was encountered at a depth of 8m during drilling. On completion of down hole hammer drilling, standing water was measured at a depth of 9.9m in BH5 and on completion of coring, standing water was measured at a depth of 6.5m in BH1. We note that water is injected into the borehole during rotary washboring and coring and groundwater levels had likely not stabilised in the limited observation period in BH5.

### 3.3 Laboratory Test Results

The point load strength index tests on the recovered core generally correlated well with our field assessment of the bedrock strength. The estimated Unconfined Compressive Strength (UCS) of the bedrock ranged from 12MPa to 104MPa.

The results of the soil aggressivity are summarised in the table below:

|   | BH1<br>(1.5m to 1.95m<br>depth) | BH1<br>(4.5m to 4.95m<br>depth) | BH3<br>(1.5m to 1.8m<br>depth) | BH3<br>(4.5m to 4.95m<br>depth) |
|---|---------------------------------|---------------------------------|--------------------------------|---------------------------------|
| Strata                                      | Silty Clay                      | Silty Sand                      | Silty Clay                     | Sandy Silt                      |
| pH  | 4.4                             | 7.9                             | 5.1                            | 7.4                             |
| Sulfate content<br>(mg/kg)                  | <10                             | <10                             | <10                            | 10                              |
| Chloride content<br>(mg/kg)                 | 1,200                           | 200                             | 600                            | 300                             |
| Electrical<br>Conductivity<br>( $\mu$ S/cm) | 710                             | 150                             | 390                            | 230                             |
| Resistivity<br>(ohm/m)                      | 14                              | 68                              | 26                             | 43                              |



## **4 COMMENTS AND RECOMMENDATIONS**

The following sections of the report have been prepared on the basis that the development will have only a single level of basement carparking. If a second basement level is proposed, then the comments and recommendations below should be reviewed and amended as required.

### **4.1 Excavation**

#### **4.1.1 Excavation Conditions**

The proposed basement is expected to require excavation to a maximum depth of about 3m below existing levels, with locally deeper excavation required for services and lift overrun pits. Such excavation is expected to encounter the alluvial sands, clays and silts only.

Excavation of such materials is expected to be readily completed using conventional techniques such as the buckets of hydraulic excavators.

#### **4.1.2 Seepage**

Groundwater, where encountered, was at least 2m below anticipated bulk excavation levels and is not expected to be encountered.

We recommend that monitoring be continued in the installed standpipes to assess groundwater fluctuation with time.

### **4.2 Retention**

#### **4.2.3 Retention Options**

Where space permits, temporary batters in the alluvial sands, clays and silts, above the groundwater table of 1 Vertical (V) to 1.5 Horizontal (H) are deemed appropriate and should remain stable in the short term, provided no surcharge loads are placed at the crest of the excavation. Steeper temporary batters of 1V to 1H may also be adopted for areas where only alluvial clays are present.

However, we understand that the proposed basement excavation will extend to, or close to, the site boundaries, and that it will most likely not be feasible to accommodate such temporary batter slopes within the site. We therefore recommend that the excavation be supported by an engineered retention system.



Given the subsurface conditions encountered, a conventional soldier pile wall with shotcrete infill panels could be considered for the majority of the excavation perimeter, however, in any areas where the alluvial sands extend above bulk excavation level, e.g. at BH2, such a system would not be feasible due to the collapsing nature of the sands and a contiguous pile wall would be required. If a soldier pile wall is to be adopted, we strongly recommend that additional spiral auger drilled boreholes be completed down to say 0.5m below bulk excavation level to confirm the subsurface profile around the perimeter of the proposed basement, and hence, the areas where a contiguous pile wall is necessary. Alternatively, as there appears to be no vibration sensitive structures within at least 30m of the site boundaries, consideration could be given to adopting a steel sheet pile wall for the entire excavation perimeter.

For a soldier pile wall, the shotcrete would need to be placed progressively as the excavation proceeds and regardless of what wall type is adopted, anchors would be required to limit deflections of the wall. We assume that permanent support of the retention system would be provided by the building structure.

We also note that for a soldier pile or contiguous pile wall, conventional bored piles would not be suitable due to the collapsing nature of the sandy soils and continuous flight auger CFA piling techniques would be required. We also note that using either CFA piling or sheet piling techniques it will most likely not be feasible to penetrate into the alluvial gravel profile. Therefore, the retention system will need to generate sufficient passive resistance within the alluvial soils above the gravels.

#### **4.2.4 Retaining Wall Design Parameters**

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

- For anchored or propped walls, where minor movements can be tolerated, provided there are no buried movement sensitive services present within the road reserve, we recommend the use of rectangular lateral earth pressure distribution of  $6H$  (kPa) for the soil profile, where  $H$  is the retained height in metres.
- For anchored or propped walls, supporting areas which are relatively sensitive to movement, e.g. if there are movement sensitive services present (at the time of construction



or proposed in the future), a rectangular lateral earth pressure distribution of  $8H$  (kPa) should be adopted for the soil profile.

- Any surcharge affecting the walls (e.g. road traffic loading, construction loads, etc.) should be allowed in the design using an 'at rest' earth pressure coefficient,  $K_o$ , of 0.55.
- The retaining walls should be designed as drained and measures taken to induce complete and permanent drainage of the ground behind the wall. Strip drains incorporating a geofabric to act as a filter against subsoil erosion would be appropriate for soldier pile walls. For a contiguous pile wall or sheet pile wall, drainage should comprise say 40mm diameter PVC pipes pushed through holes drilled through the wall say 0.2m above the basement finished floor level at say 2m horizontal centres with the inserted end of the PVC wrapped in geofabric to act as a filter against subsoil erosion. The hole surrounding the PVC pipe should be grouted up subsequent to installation of the pipe.
- Lateral toe restraint may be achieved by embedding the footing to sufficient depth below bulk excavation level, and any service excavations within 5m in front of the wall. A triangular lateral earth pressure coefficient should be adopted for embedment depth design with a "passive" earth pressure coefficient,  $K_p$ , of 3.0, assuming horizontal ground in front of the wall. We note that significant deflection is required in order to mobilise the full passive resistance of a soil and therefore a Factor of Safety of at least 2 should be adopted. We note that the upper 0.3m below bulk excavation level and any service excavations should be ignore due to potential disturbance effects. For soldier piles, soil arching to 3 times the actual pile diameter (assuming the piles are spaced at greater than 3 pile diameter centres) can be adopted to assess the passive resistance of the piles.
- If anchors are to run below adjoining properties, then permission of the owners must be obtained before installation.
- Anchors bonded into alluvial sands or gravels above the groundwater table can be designed based on an effective friction angle of  $30^\circ$  on the grout soil interface subject to the following conditions:
  - Anchor bond length of at least 3m behind the 'active' zone of the excavation (taken as a  $45^\circ$  zone above the base of the excavation).
  - Overall stability, including anchor group interaction, is satisfied.
  - All anchors are proof loaded to at least 1.3 times the design working load before being locked off at working load. We strongly recommend that such proof loading be inspected by an experience geotechnical engineer.



We recommend that consideration be given to carrying out computer modelling (e.g. WALLAP) of the proposed retaining wall system to analyse loads on the retention system and potential movements of the retention system. We can complete such modelling if commissioned to do so.

### **4.3 Footings**

On the completion of excavation, alluvial soils are expected to be uniformly exposed across the basement excavation. Given the column loads advised (6,000kN), we anticipate that pad footings within the soil profile will not be feasible.

For the proposed development, we consider driven piles, e.g. precast concrete or timber piles, founded within the alluvial gravel profile, will be the most suitable footing type. Push in piles could also be considered, adopting the same design criteria as for driven piles. The advantage of push in piles is that they are effectively 'self-proving' with the push in system providing a short term static load test for each pile.

For driven piles founded on the alluvial gravels at a depth of 3m below bulk excavation level, and with a minimum embedment of 4 pile diameters below bulk excavation level, an allowable end bearing pressure of 2,000kPa could be provisionally adopted. However, higher bearing pressures could be feasible pending the driving of test piles.

We note that driven piles are typically installed on a design and construct basis by piling contractors with the contractor also certifying the piles. However, we would be able to review proposed pile designs prepared by piling contractors if requested to do so.

The building may also be supported on piles founded in the underlying bedrock profile. However, drilling of piles through the alluvial gravel profile will likely be problematic and may not be achievable in practice. If piles to the bedrock profile are proposed, comment on the feasibility of these should be sought from specialist piling contractors. For piles socketed a nominal 0.3m into bedrock of at least high strength, an allowable end bearing pressure of 3MPa can be adopted, based on serviceability criteria. For sockets longer than the nominal 0.3m above, an allowable shaft adhesion of 300kPa in compression and 150kPa in tension can be adopted. If piles to the bedrock profile are to be adopted, we strongly recommend that consideration be given to the drilling of additional cored borehole to confirm the depth to and quality of the bedrock profile across the site. If conventional bordered piles, or cased bored piles are adopted, the initial stages of pile drilling should be inspected by a geotechnical engineer to confirm the appropriate foundation material has been achieved.



The proposed piling contractor(s) should be provided with a full copy of this report so they are able to make their own assessment of installation and founding conditions.

#### **4.4 Basement On-Grade Floor Slab**

The soil subgrade at basement level must be proof rolled with at least 8 passes of a minimum 10 tonne deadweight smooth drum roller. The final pass of proof rolling should be carried out under the direction of an experienced geotechnical engineer for the detection of unstable or soft areas. The purpose of the proof rolling is to assist in the detection of any soft or unstable areas where replacement or improvement of the existing subgrade is required. If any soft or unstable areas are detected, advice on replacement/improvement would be provided during the inspection. Allowance should be made for possible replacement excavations in the design of the basement retaining walls.

The basement level on-grade floor slab should be provided with underfloor drainage. The underfloor drainage should comprise a strong, durable, single-sized washed aggregate (such as 'blue metal' gravel), which can also act as the subbase. The underfloor drainage should connect with the retaining wall drains (if applicable) and direct groundwater seepage to a sump for pumped disposal to the stormwater system.

Concrete on-grade floor slabs and pavements should be provided with effective shear connection at joints by using dowels or keys. The concrete on-grade floor slabs should be structurally isolated from all columns and footings, i.e. designed as a 'floating' slab.

#### **4.5 Soil Aggressivity**

Based on the results of the aggressivity testing, a 'Moderate' exposure classification is applicable for concrete piles in accordance with Table 6.4.2(C) of 'AS2159-2009: Piling – Design and Installation'.

In accordance with Table 6.5.2(C) of 'AS2159-2009', a 'Severe' exposure classification is applicable for steel piles.



#### **4.6 Additional Geotechnical Work Required**

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

- Additional boreholes around the site perimeter to confirm subsurface conditions for shoring design.
- Additional cored boreholes if piles to bedrock are proposed.
- Additional groundwater monitoring to assess groundwater level fluctuations.
- Review of piling contractors designs.
- Witnessing of proof testing of temporary anchors.
- Geotechnical inspection of the initial stages of bored pile drilling, if appropriate.
- Proof rolling of exposed subgrade.

### **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.

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

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



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

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.

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**TABLE A**  
**POINT LOAD STRENGTH INDEX TEST REPORT**

|                  |  |                     |            |
|------------------|--|---------------------|------------|
| <b>Client:</b>   | JK Geotechnics   | <b>Ref No:</b>      | 27694ZN    |
| <b>Project:</b>  | Proposed Residential Development                                       | <b>Report:</b>      | A          |
| <b>Location:</b> | Lot 3007 Thornton Development,<br>Lord Sheffield Circuit, Penrith, NSW | <b>Report Date:</b> | 15/09/2014 |

**Page 1 of 1**

| BOREHOLE NUMBER | DEPTH<br>m  | $I_{S(50)}$<br>MPa | ESTIMATED UNCONFINED<br>COMPRESSIVE STRENGTH<br>(MPa) |
|-----------------|-------------|--------------------|---|
| 5               | 12.89-12.93 | 0.6                | 12  |
|                 | 13.24-13.28 | 0.7                | 14  |
|                 | 13.53-13.56 | 5.2                | 104   |
|                 | 14.06-14.09 | 0.6                | 12  |
|                 | 14.57-14.60 | 2.6                | 52  |
|                 | 15.17-15.21 | 1.2                | 24  |
|                 | 15.46-15.49 | 1.0                | 20  |

**NOTES:**

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



Borehole No.

1

1/2

# BOREHOLE LOG

**Client:** ST HILLIERS  
**Project:** PROPOSED RESIDENTIAL DEVELOPMENT  
**Location:** LOT 3007, THORNTON DEVELOPMENT, LORD SHEFFIELD CIRCUIT, PENRITH, NSW

**Job No.** 27694ZN      **Method:** SPIRAL AUGER/ROTARY WASHBORE JK500      **R.L. Surface:** N/A  
**Date:** 2-9-14      **Datum:**  
**Logged/Checked by:** D.S./N.E.S. *(Signature)*

| Groundwater Record | SAMPLES |     |    |                                      | Field Tests | Depth (m) | Graphic Log | Unified Classification | DESCRIPTION  | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks             |
|--------------------|---------|-----|----|--------------------------------------|-------------|-----------|-------------|------------------------|--|--------------------------------|------------------------|-----------------------------------|---------------------|
|                    | FS      | U30 | DB | DS                                   |             |           |             |                        |  |                                |                        |                                   |                     |
|                    |         |     |    |                                      |             | 0         |             | CH                     | FILL: Silty clay topsoil, low plasticity, brown, with fine to medium grained ironstone, shale and igneous gravel.<br>SILTY CLAY: high plasticity, brown. | MC<PL                          | H                      |                                   | ALLUVIAL            |
|                    |         |     |    | N = 12<br>8,6,6                      |             | 1         |             |                        | as above,<br>but light grey mottled orange brown.  |                                |                        | >600<br>>600<br>>600              |                     |
|                    |         |     |    | N = 17<br>4,8,9                      |             | 2         |             | CL                     | SILTY CLAY: low plasticity, light grey and red brown, trace of fine grained sand.  |                                |                        | >600<br>>600<br>>600              |                     |
|                    |         |     |    |                                      |             | 3         |             |                        |  |                                |                        | >600<br>>600<br>>600              |                     |
|                    |         |     |    |                                      |             | 4         |             | SM                     | SILTY SAND: fine grained, orange brown, with clay fines.   | D                              | MD                     |                                   |                     |
|                    |         |     |    |                                      |             | 5         |             |                        |  |                                |                        |                                   |                     |
|                    |         |     |    |                                      |             | 6         |             | SG                     | SILTY GRAVELLY SAND: fine grained, orange brown, medium to coarse alluvial gravel.   | M                              |                        |                                   | COMMENCE WASHBORING |
|                    |         |     |    | N > 25<br>18,25/<br>100mm<br>REFUSAL |             | 7         |             | GM                     | SILTY GRAVEL: medium to coarse grained, alluvial, with alluvial cobbles.   |                                |                        |                                   |                     |

ON COMPLETION OF WASHBORING

AFTER 18 HRS

ON 9/9/14

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# BOREHOLE LOG

**Client:** ST HILLIERS  
**Project:** PROPOSED RESIDENTIAL DEVELOPMENT  
**Location:** LOT 3007, THORNTON DEVELOPMENT, LORD SHEFFIELD CIRCUIT, PENRITH, NSW

**Job No.** 27694ZN      **Method:** SPIRAL AUGER JK500      **R.L. Surface:** N/A  
**Date:** 3-9-14      **Datum:**  
**Logged/Checked by:** D.S./N.E.S.

| Groundwater Record                | SAMPLES |     |    |                   | Field Tests       | Depth (m) | Graphic Log | Unified Classification  | DESCRIPTION   | Moisture Condition/Weathering | Strength/Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks          |
|-----------------------------------|---------|-----|----|-------------------|-------------------|-----------|-------------|---|---|-------------------------------|-----------------------|-----------------------------------|------------------|
|                                   | FS      | U50 | DB | DS                |                   |           |             |   |   |                               |                       |                                   |                  |
| DRY ON COMPLETION & AFTER 3.5 HRS |         |     |    |                   |                   | 0         |             |   | FILL: Silty clay topsoil, low plasticity, brown, with fine to coarse grained sandstone, shale and igneous gravel, trace of fine to medium grained sand and root fibres. | MC>PL                         |                       |                                   | GRASS COVER      |
|                                   |         |     |    |                   | N = 22<br>7,10,12 | 0.5       |             | CH  | SILTY CLAY: high plasticity, brown.   | MC<PL                         | H                     | >600<br>>600<br>>600              | ALLUVIAL         |
|                                   |         |     |    |                   | N = 30<br>6,14,16 | 1.5       |             | CL  | SILTY SANDY CLAY: low plasticity, brown, orange brown and light grey, fine to medium grained sand.  |                               |                       | >600<br>>600<br>>600              |                  |
|                                   |         |     |    |                   | N = 20<br>6,10,10 | 2.5       |             | SC  | SILTY CLAYEY SAND: fine to medium grained, brown, orange brown and light grey.  | D                             | MD                    |                                   |                  |
|                                   |         |     |    |                   | N = 13<br>8,6,7   | 4.5       |             | SM  | SILTY SAND: fine grained, brown.  |                               |                       |                                   |                  |
|                                   |         |     |    |                   |                   | 5.5       |             | GP  | as above, but with medium to coarse grained alluvial gravel and alluvial cobbles.   |                               | (MD)                  |                                   |                  |
|                                   |         |     |    | Nc= 12/50<br>REF. | 6                 |           |             | GRAVEL: medium to coarse grained, alluvial, blue grey, with fine to medium grained sand, silt fines and alluvial cobbles.<br>END OF BOREHOLE AT 5.85m |   |                               |                       |                                   | 'TC' BIT REFUSAL |
|                                   |         |     |    |                   | 7                 |           |             |   |   |                               |                       |                                   |                  |

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Borehole No.  
**3**  
 1/1

# BOREHOLE LOG

**Client:** ST HILLIERS  
**Project:** PROPOSED RESIDENTIAL DEVELOPMENT  
**Location:** LOT 3007, THORNTON DEVELOPMENT, LORD SHEFFIELD CIRCUIT, PENRITH, NSW

**Job No.** 27694ZN      **Method:** SPIRAL AUGER JK500      **R.L. Surface:** N/A  
**Date:** 3-9-14      **Datum:**  
**Logged/Checked by:** D.S./N.E.S.

| Groundwater Record              | SAMPLES |     |                         | Field Tests      | Depth (m) | Graphic Log | Unified Classification  | DESCRIPTION   | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.)    | Remarks   |
|---------------------------------|---------|-----|-------------------------|------------------|-----------|-------------|-------------------------|---|--------------------------------|------------------------|--------------------------------------|---|
|                                 | ES      | USO | DB DS                   |                  |           |             |                         |   |                                |                        |                                      |   |
| DRY ON COMPLETION AND ON 9/9/14 |         |     |                         |                  | 0         |             | CH                      | FILL: Silty gravelly clay, low plasticity, dark brown, fine to medium grained shale, sandstone and igneous gravel trace of root fibres.<br>SILTY CLAY: high plasticity, light brown mottled light grey. | MC>PL / MC>PL                  | VSt                    |                                      | GRASS COVER ALLUVIAL  |
|                                 |         |     |                         | N = 9<br>3,4,5   | 1         |             |                         | as above, but light grey.   | MC<PL                          | H                      | 300<br>310<br>320                    |   |
|                                 |         |     |                         | N = 24<br>3,6,18 | 2         |             | CL                      | SILTY CLAY: low plasticity, light grey and orange brown, with fine to medium grained sand.  |                                |                        | >600<br>>600<br>>600<br>>600<br>>600 |   |
|                                 |         |     |                         |                  | 3         |             | SM                      | SILTY SAND: fine grained, light grey and orange brown.  | D                              | MD                     |                                      | TOO FRIABLE FOR HP TESTING  |
|                                 |         |     |                         | N = 16<br>5,7,9  | 4         |             | ML                      | SANDY SILT: low plasticity, brown, fine grained sand.   | MC<PL                          | (VSt-H)                |                                      | CLASS 18 uPVC STANDPIPE INSTALLED TO 5.8m DEPTH, MACHINE SLOTTED BETWEEN 5.8m AND 1m, CASING FROM 1m TO SURFACE, BACKFILLED WITH 2mm SAND FILTER SAND BETWEEN 5.8m AND 1m, BENTONITE SEAL BETWEEN 1m AND 0.5m, BACKFILLED WITH DRILL SPOIL TO SURFACE |
|                                 |         |     |                         | N = 18<br>5,9,9  | 5         |             | SG                      | SANDY SILTY GRAVEL: medium to coarse grained, alluvial, blue grey, with alluvial cobbles.   | D                              | MD                     |                                      |   |
|                                 |         |     | Nc= 10/<br>100mm<br>REF | 6                |           |             | END OF BOREHOLE AT 5.8m |   |                                |                        |                                      | 'TC' BIT REFUSAL  |
|                                 |         |     |                         | 7                |           |             |                         |   |                                |                        |                                      |   |

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Borehole No.  
**4**  
 1/1

# BOREHOLE LOG

**Client:** ST HILLIERS  
**Project:** PROPOSED RESIDENTIAL DEVELOPMENT  
**Location:** LOT 3007, THORNTON DEVELOPMENT, LORD SHEFFIELD CIRCUIT, PENRITH, NSW

**Job No.** 27694ZN      **Method:** SPIRAL AUGER JK500      **R.L. Surface:** N/A  
**Date:** 3-9-14      **Datum:**  
**Logged/Checked by:** D.S./N.E.S.

| Groundwater Record | SAMPLES |     |  | Field Tests       | Depth (m) | Graphic Log | Unified Classification  | DESCRIPTION  | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks              |
|--------------------|---------|-----|--|-------------------|-----------|-------------|---|--|--------------------------------|------------------------|-----------------------------------|----------------------|
|                    | ES      | U50 | DB   |                   |           |             |   |  |                                |                        |                                   |                      |
| DRY ON COMPLETION  |         |     |  |                   | 0         |             | CL  | FILL: Silty gravelly clay, low plasticity, brown, fine to coarse grained igneous gravel, trace of root fibres.<br>SILTY CLAY: medium plasticity, light grey, trace of ash. | MC>PL<br>MC>PL                 | St                     |                                   | GRASS COVER ALLUVIAL |
|                    |         |     |  | N = 7<br>2,3,4    | 1         |             |   | SILTY CLAY: medium plasticity, light grey and orange brown, trace of fine grained sand.  |                                | VSt                    | 180<br>180<br>180                 |                      |
|                    |         |     |  | N = 11<br>3,4,7   | 2         |             |   | SILTY SANDY CLAY: low plasticity, light grey mottled dark grey and orange brown.   | MC~PL                          | H                      |                                   |                      |
|                    |         |     |  | N = 20<br>7,10,10 | 3         |             |   |  |                                |                        | >600<br>540<br>>600               |                      |
|                    |         |     |  | N = 22<br>6,10,12 | 4         |             | SC  | SILTY CLAYEY SAND: fine to medium grained, light grey and orange brown.  | D                              | MD                     |                                   |                      |
|                    |         |     |  |                   | 5         |             | SM  | SILTY SAND: fine to medium grained, orange brown.  |                                |                        |                                   |                      |
|                    |         |     | SPT<br>11/150mm<br>REFUSAL<br>Nc=15<br>REF | 6                 |           | GP          | SILTY SANDY GRAVEL: medium to coarse grained, alluvial, blue grey, with alluvial cobbles.<br>END OF BOREHOLE AT 6.45m |  |                                |                        |                                   | 'TC' BIT REFUSAL     |
|                    |         |     |  | 7                 |           |             |   |  |                                |                        |                                   |                      |

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# BOREHOLE LOG

**Client:** ST HILLIERS  
**Project:** PROPOSED RESIDENTIAL DEVELOPMENT  
**Location:** LOT 3007, THORNTON DEVELOPMENT, LORD SHEFFIELD CIRCUIT, PENRITH, NSW

**Job No.** 27694ZN      **Method:** SPIRAL AUGER AND TUBEX JK305      **R.L. Surface:** N/A  
**Date:** 9-9-14      **Datum:**

**Logged/Checked by:** D.S./N.E.S. *[Signature]*

| Groundwater Record | SAMPLES |     |    |    | Field Tests | Depth (m) | Graphic Log | Unified Classification | DESCRIPTION  | Moisture Condition/Weathering | Strength/Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks  |
|--------------------|---------|-----|----|----|-------------|-----------|-------------|------------------------|--|-------------------------------|-----------------------|-----------------------------------|--|
|                    | ES      | U50 | DB | DS |             |           |             |                        |  |                               |                       |                                   |  |
|                    |         |     |    |    |             | 0         |             |                        | FILL: Silty clay, medium plasticity, brown, with fine to coarse grained igneous and shale gravel.                      | MC<PL                         |                       |                                   |  |
|                    |         |     |    |    |             | 1         |             | CH                     | SILTY CLAY: high plasticity, light grey mottled brown, trace of ash.   | MC<PL                         | H                     | >600<br>>600<br>>600              | ALLUVIAL<br><br>HAND PENETROMETER TESTING ON REMOULDED SAMPLES |
|                    |         |     |    |    |             | 2         |             |                        | SILTY CLAY: high plasticity, light brown.  | MC>PL                         | VSt-H                 | 350<br>380<br>400                 |  |
|                    |         |     |    |    |             | 3         |             | CL                     | SILTY CLAY: medium plasticity, orange brown mottled light grey, trace of fine grained sand.                            | MC<PL                         | H                     | >600<br>>600<br>>600              |  |
|                    |         |     |    |    |             | 4         |             | CL                     | SILTY SANDY CLAY: low plasticity, orange brown and light grey, fine grained sand.                                      |                               |                       |                                   |  |
|                    |         |     |    |    |             | 5         |             | SM                     | SILTY SAND: fine to medium grained, orange brown, with clay fines.   | D                             |                       |                                   | TOO FRIABLE FOR HAND PENETROMETER TESTING                      |
|                    |         |     |    |    |             | 6         |             |                        |  |                               |                       |                                   |  |
|                    |         |     |    |    |             | 7         |             | GS                     | SILTY SANDY GRAVEL: medium to coarse grained, alluvial, blue grey, fine to medium grained sand, with alluvial cobbles. | D                             | (MD)                  |                                   | COMMENCE TUBEX DRILLING  |

ON COMPLETION OF CORING

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Borehole No.  
**5**  
 2/3

# BOREHOLE LOG

**Client:** ST HILLIERS  
**Project:** PROPOSED RESIDENTIAL DEVELOPMENT  
**Location:** LOT 3007, THORNTON DEVELOPMENT, LORD SHEFFIELD CIRCUIT, PENRITH, NSW

**Job No.** 27694ZN      **Method:** SPIRAL AUGER AND TUBEX JK305      **R.L. Surface:** N/A  
**Date:** 9-9-14      **Datum:**  
**Logged/Checked by:** D.S./N.E.S.

| Groundwater Record | SAMPLES |     |    |    | Field Tests | Depth (m) | Graphic Log | Unified Classification | DESCRIPTION  | Moisture Condition/ Weathering | Strength/ Rel. Density | Hand Penetrometer Readings (kPa.) | Remarks   |
|--------------------|---------|-----|----|----|-------------|-----------|-------------|------------------------|--|--------------------------------|------------------------|-----------------------------------|---|
|                    | FS      | U50 | DB | DS |             |           |             |                        |  |                                |                        |                                   |   |
|                    |         |     |    |    |             | 8         |             | GS                     | SANDY GRAVEL: medium to coarse grained, alluvial, blue grey, with alluvial cobbles.                            | D                              | (MD)                   |                                   |   |
|                    |         |     |    |    |             | 9         |             | GP                     | GRAVEL: medium to coarse grained, alluvial, blue grey, with fine to medium grained sand, and alluvial cobbles. |                                |                        |                                   |   |
|                    |         |     |    |    |             | 10        |             |                        |  |                                |                        |                                   |   |
|                    |         |     |    |    |             | 11        |             |                        |  |                                |                        |                                   |   |
|                    |         |     |    |    |             | 12        |             |                        |  |                                |                        |                                   |   |
|                    |         |     |    |    |             |           |             | -                      | INTERBEDDED SANDSTONE AND SHALE: fine grained, light grey and dark grey.                                       | DW                             | (L)                    |                                   | CLASS 18 uPVC STAND PIPE INSTALLED TO 15.65m DEPTH. MACHINE SLOTTED BETWEEN 3.65m DEPTH TO 15.65m DEPTH. CASING BETWEEN 3.65m DEPTH AND SURFACE. BACK FILLED WITH 2mm FILTER SAND BETWEEN 15.65m DEPTH AND 1m DEPTH. BENTONITE SEAL BETWEEN 0.5m TO 1m DEPTH. BACK FILLED WITH SOIL TO SURFACE. |
|                    |         |     |    |    |             | 13        |             |                        | REFER TO CORED BOREHOLE LOG  |                                |                        |                                   |   |
|                    |         |     |    |    |             | 14        |             |                        |  |                                |                        |                                   |   |

ON COMPLETION OF HAMMER DRILLING

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# CORED BOREHOLE LOG

Borehole No.

**5**

3/3

|                          |  |                                       |
|--------------------------|--|---------------------------------------|
| <b>Client:</b>           | ST HILLIERS  |                                       |
| <b>Project:</b>          | PROPOSED RESIDENTIAL DEVELOPMENT                                     |                                       |
| <b>Location:</b>         | LOT 3007, THORNTON DEVELOPMENT, LORD SHEFFIELD CIRCUIT, PENRITH, NSW |                                       |
| <b>Job No.</b> 27694ZN   | <b>Core Size:</b> NMLC   | <b>R.L. Surface:</b> N/A              |
| <b>Date:</b> 9-9-14      | <b>Inclination:</b> VERTICAL   | <b>Datum:</b>                         |
| <b>Drill Type:</b> JK305 | <b>Bearing:</b> -  | <b>Logged/Checked by:</b> D.S./N.E.S. |

| Water Loss/Level | Barrel Lift | Depth (m) | Graphic Log | CORE DESCRIPTION<br>Rock Type, grain characteristics, colour, structure, minor components.                        | Weathering | Strength | POINT LOAD STRENGTH INDEX<br>I <sub>s</sub> (50) | DEFECT DETAILS      |    |   |   |   |             |    |     |     |  |
|------------------|-------------|-----------|-------------|---|------------|----------|--|---------------------|----|---|---|---|-------------|----|-----|-----|--|
|                  |             |           |             |   |            |          |  | DEFECT SPACING (mm) |    |   |   |   | DESCRIPTION |    |     |     |  |
|                  |             |           |             |   |            |          |  | EL                  | VL | L | M | H | VH          | EH | 500 | 300 | 100  |
|                  |             | 12        |             | START CORING AT 12.78m  |            |          |  |                     |    |   |   |   |             |    |     |     |  |
| NO RETURN        |             | 13        |             | SANDSTONE: fine grained, light grey.  | DW         | M        | .  |                     |    |   |   |   |             |    |     |     | - CS, 0°, 2mm.t<br>- CS, 0°, 2mm.t   |
|                  |             | 13        |             | CORE LOSS 0.12m   | DW         | M        | .  |                     |    |   |   |   |             |    |     |     | - J, 0°, IS<br>- J, 0°, IS<br>- CS, 0°, 20mm.t<br>- Be, 0°, P, S, 10mm.t, CLAY INFILL<br>- CS, 0°, 5mm.t |
|                  |             | 14        |             | INTERBEDDED SANDSTONE AND SHALE: fine grained, light grey and dark grey, bedded @ 0°-10°, with VH strength bands. |            |          | .  |                     |    |   |   |   |             |    |     |     | - CS, 0°, 3mm.t<br>- CS, 10°, 10mm.t<br>- XWS, 0°, 10mm.t<br>- XWS, 0°, Un, 3mm.t                        |
|                  |             | 14        |             | CORE LOSS 0.12m   |            |          | .  |                     |    |   |   |   |             |    |     |     | - Be, 0°, P, S   |
|                  |             | 15        |             | INTERBEDDED SANDSTONE AND SHALE: fine grained, light grey and dark grey, bedded at 0°-10°.                        | DW         | H        | .  |                     |    |   |   |   |             |    |     |     | - NUMEROUS BEDDING, 0°-10°, P, S, SPACED ≈ 20mm APART  |
|                  |             | 15        |             | END OF BOREHOLE AT 15.65m   |            |          |  |                     |    |   |   |   |             |    |     |     |  |
|                  |             | 16        |             |   |            |          |  |                     |    |   |   |   |             |    |     |     |  |
|                  |             | 17        |             |   |            |          |  |                     |    |   |   |   |             |    |     |     |  |
|                  |             | 18        |             |   |            |          |  |                     |    |   |   |   |             |    |     |     |  |

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**JK Geotechnics**



JOB No. 276942N BH5 START CORING AT 12.78m

12

13

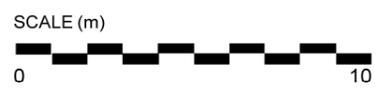
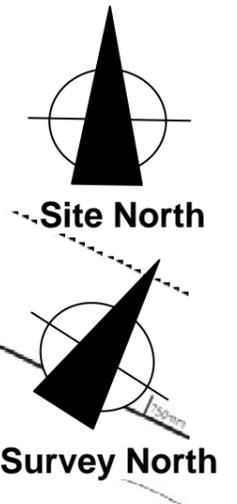
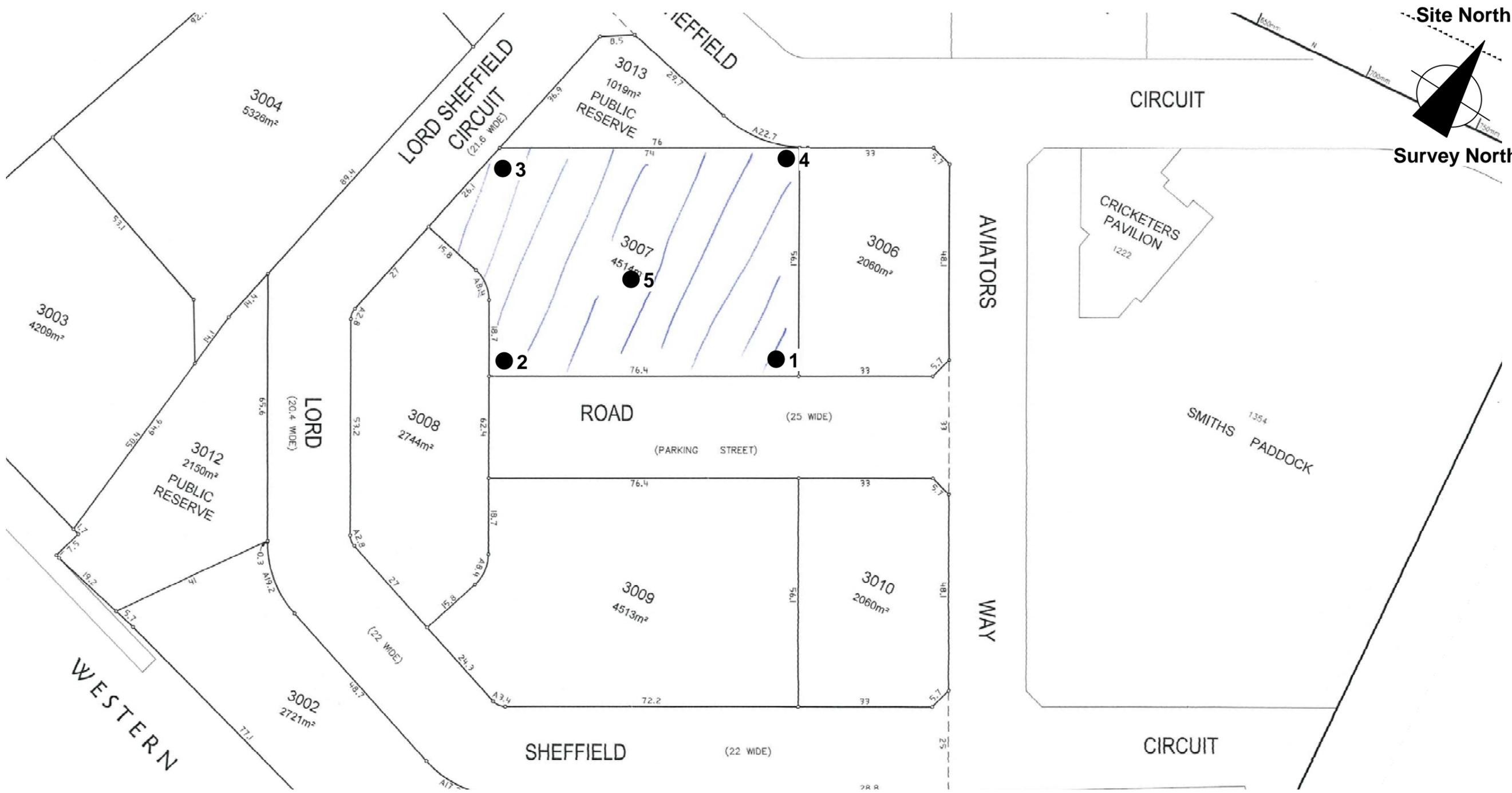
CORE  
LOSS  
0.12m

14

CORE  
LOSS 0.12m

15

END BH AT 15.65m

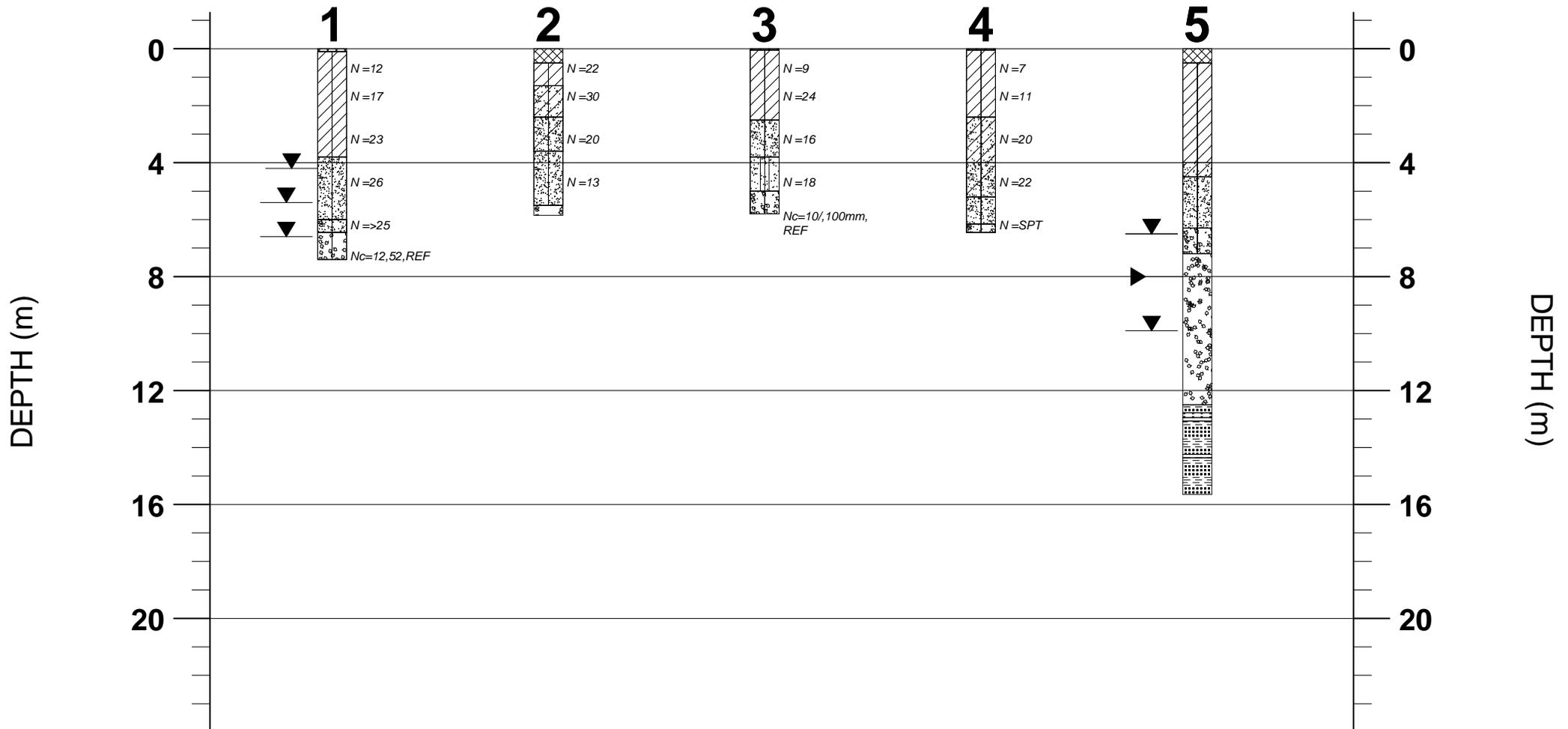


### BOREHOLE LOCATION PLAN

**JK Geotechnics**  
 GEOTECHNICAL & ENVIRONMENTAL ENGINEERS  
 Report No. 27694ZN      Figure No. 1



# GRAPHICAL BOREHOLE SUMMARY





## REPORT EXPLANATION NOTES

### INTRODUCTION

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

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

### DESCRIPTION AND CLASSIFICATION METHODS

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

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

| Soil Classification | Particle Size     |
|---------------------|-------------------|
| Clay                | less than 0.002mm |
| Silt                | 0.002 to 0.075mm  |
| Sand                | 0.075 to 2mm      |
| Gravel              | 2 to 60mm         |

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

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

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

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

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

### SAMPLING

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

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

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

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

### INVESTIGATION METHODS

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



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

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

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

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

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

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

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

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

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

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as  
N = 13  
4, 6, 7
- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as  
N > 30  
15, 30/40mm

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

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

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



### Static Cone Penetrometer Testing and Interpretation:

Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

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

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

The information provided on the charts comprise:

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

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

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

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

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

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

Two relatively similar tests are used:

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

### LOGS

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

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

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

### GROUNDWATER

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

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



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

#### **FILL**

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

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

#### **LABORATORY TESTING**

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

#### **ENGINEERING REPORTS**

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

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

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

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

#### **SITE ANOMALIES**

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

#### **REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES**

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

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

#### **REVIEW OF DESIGN**

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

#### **SITE INSPECTION**

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

Requirements could range from:

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



**GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS**

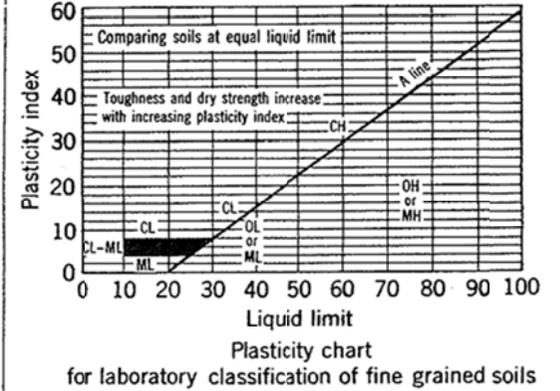
| SOIL  |                        | ROCK  |                                | DEFECTS AND INCLUSIONS  |                                   |
|---|------------------------|---|--------------------------------|---|-----------------------------------|
|    | FILL                   |    | CONGLOMERATE                   |    | CLAY SEAM                         |
|    | TOPSOIL                |    | SANDSTONE                      |    | SHEARED OR CRUSHED SEAM           |
|    | CLAY (CL, CH)          |    | SHALE                          |    | BRECCIATED OR SHATTERED SEAM/ZONE |
|    | SILT (ML, MH)          |    | SILTSTONE, MUDSTONE, CLAYSTONE |    | IRONSTONE GRAVEL                  |
|    | SAND (SP, SW)          |    | LIMESTONE                      |    | ORGANIC MATERIAL                  |
|    | GRAVEL (GP, GW)        |    | PHYLLITE, SCHIST               | <b>OTHER MATERIALS</b>  |                                   |
|  | SANDY CLAY (CL, CH)    |  | TUFF                           |  | CONCRETE                          |
|  | SILTY CLAY (CL, CH)    |  | GRANITE, GABBRO                |  | BITUMINOUS CONCRETE, COAL         |
|  | CLAYEY SAND (SC)       |  | DOLERITE, DIORITE              |  | COLLUVIUM                         |
|  | SILTY SAND (SM)        |  | BASALT, ANDESITE               |   |                                   |
|  | GRAVELLY CLAY (CL, CH) |  | QUARTZITE                      |   |                                   |
|  | CLAYEY GRAVEL (GC)     |   |                                |   |                                   |
|  | SANDY SILT (ML)        |   |                                |   |                                   |
|  | PEAT AND ORGANIC SOILS |   |                                |   |                                   |



## UNIFIED SOIL CLASSIFICATION TABLE

| Field Identification Procedures<br>(Excluding particles larger than 75 μm and basing fractions on estimated weights)   |  |  | Group Symbols<br>&                                      | Typical Names   | Information Required for Describing Soils   | Laboratory Classification Criteria  |   |  |  |           |
|--|--|--|---|---|---|---|---|--|--|-----------|
| <b>Coarse-grained soils</b><br>More than half of material is larger than 75 μm sieve size <sup>b</sup><br>(The 75 μm sieve size is about the smallest particle visible to naked eye) | <b>Gravels</b><br>More than half of coarse fraction is larger than 4 mm sieve size   | Clean gravels (little or no fines)   | <i>GW</i>   | Well graded gravels, gravel-sand mixtures, little or no fines   | Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses<br><br>For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics<br><br>Example:<br><i>Silty sand, gravelly</i> ; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; ( <i>SM</i> ) | $C_U = \frac{D_{60}}{D_{10}} \text{ Greater than 4}$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} \text{ Between 1 and 3}$ Not meeting all gradation requirements for <i>GW</i> |   |  |  |           |
|  |  | Gravels with fines (appreciable amount of fines)                                   | <i>GP</i>   | Poorly graded gravels, gravel-sand mixtures, little or no fines |   |   | Atterberg limits below "A" line, or <i>PI</i> less than 4<br><br>Atterberg limits above "A" line, with <i>PI</i> greater than 7   |  |  |           |
|  |  | Nonplastic fines (for identification procedures see <i>ML</i> below)               | <i>GM</i>   | Silty gravels, poorly graded gravel-sand-silt mixtures          |   |   |   |  |  |           |
|  | <b>Sands</b><br>More than half of coarse fraction is smaller than 4 mm sieve size  | Clean sands (little or no fines)   | <i>GC</i>   | Clayey gravels, poorly graded gravel-sand-clay mixtures         |   |   | Determine percentages of gravel and sand from grain size curve<br>Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows:<br>Less than 5% <i>GW, GP, SW, SP</i><br>More than 5% to 12% <i>GM, GC, SM, SC</i><br>5% to 12% <i>Borderline</i> cases requiring use of dual symbols | $C_U = \frac{D_{60}}{D_{10}} \text{ Greater than 6}$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} \text{ Between 1 and 3}$ Not meeting all gradation requirements for <i>SW</i>  |  |           |
|  |  |  | <i>SW</i>   | Well graded sands, gravelly sands, little or no fines           |   |   |   |  |  |           |
|  |  | <i>SP</i>  | Poorly graded sands, gravelly sands, little or no fines |   |   |   |   |  |  |           |
|  |  | Sands with fines (appreciable amount of fines)                                     | <i>SM</i>   | Silty sands, poorly graded sand-silt mixtures                   |   |   |   |  |  |           |
|  | <b>Fine-grained soils</b><br>More than half of material is smaller than 75 μm sieve size<br>(The 75 μm sieve size is about the smallest particle visible to naked eye) | Identification Procedures on Fraction Smaller than 380 μm Sieve Size               |   |   |   |   |   | Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses<br><br>For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions<br><br>Example:<br><i>Clayey silt, brown</i> ; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; ( <i>ML</i> ) | Atterberg limits below "A" line with <i>PI</i> greater than 5<br><br>Atterberg limits below "A" line with <i>PI</i> greater than 7 |           |
|  |  | Silts and clays liquid limit less than 50  | Dry Strength (crushing characteristics)                 | Dilatancy (reaction to shaking)                                 |   |   | Toughness (consistency near plastic limit)  |  |  |           |
|  |  |  | None to slight  | Quick to slow   |   |   | None  |  |  | <i>ML</i> |
| Medium to high   |  |  | None to very slow                                       | Medium  | <i>CL</i>   | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays   |   |  |  |           |
| Slight to medium   |  |  | Slow  | Slight  | <i>OL</i>   | Organic silts and organic silt-clays of low plasticity  |   |  |  |           |
| Slight to medium   |  |  | Slow to none  | Slight to medium  | <i>MH</i>   | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts   |   |  |  |           |
| High to very high  |  |  | None  | High  | <i>CH</i>   | Inorganic clays of high plasticity, fat clays   |   |  |  |           |
| Medium to high   | None to very slow  | Slight to medium   | <i>OH</i>   | Organic clays of medium to high plasticity                      |   |   |   |  |  |           |
| Highly Organic Soils   |  | Readily identified by colour, odour, spongy feel and frequently by fibrous texture | <i>Pt</i>   | Peat and other highly organic soils                             |   |   |   |  |  |           |

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



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



**LOG SYMBOLS**

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



## LOG SYMBOLS continued

### ROCK MATERIAL WEATHERING CLASSIFICATION

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

### ROCK STRENGTH

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

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

### ABBREVIATIONS USED IN DEFECT DESCRIPTION

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

# APPENDIX A

**CERTIFICATE OF ANALYSIS**

**115736**

**Client:**

**JK Geotechnics**  
PO Box 976  
North Ryde BC  
NSW 1670

**Attention:** David Schwarzer

**Sample log in details:**

Your Reference:

**27694ZN, Lord Sheffield Circuit**

No. of samples:

4 Soils

Date samples received / completed instructions received

05/09/2014 / 05/09/2014

**Analysis Details:**

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

***Please refer to the last page of this report for any comments relating to the results.***

**Report Details:**

Date results requested by: / Issue Date:

12/09/14 / 12/09/14

Date of Preliminary Report:

Not Issued

NATA accreditation number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025.

**Tests not covered by NATA are denoted with \*.**

**Results Approved By:**

  
Jacinta Hurst  
Laboratory Manager

Envirolab Reference: 115736  
Revision No: R 00



| Miscellaneous Inorg - soil             |          |            |            |            |            |
|--|----------|------------|------------|------------|------------|
| Our Reference:                         | UNITS    | 115736-1   | 115736-2   | 115736-3   | 115736-4   |
| Your Reference                         | -----    | 1          | 1          | 3          | 3          |
| Depth                                  | -----    | 1.5-1.95   | 4.5-4.95   | 1.5-1.8    | 4.5-4.95   |
| Date Sampled                           |          | 2/09/2014  | 2/09/2014  | 3/09/2014  | 3/09/2014  |
| Type of sample                         |          | Soil       | Soil       | Soil       | Soil       |
| Date prepared                          | -        | 08/09/2014 | 08/09/2014 | 08/09/2014 | 08/09/2014 |
| Date analysed                          | -        | 09/09/2014 | 09/09/2014 | 09/09/2014 | 09/09/2014 |
| pH 1:5 soil:water                      | pH Units | 4.4        | 7.9        | 5.1        | 7.4        |
| Sulphate, SO4 1:5 soil:water           | mg/kg    | <10        | <10        | <10        | 10         |
| Chloride, Cl 1:5 soil:water            | mg/kg    | 1,200      | 200        | 600        | 300        |
| Electrical Conductivity 1:5 soil:water | µS/cm    | 710        | 150        | 390        | 230        |
| Resistivity in soil*                   | ohmm     | 14         | 68         | 26         | 43         |

Client Reference: 27694ZN, Lord Sheffield Circuit

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

Envirolab Reference: 115736  
Revision No: R 00

Client Reference: 27694ZN, Lord Sheffield Circuit

| QUALITY CONTROL                        | UNITS    | PQL | METHOD    | Blank      | Duplicate Sm#           | Duplicate results         | Spike Sm#        | Spike % Recovery |
|--|----------|-----|-----------|------------|-------------------------|---------------------------|------------------|------------------|
| Miscellaneous Inorg - soil             |          |     |           |            |                         | Base    Duplicate    %RPD |                  |                  |
| Date prepared                          | -        |     |           | 08/09/2014 | 115736-1                | 08/09/2014    08/09/2014  | LCS-1            | 08/09/2014       |
| Date analysed                          | -        |     |           | 09/09/2014 | 115736-1                | 09/09/2014    09/09/2014  | LCS-1            | 09/09/2014       |
| pH 1:5 soil:water                      | pH Units |     | Inorg-001 | [NT]       | 115736-1                | 4.4    4.2    RPD: 5      | LCS-1            | 102%             |
| Sulphate, SO4 1:5 soil:water           | mg/kg    | 10  | Inorg-081 | <10        | 115736-1                | <10    <10                | LCS-1            | 105%             |
| Chloride, Cl 1:5 soil:water            | mg/kg    | 10  | Inorg-081 | <10        | 115736-1                | 1200    1000    RPD: 18   | LCS-1            | 90%              |
| Electrical Conductivity 1:5 soil:water | µS/cm    | 1   | Inorg-002 | <1         | 115736-1                | 710    840    RPD: 17     | LCS-1            | 101%             |
| Resistivity in soil*                   | ohm m    | 1   | Inorg-002 | <1.0       | 115736-1                | 14    12    RPD: 15       | LCS-1            | 101%             |
| QUALITY CONTROL                        | UNITS    |     | Dup. Sm#  |            | Duplicate               | Spike Sm#                 | Spike % Recovery |                  |
| Miscellaneous Inorg - soil             |          |     |           |            | Base + Duplicate + %RPD |                           |                  |                  |
| Date prepared                          | -        |     | [NT]      |            | [NT]                    | 115736-2                  | 08/09/2014       |                  |
| Date analysed                          | -        |     | [NT]      |            | [NT]                    | 115736-2                  | 09/09/2014       |                  |
| pH 1:5 soil:water                      | pH Units |     | [NT]      |            | [NT]                    | [NR]                      | [NR]             |                  |
| Sulphate, SO4 1:5 soil:water           | mg/kg    |     | [NT]      |            | [NT]                    | 115736-2                  | 99%              |                  |
| Chloride, Cl 1:5 soil:water            | mg/kg    |     | [NT]      |            | [NT]                    | 115736-2                  | 72%              |                  |
| Electrical Conductivity 1:5 soil:water | µS/cm    |     | [NT]      |            | [NT]                    | [NR]                      | [NR]             |                  |
| Resistivity in soil*                   | ohm m    |     | [NT]      |            | [NT]                    | [NR]                      | [NR]             |                  |

Envirolab Reference: 115736  
Revision No: R 00

**Report Comments:**

Asbestos ID was analysed by Approved Identifier:  
Asbestos ID was authorised by Approved Signatory:

Not applicable for this job  
Not applicable for this job

INS: Insufficient sample for this test  
NA: Test not required  
<: Less than

PQL: Practical Quantitation Limit  
RPD: Relative Percent Difference  
>: Greater than

NT: Not tested  
NA: Test not required  
LCS: Laboratory Control Sample

### Quality Control Definitions

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

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

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

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

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

### Laboratory Acceptance Criteria

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

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC 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.