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TCG PLANNING

PROPOSED LIFE CITY WOLLONGONG

WARWICK STREET BERKELEY

GEOTECHNICAL INVESTIGATION

REPORT G09/1100-Ar JANUARY 2014

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G09/1100 Ar LT: lt
29th January 2014

TCG Planning
5-174/182 Gipps Road
GWYNNEVILLE NSW 2500

Attention: Elaine Treglown

Dear Madam

Re: Proposed Life City Wollongong, Warwick Street, Berkeley

This report presents the results of a geotechnical investigation carried out for the above project.

We have reviewed the data available from previous investigations by others and carried out field and laboratory testing in order to provide a geotechnical model including material properties and design parameters.

The investigation comprised twelve (12) boreholes (BH1 to BH9 and BH31 to BH33) drilled for geotechnical investigation and thirteen boreholes (BH10 to BH22) drilled for preliminary contamination assessment.

Laboratory tests included Acid Sulphate Screening, Point Load Strength Index on rock core samples and chemical tests for exposure classification.

A separate report is issued providing details of contamination assessment and acid sulphate assessment.

This report should be read in conjunction with the attached General Notes. Please contact the undersigned if you require any further assistance.

For and on behalf of
Network Geotechnics Pty Ltd

Long Tsang *BEng, MEng, MIE Aust*
Geotechnical Engineer

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EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation carried out by Network Geotechnics Pty Ltd (NG) for the proposed Life City Wollongong in Berkeley, NSW.

The objective of the investigation was to assess surface and subsurface condition in order to assist in the evaluation of the Development Application Lodged with the Department of Planning for the proposed Life City Project which includes a multi stage development comprising a medical centre, accommodation for patients, hospital, seniors accommodation and other facilities.

The sampling program included total 25 boreholes, BH1 to BH9 and BH31 to BH33 were drilled for geotechnical investigation and BH10 to BH22 were drilled for Stage 1 Contamination Assessment. A separate report is issued providing details of contamination assessment.

Based on the boreholes drilled, subsurface profiles in the study area may be generally summarised below:

- Fill: mostly comprised of Silty CLAY, medium to high plasticity, with fine to medium grained sandstone, igneous and ironstone gravel and roots inclusions.
- Topsoil: Silty CLAY/Silty SAND, high plasticity, fine to medium grained sand, dark brown, with roots.
- Residual Soils: Silty CLAY/Sandy CLAY, medium to high plasticity, fine to medium grained sand, generally orange brown and red brown, trace of fine grained sandstone and ironstone gravel.
- Bedrock: SANDSTONE, fine to medium grained, generally orange brown and red brown, typically extremely low to very low strength over the upper layers and becoming high to very high strength. Latite was only encountered below the proposed basement levels in the boreholes drilled.

In the view of above, a summary of findings and recommendations are listed below:

- Fill was predominantly encountered in the northern part of the site to maximum depths of 1.7m below the existing grade. Some surface rubbish was noted along the existing top ridgeline vehicular track.

- Majority of the site surface was covered by Silty CLAY/Silty SAND topsoil with thick grass. Shrub and small to medium size trees spread around the site.

- Slope instability would not be an issue provided the design and construction is carried out based on good hill side development practice as outlined in this report.

- Fill, Residual/Colluvial soils and extremely weathered rock profiles can be excavated by medium size excavators with 'teeth' bucket attachments. Rock hammer/rock saw might be required to break through iron indurated bands and medium to high strength Sandstone and Latite bedrock.

- Groundwater may be encountered during the construction; but it could be controlled using a sump pump system.

- Potential Acid Sulphate and Actual Acid Sulphate soils were not encountered in this site.

- Footings for major structures should be founded on underlying bedrock.

- Localised retaining structures should be provided for supporting the proposed cuts and fill batters. The structures should be designed by an experienced engineering consultant. Where excavation is in good quality rock, steep unsupported batters may be possible subjected to geotechnical assessment

- Temporary excavations may be battered at 1.5H:1V in overburden soils and 1H:1V to 0.5H:1V in rock depending upon the quality of rock and subject to assessment by a geotechnical consultant.

- Further geotechnical investigations and review may be required during the detailed design and construction stages.

1.0 INTRODUCTION

Network Geotechnics Pty Ltd (NG) was engaged by TCG Planning Pty Ltd to undertake a Geotechnical and Preliminary Contamination Assessment for the proposed Life City Wollongong in Berkeley, NSW. The investigation was carried out in accordance with NG proposal (Ref: G09/1100r dated 04 September 2013).

A preliminary geotechnical investigation has been carried out by Coffey Geotechnics (report Reference GEOTWOLLO3229AC-AB dated February 2013). The geotechnical investigation report has been assessed by SKM during the assessment of the development application by the Department of Planning and additional geotechnical investigations to supplement the preliminary investigation have been requested.

The purpose of the investigation was to obtain geotechnical information on subsurface conditions at twelve boreholes in correlation with Coffey's test pit logs and laboratory testing to form a basis for comments and recommendations for the proposed developments.

A preliminary contamination investigation was carried out in conjunction with the geotechnical investigation. A separate report is issued providing details of contamination assessment and acid sulphate assessment.

2.0 PROPOSED DEVELOPMENT

Based on the supplied conceptual plans, we understand the proposed Life City Wollongong project includes the following six stages:

- Stage 1: Medical Centre and Child Care Centre
- Stage 2: Medical Accommodation
- Stage 3: Hospital Building
- Stage 4: Seniors Independent Living Units
- Stage 5: Seniors Residential Care Facility
- Stage 6: Holistic Health Care Course

A brief description of the proposed developments is presented below:

- Stage 1 developments would comprise a day surgery and a child care/ respite centre. The surgery proposed is a two storey building with a basement car park. The basement car park floor level ranged from RL 48m to RL 47m which would involve about 5m cut over the east and northern part of the area. The buildings would comprise medical centre, day surgery, child care centre and respite care centre.

- Stage 2 developments would include a medi hostel and serviced apartments comprising three and four storey buildings with basement car parks. The basement car park floor level is proposed to be RL 55.0m, which would involve about 5m cut over the eastern part of the area. The ground surface

level within this area ranges from about RL 55m in the west to RL 60m in the east.

- Stage 3 developments would be a medical hospital comprising five storey buildings with four levels of car park. Its lowest car park floor level is to be RL 46m, which would involve up to 5m cut over the north eastern part of the area. The ground level within this area range from RL 44 to RL 63m. The building will be used for a Hi Tech Holistic Cancer and Medical Hospital.

- Stage 4 developments would comprise three sections of two storey apartment buildings. Each apartment has its own car park with floor levels ranging from RL 46m to RL 57m.The buildings would be for seniors living. The ground level in this area ranges from about RL 46m to RL 60m. The development would involve up to 6m depth of cut and about 1m depth of fill.

- Stage 5 developments would comprise a four storey residential care facility with at grade car parking space. The ground floor level varies between RL 60m (west) and RL 61m (east), which would involve about 6m cut over the southern part of the area.

- Detail of stage 6 developments is unknown at the time of report preparation. But, it is understood to comprise holistic health care course.

- Five roads (Road Nos. 1 to 5) are to be constructed, with one access entering the site from Warwick Street and the other from Nolan Street.

3.0 PREVIOUS GEOTECHNICAL INFORMATION

Prior to commencement of our investigation, we were provided with the following geotechnical reports by other engineering consultants for review.

- Preliminary Environmental Assessment (Phase 1 Study) by Clearsafe Environmental Solutions, report ref: 1357-01-LC Rev 0 dated November 2012;

- Preliminary Geotechnical Assessment Report by Coffey Geotechnics, report ref: GEOTWOLL03229AC-AB Feb 2013;

- Geotechnical Review Report by Coffey Geotechnics, report ref: GEOTWOLL032229AD-AA dated May 2013;

- Review of Geotechnical Assessment Second Draft Report by Sinclair Knight Merz (SKM), report ref: ENO4222 dated July 2013;

A summary of those report contents is briefly discussed below:

Clearsafe's report 1357-01-LC provided an Environmental Assessment (Phase 1 study) at the above site. They identified the site was contaminated due to illegal dumping based on their historical search and site inspection. They recommended that a Stage 2 environmental assessment to be carried out.

Coffey's report GEOTWOLL03229AC-AB provided a preliminary geotechnical assessment at the above site. The report included technical comments on the following:

- Landslide Risk Assessment
- Site Classification to Australian Standard AS2870-2011
- Site Earthwork Conditions
- Site Maintenance and Drainage Issues
- Recommended Additional Works

Coffey investigation included 12 test pits excavated using a 5t excavator to maximum depth of 2.8m or prior refusal. Most test pits refused at depths ranging from 0.7m to 2.8m except test pits TP3 and TP11 which were terminated in fill and colluvial soils respectively.

Coffey has carried out a desk study and surface mapping of the area and assessed that the north western corner (about 200m long and 100m wide) contained uncontrolled fill to more than 2.5m depth. Coffey found that the area is underlain by mainly two geological units, Pheasant Nest formation (Illawarra Coal measures) and Berkeley Latite.

Coffey assessed the risk of landslide over the whole site and identified area of low, medium and high risk. Coffey stated that the basis of assessment was that "Good hillside Construction practice "to be adopted which included cut and fill depths to be limited to 1.5m depth. On the basis of this assumption Coffey assessed that there is a high risk of soil creep over the middle valley section of the site where the depth of colluvial soils in one test pit (TP11) was found to be more than 2.5m.

Coffey's report GEOTWOLL03229AD-AA provided a geotechnical review for the proposed developments based on revised preliminary bulk earthworks plans at that time. The report also provided an additional comment on earthwork and geotechnical aspects related to responses received from the public.

SKM's report ENO 422 provided an opinion and appraisal of the suitability of proposal against the requirements of E12 and E19 of Wollongong Development Control Plan and Practice Note Guidelines for Landslide Risk Management Australian Society (AGS) 2007. They provided a geotechnical model based on Coffey's report. They concluded that due to insufficient data obtained during Coffey's investigation, they could not provide an adequate assessment on geotechnical constraints on the above site. They recommended further geotechnical investigation and assessment prior to planning approval.

4.0 FIELDWORK

The fieldwork for the investigation was carried out between 21st November 2013 and 8th January 2014 by NG Geotechnical Engineers on a full time basis and comprised the following works:

- One of NG Principal Geotechnical Engineers visited the site during site investigation works on 21st November 2013 to carry out a visual risk assessment of slope instability including observations of the general site topography, approximate slope angles and any potential contamination of the site.

- Twenty two borehole (BH1 to BH22 and BH 31 to BH33) locations were located and levels were measured using a Trimble Global Positioning System with Ground Control at a remote base. Borehole coordinates and reduced levels are shown on the attached borehole logs. The survey datum is Australian Height Datum.

- Boreholes BH1 to BH9 and BH31 were auger drilled to depths between 4.4m to 8m using truck mounted drilling rig. BH1, BH2, and BH7 to BH9 were auger drilled with a Tungsten Carbide 'TC' bit attachment to termination depths of 4.5m, 4.4m, 4.4m and 5.1m respectively, where the 'TC' bit is refused. BH3 to BH6 and BH31 to BH33 were drilled to depths ranging from 4m to 8m by auguring to TC bit refusal followed by NMLC diamond core drilling with water flush.

- Boreholes BH10 to BH22 were drilled by hand auger to practical refusal depths between 0.2m and 1m to collect soil samples for contamination assessment.

Standard penetration tests (SPT) were carried out at 1.5m depth intervals in BH1 to BH9 and BH31 to BH33 to assess the strength of soil profile. The consistency of clay samples recovered in the SPT split tube sampler was assessed by hand held pocket penetrometers (HP) readings.

The strength of the augured bedrock was assessed by our observation of drilling resistance together with tactile examination of the recovered rock cuttings. We note that the rock strength assessed in this way should be considered approximate. Variance of one strength order should not be unexpected.

The strength of the cored rock was assessed from Point Load Strength Index ($Is_{(50)}$) tests.

Groundwater observations were recorded during and on completion of borehole drilling. Groundwater monitoring wells were installed into BH3, BH6 and BH8 with monuments concreted at top.

The remaining boreholes were backfilled with the excavated spoils after the completion of auger drilling.

Selected soil samples were delivered to NATA registered laboratory to carry out Acid Sulphate Screening and Emerson and Dispersion test.

Borehole logs are attached in Appendix A and the borehole locations are shown on the attached Drawing No G09/1100-A.

5.0 LABORATORY TEST RESULTS

Laboratory testing program carried out on soil and rock samples recovered for geotechnical investigation included the following:

- Acid sulphate screening tests on samples collected from boreholes close to valley floor.

- Soil dispersion and Emerson Class number tests to assess soil dispersion characteristics.

- Point Load Strength Index testing on recovered rock core.

Acid Sulphate Screening pH tests were carried out on 8 soil samples to assess the presence of Acid Sulphate Soils. All pH tests in water recorded pH>4.7 and pH tests in Hydrogen Peroxide recorded pH>3.0.

The following scale was adopted for assessment of rock strength in rock cored section based on Point Load Index (PLI) tests.

Typical Rock Strength Assessment Based on PLI

PLI (MPa)	Rock Strength Grade
0.03 to 0.1	Very Low
0.1 to 0.3	Low
0.3 to 1.0	Medium
1.0 to 3.0	High
>3.0	Very High

Rock Strength Classification

Borehole No.	Depth (m)	PLI (MPa)	Rock Strength Grade
3	4.46m-4.50m	0.08	Very Low
3	5.61m-5.65m	0.05	Very Low
3	6.72m-6.76m	0.04	Very Low
3	7.22m-7.26m	0.04	Very Low
4	4.81m-4.84m	0.55	Medium
4	5.20m-5.24m	0.22	Low
5	4.55m-4.58m	0.16	Low
5	5.48m-5.53m	0.50	Medium
5	6.51m-6.56m	3.70	Very High
6	2.80m-2.84m	0.16	Low
6	3.66m-3.70m	0.27	Low
6	4.40m-4.44m	0.57	Medium
31	4.45-4.48	0.14	Low
31	4.9-4.93	0.17	Low
32	1.52-1.55	1.13	High
32	2.72-2.75	6.44	Very High
32	3.79-3.83	3.50	Very High
32	4.54-4.58	2.69	High
33	2.30-2.34	0.59	Medium
33	2.93-2.97	1.62	High
33	3.45-3.47	2.56	High
33	4.00-4.03	3.77	Very High

The Point Load Strength Index quoted above is based on axial tests. The attached test reports in Appendix B show both axial and diametrical test results.

For Sandstone samples tested the ratio between diametrical test and axial test result was generally close to unity indicating less degree of anisotropy.

6.0 SITE CONDITION

6.1 Site Description

The site covered about 20 hectares. The topography of the site is a ridgeline that bounded a centre valley. The average site slope is between 5° and 17° dipping toward the M1 Princess Motorway.

For site description purpose, we have assumed the M1 Princess Motorway abuts the site to the west.

At the time of the investigation, the site surface was covered with thick grasses to a height of up to 0.5m. Shrub and small to large size trees were spread around.

During our walkover assessment and locating the borehole locations, the site surface appeared uneven sloping ground due to previous weathering and soil erosion. Several soil erosion drains are present in the centre of the site, running toward the centre valley.

The north western area closer to the Motorway appeared to be filled with hummocky and irregular ground surface. The extent of filled area could not be assessed due to thick grass cover. Boreholes BH1 and BH9 and Coffey test pits TP1 to TP3 exposed fill in this area.

A marshy area covered with reed was noted close to south western area of the proposed development.

Two vehicular tracks pass through the site. One is located at the top of the ridgeline (east of the site), the other is located near the middle of the site.

Natural silty CLAY and Sandstone bedrock were exposed on the northern part of the site surface, near northern end of the top ridgeline vehicular track.

A valley is situated at the centre of the site, which is surrounded by land sloping up to 17° when viewed from the valley floor. The valley floor slopes down to the west at about 3°.

Two stockpiles were observed in the area covered by boreholes BH5, BH6 and BH8. The stockpiles comprised concrete boulders and steel fragments. The location of the stockpiles is shown on our borehole location plans. Some surfaced rubbish was noted along the top ridgeline vehicular track.

Residential houses and local roads bounded the site to the north, east and south. High voltage power lines were located on the southern end of the site.

6.2 Subsurface Condition

The 1:100,000 Geological Series Sheet of Wollongong-Port Hacking indicates the site to be underlain Illawarra Coal Measures, Cumberland Subgroup Pheasant Nest Formation (Pip) comprising inter-bedded lithic sandstone, grey siltstone, claystone, carbonaceous claystone, clay, laminate and coal and surrounded by Dapto Latite (Psud) comprising coarse grained Latite. The eastern area of the site is shown to be underlain mid-grey Dolerite.

Subsurface conditions encountered in the NG boreholes and Coffey test pits are discussed at each development stages. Reference should be made to the attached engineering logs for details at each specific location.

Stage 1 Development: Geotechnical Profile Encountered in NG Boreholes BH1, BH9 and BH31

LAYER	DESCRIPTION	DEPTH TO BASE OF LAYER (m)
TOPSOIL	Sandy Silt, low plasticity, dark grey, fine grained sand with roots	0.3 – 0.5
FILL	Silty CLAY, medium to high plasticity, dark brown, with fine to medium sandstone and ironstone.	0 – 1.5
RESIDUAL	Silty CLAY, high plasticity, light brown and orange	>0.5-3.2
ROCK	Sandstone, fine to medium grained, orange brown	>5.1

Stage 2 Development: Geotechnical Profile Encountered in NG's Boreholes BH5, BH21 and BH, Coffey's TP11 and TP12

LAYER	DESCRIPTION	DEPTH TO BASE OF LAYER (m)
TOPSOIL	Silty Clay, high plasticity, dark brown, with roots and trace of fine to medium grained ironstone gravel	0.2
FILL	Silty CLAY, medium to high plasticity, dark brown, with fine to medium sandstone and ironstone.	1.0 – 1.5
RESIDUAL	Silty CLAY, medium to high plasticity, light brown and orange, trace of fine to medium grained ironstone gravel	1.1-3.2
ROCK	Latite, Highly weathered, coarse grained, brown	>7.0

Stage 3 Development: Geotechnical Profile Encountered in NG's Boreholes 2, 3 and 6, Coffey's TPs 1 and 2

LAYER	DESCRIPTION	DEPTH TO BASE OF LAYER (m)
TOPSOIL	Silty Clay, high plasticity, dark brown, with roots	0.2-0.6
FILL	Silty CLAY, medium to high plasticity, dark brown, with fine to medium sand, fine to medium grained sandstone and ironstone and latite cobbles and boulders.	0.5 – 1.7
RESIDUAL	Silty CLAY/Sandy CLAY, medium to high plasticity, light brown and orange, trace of fine to medium grained sandstone and ironstone gravel	1.1-2.8
ROCK	Weathered Sandstone/Latite, fine to medium grained, brown BH2 and BH6	>4.4, >4.7
ROCK	Latite, Coarse grained, brown (BH3)	>7.35

Stage 4 Development: Geotechnical Profile Encountered in NG BH4, BH5 and BH32, Coffey TP 10

LAYER	DESCRIPTION	DEPTH TO BASE OF LAYER (m)
TOPSOIL	Silty Clay, high plasticity, dark brown, with roots and fine to medium grained ironstone gravel	0.2-0.5
RESIDUAL	Silty CLAY, medium to high plasticity, dark brown, with fine to medium sand, fine to medium grained sandstone and ironstone and Latite cobbles and boulders.	1.65
RESIDUAL	Sandy CLAY, medium plasticity, orange brown, dark brown and red brown, trace of fine to medium grained sand.	1.5-3.0
ROCK	Latite, fine to coarse grained, brown	>1.6, >8
ROCK	Sandstone, fine grained, grey	>5.09

Stage 5 Development: Geotechnical Profile Encountered in NG BH33

LAYER	DESCRIPTION	DEPTH TO BASE OF LAYER (m)
TOPSOIL	Silty Clay, high plasticity, dark brown, with roots and fine to medium grained ironstone gravel	0.3
RESIDUAL	Sandy CLAY, low plasticity, brown,	3.4
ROCK	Sandstone, fine grained, brown, with iron indurated band	>4.17

6.3 Proposed Cut/Fill Earthwork

We anticipate that where the proposed roads/buildings are cut into natural hill slopes, silty CLAY natural soils would be encountered in the subgrade. Weathered sandstone bedrock would be encountered in the subgrade at some section. Fill earthwork methodology should be referenced in Section 9.

Based on the borehole logs and test pit logs, we expect that the excavation would predominantly involve cutting through the topsoil/fill and clayey soils. Some sections may possibly involve cutting through extremely low to low strength sandstone or Latite bedrock. Some medium to high strength Latite or ironstone band should be expected during the earthwork. Excavation characteristic is discussed in Section 9.1.

We advise that a stability assessment of cut/fill earthworks should be carried out by an experienced geotechnical consultant in a regular basis.

7.0 GEOTECHNICAL MODEL

7.1 Surface Soil

Silty CLAY fill was mainly encountered over northern end of the site, where BH9 to BH11 located, to maximum depths of 1.5m below the existing grade. Either Colluvial or residual silty CLAY of high plasticity and of stiff strength was encountered below the topsoil/fill.

7.2 Bedrock

Sandstone rock was exposed on the northern part of the site surface, exposed along the upper ridgeline vehicular track.

Weathered sandstone/Latite bedrock was encountered below the natural silty CLAY and extended to the borehole termination depths. The upper sandstone/Latite profile was generally extremely weathered and extremely low strength. The strength of the bedrock is increased with depths.

The predominant bed rock type encountered in the boreholes by NG and test pits by Coffey was Sandstone which appears to be overlain on Latite bed rock. Latite

was found in Ng boreholes BH3, BH4, BH5 and BH8 at reduced levels ranging from RL 38.8m to RL 47.3m. It may be noted that most excavations proposed are above the level of Latite encountered in boreholes and entirely in Sandstone.

7.3 Groundwater

Groundwater monitoring wells were installed in BH3, BH6 and BH8 after completion of core drilling.

Groundwater was measured in BH's 3 and 6 wells at depths of 3.31m and 0.68, respectively after one day of drilling completion. Groundwater was not recorded in BH8 well. We note that the groundwater level might not be at equilibrium level after a short time of core drilling completion as fresh water was introduced for drilling.

7.4 Geotechnical Parameters for Design

The following shear strength parameters may be used in the footing and retaining wall designs:

Shear Strength Parameters	Colluvial/ Residual Soil	Extremely weathered rock	Distinctly weathered rock
Unit Weight (γ) (kN/m3)	18	20	22
Undrained Cohesion (Cu) (kPa)	75	500	1000
Undrained friction angle (Ø) (deg)	0	20	33
Drained Cohesion (C') (kPa)	3	20	50
Drained friction angle (Ø') (deg)	26	32	38
Drained Elastic Modulus (E) (MPa)	18	100	1000

8.0 SLOPE INSTABILITY

A preliminary slope stability assessment has been carried out by Coffey during their preliminary investigation. Coffey identified the risk soil creep where overburden soil depth exceed 2m to be high in the central valley area and either moderate or low over the rest of the site.

It is noted that the overburden soils would be removed for construction of buildings and most of the roads and parking areas. Under such conditions soil creep is no longer relevant and the areas where overburden soils are excavated.

Based on the proposed cut/fill design some areas would be excavated up to 6m depth. Excavations would be partially in overburden and mostly in Sandstone bed rock. Provided that the excavation batters are designed with geotechnical advice and following recommendations of this report, the risk of instability due to temporary excavations is assessed to be low.

Some areas, particularly over the North West area and the eastern parking and access roads adjoining Stage 3 development would require filling. These areas are located near deep cuts associated with building construction and the cuts will be retained by structural walls forming parts of the building. It is likely that suspended link slabs would be required to support access road and parking areas proposed.

9.0 EARTHWORKS

The recommendations for earthworks below should be complemented by reference to Australian Standard AS3798.

It is possible that cut earthworks would result in different types of materials such as Silty CLAY soils of high plasticity and Sandstone/Latite rock of different weathering grades.

The following broad recommendations should be included in an earthworks management plan:

- Vegetation within the development area should be removed and this area should be subjected to a detailed assessment by a geotechnical/environmental engineer to identify extent of fill.

- All foreign materials such as bricks, concrete, metal, timber etc should be collected and disposed appropriately.

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- As the topography site is ridgeline, if fill is to be placed on sloping land with localised slope exceeding 10°, that area should be benched and fill placed in near horizontal layers.

- All uncontrolled fill should be excavated and visually assessed for contamination. Further testing should be carried out if any contamination is suspected.

- Topsoil should be excavated and stockpiled for later use in landscaping.

- Areas where deep fill is required should be stripped to competent ground and proof roll tested.

- Different fill types to be excavated should be stockpiled separately or alternatively placed in fill in identified zones in the earthworks management plan b.

- Where fill to be battered or supported with walls, the areas should be over filled and cut back to the required profile to reduce areas of loose fill on edges.

- All fill should be placed in near horizontal layers not exceeding 300mm depth.

- Earthworks should be managed such that reactive clay should not be placed over the upper 1.5m depth of fill. It would be better if reactive clay is placed in thin layers sandwiched between granular fill.

- Earthworks should be carried out under level 1 testing in accordance with AS3798-2007. Fill should be compacted to density ratio not less than 98% Standard Compaction. Where clay fill is used the placement moisture content should be controlled within 2% of Standard Optimum Moisture Content.

- Area receiving new fill should be examined by a geotechnical consultant prior to fill placement. Any unsuitable foundation materials, such as root affected topsoil, should be excavated, and the area should be replaced by engineered fill.

- Fill abutting the existing ground should be placed by cutting benches on to the existing ground.

- Geotechnical Inspection and Testing Authority (GITA) should be engaged directly by the Principal.

9.1 Excavation Characteristics

Excavation through the clayey fill and colluvial/residual soils can be completed by medium size (ie. 12 tonne) excavator. However, removal of low to medium strength sandstone bedrock may require a larger sized excavator (ie 30 tonnes or larger) with attached "tiger teeth" buckets. High strength fine grained sandstone was encountered over some higher elevations in BH31 to BH33 which may not be excavatable with an excavator. Impact hammers and/or hard ripping with a larger machine (caterpillar D10 dozer or similar) may be required for excavation of high and very high strength rock. Rock saw may be required if ground disturbance and vibration due to hard ripping and impact hammers are unacceptable.

It may be noted that the depth of weathered rock shown on borehole logs should not be extrapolated over the area for assessment of excavation characteristics as the weathering profile can vary over short distances due to variations in rock material, joint spacing and availability of water and air.

It is recommended that further seismic surveys be carried out in a close grid pattern to provide a better assessment of excavation characteristics for contractors pricing the work.

9.2 Excavation Support

It is assessed that temporary excavations can be typically carried out to the following batters:

Stratum	**Ratio**
Fill/Colluvial/Residual soil	2H: 1V
Extremely low to low strength sandstone	1H: 1V
Distinctly weathered Sandstone	0.5H: 1V

The recommended batter should be confirmed by a geotechnical engineer after inspections during bulk excavation.. Any deeper excavation, which is more than 1.5m in high, may require benching.

The geological profiled assumed for design purposes should be confirmed during construction/excavation by a geotechnical engineer. If the actual conditions encountered are significantly different to those assumed for design it may be necessary to carry out additional analysis.

Any rock boulders, if encountered on the cut slope, should be removed.

9.3 Fill Materials

The existing topsoil can be reused for garden and park construction filling material. The existing clayey fill at the site are acceptable for re-use on condition that the soils used are clean (i.e. free of organics and inclusions greater than

75mm size), free of contaminants for landscaping and site levelling. They should not be considered as an engineered fill.

It is considered that the natural Silty CLAY and Sandy CLAY soils including extremely weathered rock at the site should be suitable for use as engineered fill subject to removal of any organic material and material greater than 150mm in size. However, in good engineering practice, we consider the materials to be used as an engineered fill are well-graded granular materials, such as ripped or crushed sandstone or good quality shale.

10 IMPACT ON ENVIRONMENT

The main impacts of open excavation are generation of dust, soil erosion from disturbed areas and noise and vibration from excavation of rock. Therefore, a detail of excavation/construction management plan should be prepared prior to commencement of excavation and construction.

10.1 Vibration and Noise

Where hard ripping or rock hamming is required (ie. Removing sandstone boulders, excavation of high/very high strength Sandstone or breaking through iron indurated bands) to achieve the required design footing level, vibration noise and dust pollution could occur and will require appropriate management.

Excavation methods which minimise noise and vibration may be required in some areas, where near the residences to the north.

As mentioned in Section 6.1, sandstone bedrock was exposed at the surface on existing vehicular track. We expect that the sandstone bedrock will be encountered at shallow depths over that area; therefore, other excavation techniques such as rock saw/drilling may be required to minimise the environmental effects.

It is recommended that vibration and noise monitoring be carried out during the initial stages of the excavation. If it is assessed vibration/noise is above the acceptable limit excavation methods should be reviewed.

10.2 Groundwater

Ground water monitoring wells were installed in BH3 (Well No.1), BH6 (Well No.2) and BH8 (Well No.3) respectively, for long term groundwater measurement.

As water was introduced into boreholes during core drilling, the measurement made after the coring might not provide meaningful groundwater readings and the groundwater level might not have sufficient time to stabilise in these boreholes shortly after the fieldwork completion, but it could provide us some indication of underlying rock quality.

The groundwater level readings were recorded the day after core drilling and again six weeks later. The results are tabulated in following Table:

Borehole	Drilling Completion Date/Time	Date and Time	Depth (m)	Date and Time	Depth (m)
BH3	21/11/13 5:30am	22/11/13 AM	3.31	06/01/14 AM	3.21
BH6	21/11/13 2:00pm	22/11/13 AM	0.68	06/01/14 AM	Dry
BH8	21/11/13 11am	22/11/13 AM	Dry	06/01/14	Dry

*The above groundwater depths were measured from its existing grade.

Based on the above groundwater appears to be present only in BH3 at 3.2m depth (RL 38.4m).

Standing groundwater and seepages may fluctuate with variations in rainfall, temperature and other factors.

Local seepage flows may possibly occur in fill and clayey soil, interface between soil and rock, through joints and defects within bedrock, particularly after period of heavy rain. Seepage, if any, during excavation, is expected to be satisfactorily controlled by conventional sump pumping.

Roof drainage and drainage from hard stand areas should be collected and directed to site drainage system without allowing to soak in to the site, in particular the centre valley area.

Care should be taken to provide drainage both during construction and for long term site maintenance. The drainage measures should promote run off and reduce ponding.

10.3 Erosion Control

Four Emersion Class Number tests and two percentage dispersion tests were carried out to assess dispersion characteristics of clay soils. Emerson Class Number 5 or higher is considered to be less dispersive and soils with Emerson Class number 4 or below are considered to be highly dispersive. One soil sample recorded Emersion Class number 2 and the rest Number 5 indicating mixed results.
Two dispersion tests carried out recorded dispersion percentage of more than 90%. These soils contained sand and silt content in excess of 80% and Clay content in excess of 45%. Therefore clay soils tested are assessed as highly dispersive and would be Type F in accordance with NSW Stormwater Management manual (Blue book).

It is recommended that sediment and erosion control plans and sediment basins be designed based on the above assessment.

11.0 FOOTING DESIGN

We recommend that the proposed new buildings be supported on underlying either sandstone or Latite as medium to heavy structural loadings are expected.

Due to the existing site sloping features, we do not recommend the proposed building to be founded on colluvial/residual clayey soil, which are anticipated generally associated with high shrink swell reactivity.

We consider that the encountered Silty CLAY soils are considered suitable for an allowable end bearing pressure (AEBP) of 75kPa, which does not comply with a minimum engineering design requirement in accordance with AS2870.

Pile foundation would be the best means to transfer the load from the column to underlying bedrock. Piles founded in extremely weathered to highly weathered sandstone or Latite bedrock with extremely low to very low strength may be designed for the AEBP of 600kPa with an allowable shaft adhesion value of 60kPa. A minimum 0.5m pile socket into the bedrock would be required.

The footing design may be carried out based on the following ABEP given below:

Design Allowable Bearing Pressure

Footing Founding	Design Allowable End Bearing pressure (kPa)
Stiff Clay	75, not recommend
Extremely low strength bedrock	600
Low strength bedrock	1000
Medium to high strength bedrock	>3000

The above parameters may be used for preliminary design. Further detailed site specific investigations may be required for design of footings for individual buildings, particularly where column loads are higher and AEBP>1000kPa is required.

All footing excavations and piers should be inspected by an experienced geotechnical engineer prior to concreting, to ensure that the founding materials are consistent with the adopted footing design parameters.

Differential settlement should not be unexpected if the footing saddled different stratum (ie. silty CLAY and ROCK). Movement joint(s) between two stratums can be used to reduce differential settlement effect.

All footings should be cleaned of debris, softened materials, and any water encountered during the excavation should be pumped out prior to placing of concrete.

Foundation materials (ie. Silty CLAY) may be softened by groundwater seepage resulting in requiring further excavation and cleaning. Therefore, water should be prevented from entering the base of the footings. If delays in pouring concrete are anticipated, we recommend the base of the footings be protected with a blinding layer of concrete.

In sites where the risk of landslip might be potentially assessed to be high (ie. centre valley area), the pier footings should be tied together by reinforced concrete tie beams at ground level to reduce the risk of ground movement.

12.0 PAVEMENT DESIGN

Due to a limited scope of our investigation carried out at this site, further Geotechnical Investigations for pavement design would be required if this is critical to the pavement thickness design.

However, in general, we consider a typical California Bearing Ratio in the range 2% to 3% may be adopted for the pavement thickness design where subgrade materials would be clay. Earthworks may be managed such that the subgrade to be on good quality fill such as ripped sandstone. In that case a subgrade CBR of 7% may be used for pavement thickness design.

Where natural clay is on subgrade, it is likely that a select fill layer to be incorporated where subgrade is deflecting or of very low strength (CBR<2%). Lime stabilisation of subgrade may be an option in such cases.

13.0 CONCLUSIONS

Based on the investigations carried out we assess that the proposed development is feasible provided the recommendations of this report are carried out.

The main concern related to the proposed development is excavation of high to very high strength sandstone in Stages 4 and 5 areas. These areas are away from existing residential developments and the impact of excavation on the residences would be minimal.

14.0 FURTHER INVESTIGATION

We recommend the following works be completed prior to construction certificate and during construction as outlined in the preceding sections of this report:

- Further geotechnical investigation targeting design of footings for buildings with high column loads and where high retaining walls to support fill would be required.
- Earthwork management plan to be prepared providing details of excavation batters, methods of excavation support, fill management and inspection and testing.
- Pavement thickness design when road alignment and grades have been finalised.
- Direction of all proof rolling by an experienced geotechnician or geotechnical engineer.
- Inspection and approval of installation of excavation support.
- Inspection of all footing excavation Area receiving new fill should be examined by a geotechnical consultant prior to fill placement. Any unsuitable foundation materials, such as root affected topsoil, should be excavated and the area should be replaced by engineered fill.
- Inspections to confirm that the design bearing pressures have been achieved.
- Density testing of engineered fill and pavement layers.

15.0 LIMITATIONS

This report presents the results of a geotechnical investigation carried out in accordance with a brief provided by the client.

The report interpretations are based on the information supplied with the geotechnical brief, the information collected during the current investigation. It may be noted that the investigation was tailored to meet the planning requirements and not necessarily addresses the requirements for the detailed design.

The analysis is based on preliminary sketches emailed to us on 3rd October 2013. The proposed cut fill plan supplied for the investigation is included at the end of the appendices. Further clarifications and or investigations may be required if the final concept design is substantially different to the one assumed in this investigation.
Please do not hesitate to contact the undersigned if you have any queries or need further assistance.

For and on behalf of
Network Geotechnics Pty Ltd

Long Tsang *BE, MEng, MIE Aust,*
Geotechnical Engineer

Reviewed by

V W de Silva *BScEng, MEng, SMIE Aust, CPEng NPER*
Principal Geotechnical Engineer

GENERAL NOTES

GENERAL
Geotechnical reports present the results of investigations carried out for a specific project and usually for a specific phase of the project (e.g. preliminary design). The report may not be relevant for other phases of the project (e.g. construction), or where project details change.

SOIL AND ROCK DESCRIPTIONS
Soil and rock descriptions are based on AS 1726 – 1993, using visual and tactile assessment except at discrete locations where field and / or laboratory tests have been carried out. Refer to the terms and symbols sheet for definitions.

GROUNDWATER
The water levels indicated on the logs are taken at the time of measurement and depending on material permeability may not reflect the actual groundwater level at those specific locations. Also, groundwater levels can vary with time due to seasonal or tidal fluctuations and construction activities.

INTERPRETATION OF RESULTS
The discussion and recommendations in the accompanying report are based on extrapolation / interpolation from data obtained at discrete locations. The actual interface between the materials may be far more gradual or abrupt than indicated. Also, actual conditions in areas not sampled may differ from those predicted.

CHANGE IN CONDITIONS
Subsurface conditions can change with time and can vary between test locations. Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations can also affect subsurface conditions.

REPRODUCTION OF REPORTS
 Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimise the likelihood of misinterpretation from logs.

FURTHER ADVICE
Network Geotechnics would be pleased to further discuss how any of the above issues could affect your specific project. We would also be pleased to provide further advice or assistance including:

- assessment of suitability of designs and construction techniques;
- contract documentation and specification;
- construction control testing (earthworks, pavement materials, concrete);
- construction advice (foundation assessments, excavation support).

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

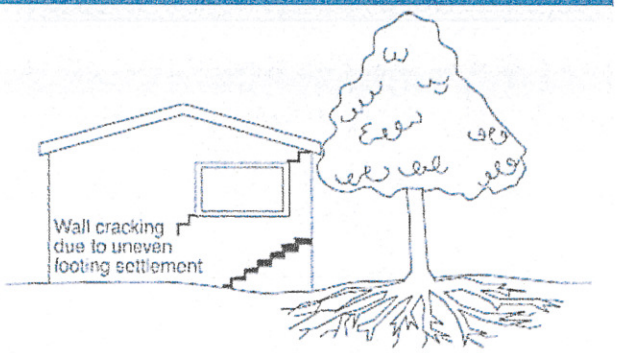
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

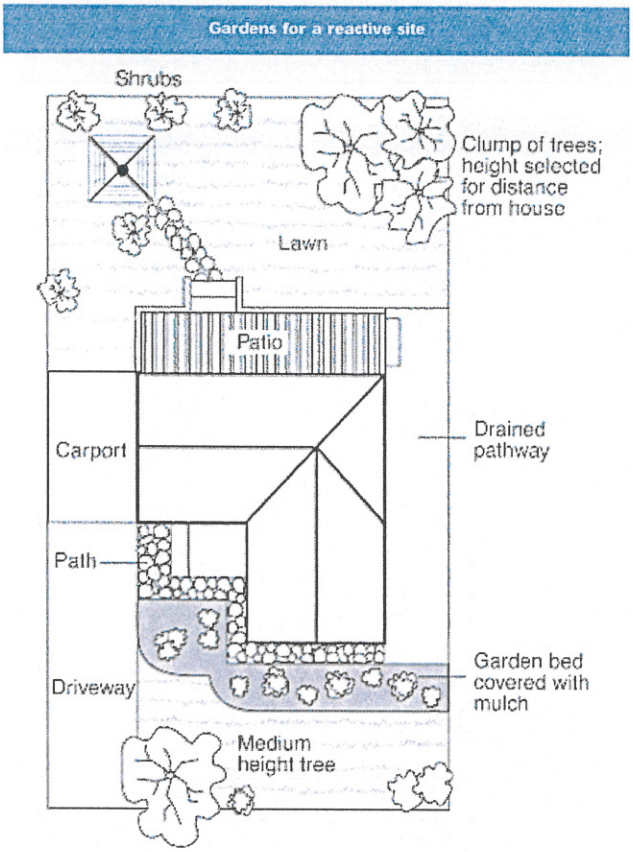
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	Notional Boundary					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-3}$	1000 years	200 years 2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-4}$	10,000 years		The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-5}$	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}	$5x10^{-6}$	1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

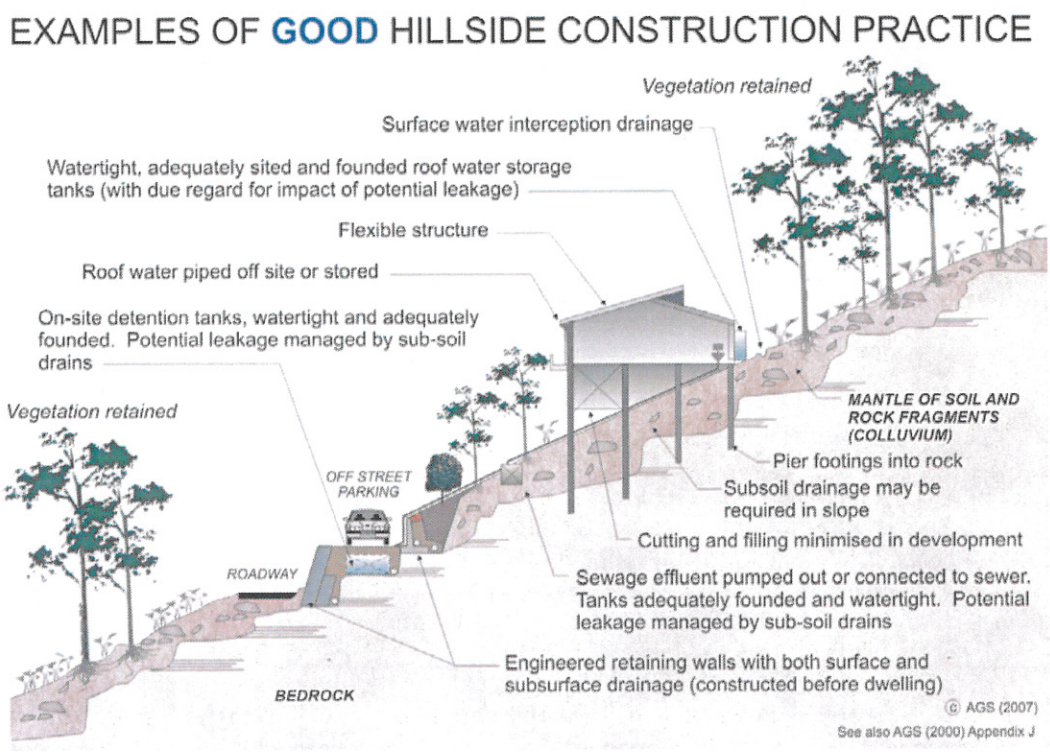
Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

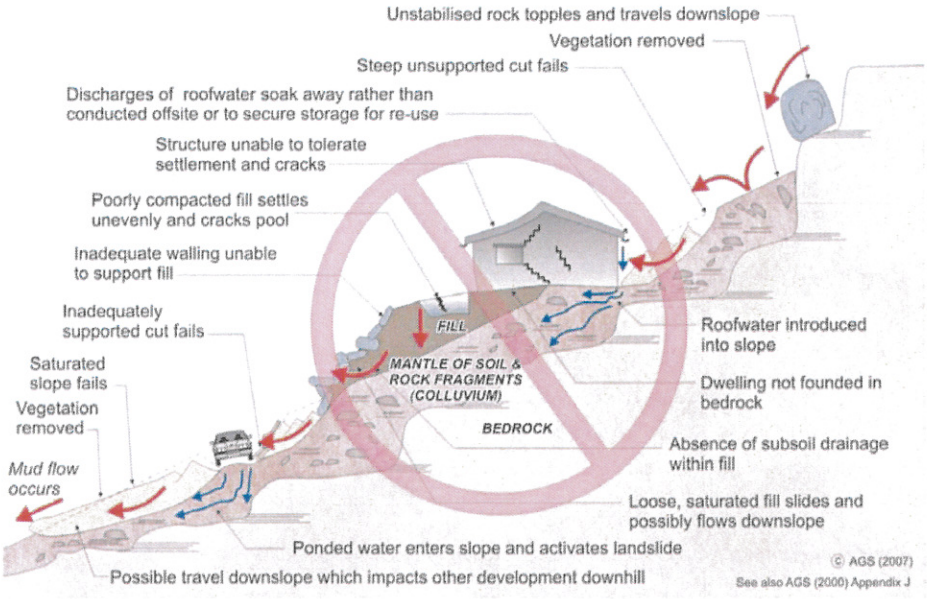
Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)

EXAMPLES OF **POOR** HILLSIDE CONSTRUCTION PRACTICE



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

APPENDIX A

Borehole Logs BH1 to BH22, BH31 to BH33

Terms and Symbols

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH01**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	LT
Checked:	VDS
RL Surface:	46.7
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301549E 6183771N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered	D				CH	Silty CLAY : high plasticity, dark brown, with roots and trace of fine to medium grained ironstone and sandstone gravel	>Pl	-	FILL, GRASS COVER
		2, 3, 4 N=7		1.0		CH	Silty CLAY : high plasticity, dark brown, with root fibres	>Pl	St	COLLUVIAL HP READING: 150, 170
		N 7,4/70mm,		2.0		-	SANDSTONE : fine to medium grained, orange brown, red brown and light grey, with occassional iron indurated band, extremely low strength	XW		'V' BIT REFUSED AT 1.8m DEPTH VL 'TC' BIT RESISTANCE
				3.0						
				4.0		-	As above, but low strength	DW	L	L 'TC' BIT RESISTANCE
		D								
				5.0			BH01 Terminated at 4.5 m			'TC' BIT REFUSAL
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH02**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	LT
Checked:	VDS
RL Surface:	45.4
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301498E 6183722N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered	D				CH	Silty CLAY : high plasticity, dark brown, with roots	>Pl	-	TOPSOIL, GRASS COVER
		1, 2, 4 N=6		1.0		CH	Silty CLAY : high plasticity, dark brown and orange brown	>Pl	St/VSt	COLLUVIAL HP READING: 170, 220, 230
		5, 10, 10 N=20		2.0		CL	Sandy Silty CLAY : low to medium plasticity, fine grained, orange brown, red brown and dark brown	<Pl	VSt	HP READING: 250, 300 'V' BIT REFUSAL
						-	SANDSTONE : fine to coarse grained, orange brown and red brown, extremely low strength	XW	-	VERY LOW 'TC' BIT RESISTANCE
		D		3.0		-	As above, but with medium strength iron indurated band			VERY LOW 'TC' BIT RESISTANCE
		D		4.0		-	As above, coarse grained			
				5.0			BH02 Terminated at 4.4 m			'TC' BIT REFUSAL
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH03**
Sheet:	PAGE 1 / 3
Started:	21/11/13
Finished:	21/11/13
Logged:	LT
Checked:	VDS
RL Surface:	41.6
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301455E 6183661N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered	D				CH	Silty CLAY : high plasticity, dark brown, with roots	>Pl	-	TOPSOIL, GRASS COVER
		D				CH	Silty CLAY : high plasticity, grey and dark brown, with roots	>Pl	F-St	COLLUVIAL HP READING: 90, 110
		1, 2, 4 N=6		1.0		CH	As above, but brown, with root fibres		St-VSt	
		2, 3, 5 N=8		2.0						HP READING: 190, 210,220
		N>23 15, 8/50mm		3.0		-	Latite, coarse, light brown and orange brown, with medium to high strength red brown iron indurated band, extremely low strength	XW		VERY LOW 'V' BIT RESISTANCE 'V' BIT REFUSAL VERY LOW 'TC' BIT RESISTANCE A 50mm PVC INSTALLED TO THE BOTTOM, MACHINE SLOTTED BETWEEN 4.47m TO 7.47m, 2mm FILTER SAND BACKFILLED TO 0.7m, BENTONITE SEALED BETWEEN 0.2m TO 0.7m. MONUMENT CONCRETED AT SURFACE
				4.0						
				5.0			BH03 continued from 4.49 m on sheet 2 / 3			
				6.0						

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH03**
Sheet:	2 / 3
Started:	21/11/13
Finished:	21/11/13
Logged:	LT
Checked:	VDS
RL Surface:	41.6
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301455E 6183661N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description rock type, grain characteristics, colour, structure and minor components	degree of weathering RS XW HW MW SW FR	Strength IS (50) Mpa EL 0.03 VL 0.1 L 0.3 M 1.0 H 3.0 VH 10.0 EH	Natural fractures and Defects spacing mm 30 100 300 1000 3000	Description type, inclination, thickness, planarity, roughness, coating
		1.0						
		2.0		BH03 continued at 4.49m depth from BH03 soil log				
		3.0						
		4.0						
NMLC	Full return	5.0		Latite, coarse, light brown and orange brown, with medium to high strength red brown iron indurated band, extremely low strength				IRON INDURATED BAND
		6.0						

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 3/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH03**
Sheet:	3 / 3
Started:	21/11/13
Finished:	21/11/13
Logged:	LT
Checked:	VDS
RL Surface:	41.6
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301455E 6183661N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description rock type, grain characteristics, colour, structure and minor components	degree of weathering RS XW HW MW SW FR	Strength IS (50) Mpa EL 0.03 VL 0.1 L 0.3 M 1.0 H 3.0 VH 10.0 EH	Natural fractures and Defects spacing mm 30 100 300 1000 3000	Description type, inclination, thickness, planarity, roughness, coating
NMLC		7.0		Latite, coarse, light brown and orange brown, with medium to high strength red brown iron indurated band, extremely low strength *(continued)*				IRON INDURATED BAND
				BH03 Terminated at 7.35 m				
		8.0						
		9.0						
		10.0						
		11.0						
		12.0						
		13.0						

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 3/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH04**
Sheet:	PAGE 1 / 3
Started:	21/11/13
Finished:	22/11/13
Logged:	LT
Checked:	VDS
RL Surface:	47.4
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301395E 6183588N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered	D				CH	Silty CLAY : high plasticity, dark brown, with fine to medium grained ironstone gravel and roots	>PI	-	TOPSOIL, GRASS COVER
		1, 2, 2 N=4				CH	Silty CLAY : high plasticity, dark brown and orange brown, trace of roots and fine grained gravel	>PI	St	COLLUVIAL, HP READING: 150, 170, 180
				1.0						
		D				CH	As above, but orange brown, without roots			
		N=16 10,9,7/50mm				SC	Sandy CLAY : medium plasticity, fine to medium grained, orange brown, red brown and dark brown	<PI		HP READING: 160, 170
				2.0						
				3.0						'V' BIT REFUSAL
						-	Latite, coarse grained, orange brown and red brown, with clay band, extremely low strength	XW		VERY LOW 'TC' BIT RESISTANCE
				4.0				DW to XW	L-VL	VERY LOW TO LOW 'TC' BIT RESISTANCE
							BH04 continued from 4.7 m on sheet 2 / 3			
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH04**
Sheet:	2 / 3
Started:	21/11/13
Finished:	22/11/13
Logged:	LT
Checked:	VDS
RL Surface:	47.4
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301395E 6183588N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description: rock type, grain characteristics, colour, structure and minor components	degree of weathering: RS XW HW MW SW FR	Strength IS (50) Mpa: EL 0.03 VL 0.1 L 0.3 M 1.0 H 3.0 VH 10.0 EH	Natural fractures and Defects: spacing mm 30 100 300 1000 3000	Description: type, inclination, thickness, planarity, roughness, coating
		1.0		BH04 continued at 4.7m depth from BH04 soil log				
		2.0						
		3.0						
		4.0						
NMLC	Full return	5.0		Latite, coarse grained, orange brown and red brown, with clay band				CLAY SM, 10mm
		6.0						

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 3/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH04**
Sheet:	3 / 3
Started:	21/11/13
Finished:	22/11/13
Logged:	LT
Checked:	VDS
RL Surface:	47.4
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301395E 6183588N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description: rock type, grain characteristics, colour, structure and minor components	degree of weathering (RS XW HW MW SW FR)	Strength IS (50) Mpa (EL 0.03, VL 0.1, L 0.3, M 1.0, H 3.0, VH 10.0, EH)	Natural fractures and Defects: spacing mm (30 100 300 1000 3000)	Description: type, inclination, thickness, planarity, roughness, coating
NMLC		7.0		Latite, coarse, orange brown and grey *(continued)*		X		CRUSHED SM, 20mm JT, 60, pl, rou, Fe CLAY SM, 5mm
		8.0		BH04 Terminated at 8 m				
		9.0						
		10.0						
		11.0						
		12.0						
		13.0						

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 3/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH05**
Sheet:	PAGE 1 / 3
Started:	22/11/13
Finished:	22/11/13
Logged:	LT
Checked:	VDS
RL Surface:	51.0
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301494E 6183551N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered	D				CH	Silty CLAY : high plasticity, dark brown, with roots	>PI	-	TOPSOIL, GRASS COVER
		2, 3, 4 N=7		1.0		CH	Silty CLAY : high plasticity, brown, trace of root fibres and fine grained ironstone gravel	>PI	VSt	COLLUVIAL HP READING: 250, 270, 290
		3, 6, 9 N=15		2.0		CH	Silty CLAY : high plasticity, grey brown, trace of root fibres and fine grained ironstone gravel	<PI		HP READING: 300, 320, 370
		N>18 4,8,10/100mm		3.0		CH	Silty CLAY : high plasticity, grey to dark brown, orange brown and red brown, fine to medium ironstone gravel			HP READING: 370, 380, 380
						-	SANDSTONE : fine to medium grained, orange brown, extremely low strength	XW		VERY LOW 'V' BIT RESISTANCE 'V' BIT REFUSAL
				4.0		-	Latite: dark grey	SW	H	MEDIUM 'TC' BIT RESISTANCE
						-	Latite, coarse grained, orange brown with iron indurated band	HW	L	LOW 'TC' BIT RESISTANCE
				5.0			BH05 continued from 4.15 m on sheet 2 / 3			
				6.0						

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH05**
Sheet:	2 / 3
Started:	22/11/13
Finished:	22/11/13
Logged:	LT
Checked:	VDS
RL Surface:	51.0
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301494E 6183551N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description: rock type, grain characteristics, colour, structure and minor components	degree of weathering: RS XW HW MW SW FR	Strength IS (50) Mpa: EL 0.03 VL 0.1 L 0.3 M 1.0 H 3.0 VH 10.0 EH	Natural fractures and Defects: spacing mm: 30 100 300 1000 3000	Description: type, inclination, thickness, planarity, roughness, coating
		1.0		BH05 continued at 4.15m depth from BH05 soil log				
		2.0						
		3.0						
		4.0						
NMLC	Full return	5.0		Latite, coarse grained, orange brown with iron indurated band				Crushed SM, 30mmt Crushed SM, 30mmt Clay SM, 15mmt Clay SM, 5mmt XWSM, 50mmt Clay SM, 15mmt
				As above, but dark grey and dark brown				
		6.0		Core loss: 0.15m				
				Latite: dark grey				JT, 60°, pl, rou, Fe Crushed SM, 15mmt BP, 5°,, pl, rou, Fe Crushed SM, 10mmt Crushed SM, 10mmt

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 3/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH05**
Sheet:	3 / 3
Started:	22/11/13
Finished:	22/11/13
Logged:	LT
Checked:	VDS
RL Surface:	51.0
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301494E 6183551N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description: rock type, grain characteristics, colour, structure and minor components	degree of weathering (RS XW HW MW SW FR)	Strength IS (50) Mpa (EL 0.03, VL 0.1, L 0.3, M 1.0, H 3.0, VH 10.0, EH)	Natural fractures and Defects: spacing mm (30 100 300 1000 3000)	Description: type, inclination, thickness, planarity, roughness, coating
NMLC		7.0		Latite, coarse grained, orange brown and dark brown *(continued)*		X		
				BH05 Terminated at 7 m				
		8.0						
		9.0						
		10.0						
		11.0						
		12.0						
		13.0						

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 3/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH06**
Sheet:	PAGE 1 / 2
Started:	21/11/13
Finished:	21/11/13
Logged:	LT
Checked:	VDS
RL Surface:	51.5
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301512E 6183598N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered	D				CH	Silty CLAY : high plasticity, dark brown, with roots and trace of fine to medium grained ironstone gravel	>PI	-	TOPSOIL, GRASS COVER
		D				CH	Silty CLAY : high plasticity, grey and dark brown, trace of fine to medium grained ironstone gravel	>PI	St	COLLUVIAL HP READING: 110, 120
		1, 2, 3 N=5		1.0		-	SANDSTONE : fine to medium grained, brown, extremely low strength	XW		VERY LOW 'V' BIT RESISTANCE 'V' BIT REFUSAL
		D						DW	VL	LOW 'TC' BIT RESISTANCE, A 50mm PVC INSTALLED TO THE BOTTOM, MACHINE SLOTTED BETWEEN 3m TO 4.74m, 2mm FILTER SAND BACKFILLED TO 0.7m, BENTONITE SEALED BETWEEN 0.2m TO 0.7m. MONUMENT CONCRETED AT SURFACE
				2.0			BH06 continued from 1.95 m on sheet 2 / 2			
				3.0						
				4.0						
				5.0						
				6.0						

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH06**
Sheet:	2 / 2
Started:	21/11/13
Finished:	21/11/13
Logged:	LT
Checked:	VDS
RL Surface:	51.5
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301512E 6183598N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description: rock type, grain characteristics, colour, structure and minor components	degree of weathering: RS XW HW MW SW FR	Strength IS (50) Mpa: EL 0.03 VL 0.1 L 0.3 M 1.0 H 3.0 VH 10.0 EH	Natural fractures and Defects: spacing mm 30 100 300 1000 3000	Description: type, inclination, thickness, planarity, roughness, coating
		1.0		BH06 continued at 1.95m depth from BH06 soil log				
NMLC	Full return	2.0		Core loss: 0.05m SANDSTONE fine grained, brown and orange brown				All defects are bedding parting, BP, 0°-10°, pl, rou, Fe; except where are noted JT, 80°, pl, rou, Fe JT, 85°, pl, smo, cl JT, 85°, cu, rou, Fe JT, 45°, pl, rou, Fe JT, 40°, cu, rou, Fe JT, 45°, cu, rou, Fe JT, 80°, pl, rou, Fe XWSM, 80mm XWSM, 60mm
		3.0		Core loss: 0.17m SANDSTONE fine grained, orange brown				Crushed SM, 10mm Crushed SM, 40mm JT, 80°, cu, smo, cl 2xJT, 70°, pl, rou, Fe XWSM, 2mm XWSM, 50mm XWSM, 20mm
		4.0						
		5.0		BH06 Terminated at 4.74 m				
		6.0						

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 3/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH07**
Sheet:	PAGE 1 / 1
Started:	21/11/13
Finished:	21/11/13
Logged:	LT
Checked:	VDS
RL Surface:	67.1
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301609E 6183584N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered					CH	Silty CLAY : high plasticity, orange brown	>PI		RESIDUAL
		4, 3, 7 N=10		1.0		CH	As above, but with fine to medium grained very low strength sandstone grave	<PI	St	
		3, 4, 7 N=11		2.0						
		N=R 6, 5,-		3.0						'V' BIT REFUSAL
		D		4.0		-	SANDSTONE : fine to medium grained, orange brown	DW	VL	VERY LOW 'TC' BIT RESISTANCE
				5.0			BH07 Terminated at 4.4 m			'TC' BIT REFUSAL
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH08**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	LT
Checked:	VDS
RL Surface:	43.3
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301461E 6183614N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered	1, 4, 4 N=8		1.0		CH	Silty CLAY high plasticity, dark grey and dark brown, with fine grained sand, fine grained ironstone gravel and roots	>Pl	-	TOPSOIL, GRASS COVER
		D				CH	Silty CLAY high plasticity, dark brown and dark grey, with root fibres	>Pl	St	COLLUVIAL HP READING: 170, 180, 190
		2, 4, 7 N=11		2.0		CH	As above, but brown and grey, trace of fine grained ironstone gravel		VSt	HP READING: 270, 290, 300
		N>18 6, 18,-		3.0		-	Latite, coarse grained, orange brown and dark grey, with clay band, extremely low strength	XW		VERY LOW 'V' BIT RESISTANCE
				4.0				XW/DW		'V' BIT REFUSAL VERY LOW 'TC' BIT RESISTANCE
				5.0						
				6.0						
				7.0			BH08 Terminated at 7 m			A 50mm PVC INSTALLED TO THE BOTTOM, MACHINE SLOTTED BETWEEN 4m TO 7m, 2mm FILTER SAND BACKFILLED TO 0.7m, BENTONITE SEALED BETWEEN 0.2m TO 0.7m. MONUMENT CONCRETED AT SURFACE
				8.0						
				9.0						
				10.0						
				11.0						
				12.0						
				13.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH09**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	LT
Checked:	VDS
RL Surface:	46.4
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301582E 6183823N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None encountered	D				CL	Silty CLAY : medium plasticity, dark brown, with fine to coarse grained sandstone and ironstone gravel	~Pl	-	TOPSOIL, GRASS COVER
		2, 2, 3 N=5		1.0						
		7, 9, 8 N=17				CH	Silty CLAY : high plasticity, dark brown, with root fibres	>Pl	St	COLLUVIAL
				2.0						'V' BIT REFUSAL
						-	SANDSTONE fine to medium grained, orange brown, extremely low strength	XW		VERY LOW 'TC' BIT RESISTANCE
		D		3.0		-	As above, but orange brown and light grey, medium strength	DW	M	MEDIUM 'TC' BIT RESISTANCE
				4.0						
		D				-	As above, but orange brown			
				5.0				SW	H	HIGH 'TC' BIT RESISTANCE
							BH09 Terminated at 5.1 m			'TC' BIT REFUSAL
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH10**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	45.8
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301600E 6183836N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None encountered	D				SC	Sandy CLAY medium to high plasticity, fine grained, dark grey, sand fine to medium grained	>Pl	-	FILL, GRASS COVER
		D		1.0			BH10 Terminated at 1 m			
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH11**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	46.9
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301596E 6183814N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None encountered during augering					ML	Sandy SILT low plasticity, fine grained, dark grey, with root fibres	W	-	TOPSOIL
						-	SANDSTONE extremely weathered, brown	-	-	ROCK
							BH11 Terminated at 0.2 m			
				1.0						
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH12**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	46.4
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301569E 6183809N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None encountered during augering					ML	Sandy SILT low plasticity, fine grained, dark grey, with root fibres	-	-	TOPSOIL
		D				CI/CH	Silty CLAY medium to high plasticity, dark grey, some gravel	>Wp	-	FILL
				1.0			BH12 Terminated at 0.5 m			
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH13**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	42.2
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301511E 6183772N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered	D D				CH	Sandy CLAY high plasticity, brown, sand fine to medium grained	>Wp	-	FILL
				1.0			BH13 Terminated at 0.5 m			
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH14**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	38.9
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301459E 6183731N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered	D				CI/CH	Sandy CLAY medium to high plasticity, dark grey, sand fine to medium grained, some gravel	≥Wp	-	FILL
							BH14 Terminated at 0.3 m			
				1.0						
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH15**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	37.4
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301433E 6183706N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered	D				SM	Silty SAND fine to medium grained, brown, traces of grass rootlets	-	-	TOPSOIL
						CI	Silty CLAY high plasticity, grey, sand fine to medium grained	>Wp	-	FILL
				1.0			BH15 Terminated at 0.5 m			
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH16**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	37.7
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301420E 6183679N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered	D				SP	Silty SAND fine to medium grained, brown, traces of grass rootlets	M	-	TOPSOIL
						CH	Silty CLAY medium to high plasticity, grey	>Wp	-	RESIDUAL
				1.0			BH16 Terminated at 0.3 m			
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH17**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	42.3
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301392E 6183635N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered	D				CI	Silty CLAY low to medium plasticity, dark grey, traces of grass rootlets	<Wp	-	TOPSOIL
						CH	Silty CLAY medium to high plasticity, dark grey	>Wp	-	RESIDUAL
				1.0			BH17 Terminated at 0.3 m			
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH18**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	41.3
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301451E 6183679N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered					ML	Sandy SILT low plasticity, dark grey, some grass rootlets	<Wp	-	TOPSOIL
						CH	Silty CLAY high plasticity, dark grey	≥Wp	-	RESIDUAL
				1.0			BH18 Terminated at 0.3 m			
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH19**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	52.4
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301553E 6183707N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered	D				CI	Sandy CLAY medium to high plasticity, grey, sand fine to medium grained	<Wp	-	TOPSOIL
						-	SANDSTONE extremely weathered, brown	-	-	ROCK
							BH19 Terminated at 0.3 m			
				1.0						
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH20**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	52.5
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301538E 6183661N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered	D				CI	Sandy CLAY medium to high plasticity, dark grey, sand fine to medium grained	<Wp	-	TOPSOIL
						-	SANDSTONE extremely weathered, brown	-	-	ROCK
							BH20 Terminated at 0.3 m			
				1.0						
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH21**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	RS
Checked:	VDS
RL Surface:	53.5
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301538E 6183619N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None Encountered	D				ML	Sandy SILT low plasticity, dark grey, sand fine to medium grained, some gravel/ironstone	<Wp		TOPSOIL
						-	SANDSTONE extremely weathered, brown	-		ROCK
							BH21 Terminated at 0.3 m			
				1.0						
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH22**
Sheet:	PAGE 1 / 1
Started:	28/11/13
Finished:	28/11/13
Logged:	LT
Checked:	VDS
RL Surface:	65.3
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301611E 6183599N

Equipment Type: HAND AUGER

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
HA	None encountered	D				CL	Silty CLAY : medium plasticity, dark brown, with roots	>PI	-	TOPSOIL, GRASS COVER
						CH	Silty CLAY : high plasticity, orange brown, with fine to medium grained sandstone gravel	<PI	St	RESIDUAL
				1.0			BH22 Terminated at 0.4 m			HAND AUGER REFDUSAL
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH31**
Sheet:	PAGE 1 / 2
Started:	08/01/14
Finished:	08/01/14
Logged:	LT
Checked:	VDS
RL Surface:	52.2
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301561E 6183740N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None Encountered					CL	Silty CLAY : medium plasticity, dark brown, with roots	<Wp	-	TOPSOIL
						CH	Silty CLAY : high plasticity, dark brown and red brown	>Wp	St	RESIDUAL
				1.0						
						CH	As above, but grey to dark grey			
				2.0						
						SC	Sandy Silty CLAY : medium plasticity, orange brown, fine grained sand	~Wp		
				3.0						'V' BIT REFUSAL
						-	SANDSTONE : fine grained, orange brown	XW		VERY LOW 'TC' BIT RESISTANCE
							BH31 continued from 3.6 m on sheet 2 / 2			
				4.0						
				5.0						
				6.0						

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	BH31
Sheet:	2 / 2
Started:	08/01/14
Finished:	08/01/14
Logged:	LT
Checked:	VDS
RL Surface:	52.2
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301561E 6183740N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description rock type, grain characteristics, colour, structure and minor components	degree of weathering RS XW HW MW SW FR	Strength IS (50) Mpa EL 0.03 VL 0.1 L 0.3 M 1.0 H 3.0 VH 10.0 EH	Natural fractures and Defects spacing mm 30 100 300 1000 3000	Description type, inclination, thickness, planarity, roughness, coating
		1.0		BH31 continued at 3.6m depth from BH31 soil log				
		2.0						
		3.0						
NMLC		4.0		SANDSTONE : fine grained, orange brown, extremely low strength				JT, 80°, cu, smo, Cl 2mm CLAY SM, 5mm CLAY SM, 30mm
				As above, but coarse grained				
				SANDSTONE : fine grained, orange brown and dark brown				
		5.0		SANDSTONE : fine grained, light grey				CLAY SM, 50mm
				BH31 Terminated at 4.98 m				
		6.0						

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 13/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH32**
Sheet:	PAGE 1 / 2
Started:	08/01/14
Finished:	08/01/14
Logged:	LT
Checked:	VDS
RL Surface:	62.0
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301442E 6183501N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None Encountered					CL	Silty CLAY : medium plasticity, dark brown, with roots	<Wp	-	TOPSOIL, GRASS COVER
						CL	Silty CLAY : medium plasticity, orange brown, fine grained sand	<Wp	St	RESIDUAL
				1.0						'V' BIT REFUSAL
		D				-	SANDSTONE : fine grained, orange brown	DW	L	
							BH32 continued from 1.52 m on sheet 2 / 2			
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	BH32
Sheet:	2 / 2
Started:	08/01/14
Finished:	08/01/14
Logged:	LT
Checked:	VDS
RL Surface:	62.0
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301442E 6183501N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description rock type, grain characteristics, colour, structure and minor components	degree of weathering RS XW HW MW SW FR	Strength IS (50) Mpa EL 0.03 VL 0.1 L 0.3 M 1.0 H 3.0 VH 10.0 EH	Natural fractures and Defects spacing mm 30 100 300 1000 3000	Description type, inclination, thickness, planarity, roughness, coating
		1.0		BH32 continued at 1.52m depth from BH32 soil log				
NMLC		2.0		SANDSTONE : fine grained, orange brown				CLAY SM, 60mm JT, 90°, un, rou, Fe JT, 70°, pl, smo, Cl 1mm CLAY SM, 20mm CRUSHED SM, 50mm JT, 80°, pl, rou, Cn
		3.0		SANDSTONE : fine grained, light grey				JT, 85°, pl, rou, Fe
		4.0		As above, but fine to medium grained				
		5.0						
		6.0		BH32 Terminated at 5.09 m				

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 13/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	**BH33**
Sheet:	PAGE 1 / 2
Started:	08/01/14
Finished:	08/01/14
Logged:	LT
Checked:	VDS
RL Surface:	62.0
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301514E 6183511N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments / notes, structure, and additional observations
ADT	None Encountered					CL	Silty CLAY : medium plasticity, dark brown, with roots	<Wp	-	TOPSOIL, GRASS COVER
						CL	Sandy CLAY : low plasticity, orange brown, fine grained sand, with fine to medium grained sandstone gravel	<Wp	St	RESIDUAL
		2, 6, 10 N=16		1.0				>Wp		'V' BIT REFUSAL AT 1.8m
						-	SANDSTONE : fine grained, orange brown, extremely low strength	XW	-	LOW 'TC' BIT RESISTANCE
				2.0			BH33 continued from 1.9 m on sheet 2 / 2			
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 21/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

CORED BOREHOLE LOG

Network Geotechnics
ACN 069 211 561
Unit 12/9-15 Gundah Road
Mt Kuring-Gai NSW 2080
02 8438 0300
02 8438 0310

Job No:	G09/1100 A
Hole No:	BH33
Sheet:	2 / 2
Started:	08/01/14
Finished:	08/01/14
Logged:	LT
Checked:	VDS
RL Surface:	62.0
Datum:	A.H.D

Client: TCG PLANNING

Project: LIFE CITY WOLLONONG

Location: Warwick Street, Berkeley
GPS 301514E 6183511N

Equipment Type: MOBILE DRILL B80

Borehole Diameter: 100mm (I.D.) Inclination: -90 deg Bearing:

method	water	depth (m)	graphic log	Rock substance description rock type, grain characteristics, colour, structure and minor components	degree of weathering RS XW HW MW SW FR	Strength IS (50) Mpa EL 0.03 VL 0.1 L 0.3 M 1.0 H 3.0 VH 10.0 EH	Natural fractures and Defects spacing mm 30 100 300 1000 3000	Description type, inclination, thickness, planarity, roughness, coating
		1.0		BH33 continued at 1.9m depth from BH33 soil log				
NMLC		2.0		SANDSTONE : fine grained, orange brown				JT, 90°, pl, rou, Fe JT, 90°, pl, rou, Fe JT, 90°, pl, rou, Fe BP, 0°, pl, Fe CRUSHED SEAM, 5mm CRUSHED SEAM, 10mm JT,40°, pl, rou, Fe CLAY SM, 50mm CLAY SM, 10mm BP, 0°, pl, Fe
		3.0		SANDSTONE : fine grained, light grey				JT, 60°, pl, rou, Cn
		4.0						
		5.0		BH33 Terminated at 4.17 m				
		6.0						

LOG OF CORED BOREHOLE G09-1100 LOGS.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 13/1/14

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

TERMS AND SYMBOLS

SOIL DESCRIPTIONS

Moisture Condition

D	Dry
M	Moist
W	Wet
Wp	Plastic Limit
Wl	Liquid Limit
MC	Moisture Content

Consistency

		Qu (kPa)
VS	Very Soft	<25
S	Soft	25 – 50
F	Firm	50 – 100
St	Stiff	100 – 200
VSt	Very Stiff	200 – 400
H	Hard	>400
Fb	Friable	

Density Index

		I_D (%)
VL	Very Loose	< 15
L	Loose	15 – 35
MD	Medium Dense	35 – 65
D	Dense	65 – 85
VD	Very Dense	> 85

ROCK DESCRIPTIONS

Weathering

Rs	Residual Soil
XW	Extremely Weathered
HW	Highly Weathered
MW	Moderately Weathered
DW	Distinctly Weathered
SW	Slightly Weathered
FR	Fresh

(DW covers both HW & MW)

Strength

		Is (50) MPa
EL	Extremely Low	< 0.03
VL	Very Low	0.03 – 0.1
L	Low	0.1 – 0.3
M	Medium	0.3 – 1
H	High	1 – 3
VH	Very High	3 – 10
EH	Extremely High	> 10

Structure

	Spacing
Thinly Laminated	< 6mm
Laminated	6 – 20mm
Very thinly bedded	20 – 60mm
Thinly bedded	60 – 200mm
Medium bedded	0.2 – 0.6m
Thickly bedded	0.6 – 2.0m
Very thickly bedded	> 2.0m

NOTE: Soil And rock descriptions are based on AS 1726 - 1993

Natural Fractures

Type		Shape	
JT	Joint	pl	Planar
BP	Bedding plane	cu	Curved
SM	Seam	un	Undulose
FZ	Fractured zone	st	Stepped
SZ	Shear zone	ir	Irregular
VN	Vein		

Infill or Coating		Roughness	
Cn	Clean	pol	Polished
Cl	Clay	slk	Slickensided
Ca	Calcite	smo	Smooth
Fe	Iron oxide	rou	Rough
Mi	Micaceous	vro	Very rough
Qz	Quartz		

EXCAVATION / DRILLING METHOD & CASING

BH	Backhoe/excavator bucket
NE	Natural exposure
HE	Hand excavation
AS	Auger Screwing *
AD	Auger Drilling *
R	Roller/Tricone
W	Washbore

** denotes bit shown by suffix*

B	Blank Bit
V	"V" Shaped Bit
T	Tungsten Carbide Bit
LB	Large Bore Push Tube Drilling
MC	Macro Core Push Tube Drilling
DT	Dual Push Tube Drilling

NMLC	NMLC Core Drilling
NQ/HQ	Wireline Core Drilling

C	Casing
M	Mud

SAMPLES / TESTS

B	Bulk sample
D	Disturbed sample
U50	Thin-walled tube sample (50mm diameter)
PP	Pocket penetrometer (kPa)
N*	SPT (blows per 300mm)
	**denotes sample taken*
Nc	SPT with solid cone
R	SPT refusal

VANE SHEAR TESTS

s_U	Vane shear strength Peak/residual (kPa) and Vane size (mm)

WATER MEASUREMENTS

▼	Water level at the time of drilling
—	
▽	Water level after drilling
▲—	Water inflow
—▲	Water outflow

PUSH TUBE DRILLING

Degree of Resistance	Factor
No percussion	0
Fast push with percussion	1
Medium push with percussion	2
Slow push with percussion	3
Very slow – nearing refusal	4

APPENDIX B

Laboratory Test Results

Network Geotechnics Pty Ltd
Geotechnical Engineering, Consulting & Testing Services

ACN 069 211 561
Unit 1/140 Industrial Road
Oak Flats NSW 2529 AUSTRALIA
Telephone 61 2 4257 4458
Facsimile 61 2 4257 4463
Email southcoast@netgeo.com.au

Client:	TCG Planning	Job No:	G09/110
Principal:		Date:	16/12/2013
Project:	Life of City	Tested By:	HU
Location:	Berkeley	Checked By:	HU

ACID SULPHATE ANALYSIS

SAMPLE NUMBER	BOREHOLE NUMBER	DEPTH (m)	pH	pH With Peroxide	Remarks
W46985	BH3	0.4-0.5	6.1	4.5	
W46986	BH2	1.5-1.7	5.4	5.1	
W46987	BH5	0.5-0.95	6.5	5.9	
W46989	BH5	0.0-0.1	7.2	4.7	
W46992	BH6	0.4-0.5	8.2	6.3	
W46993	BH8	1.0-1.2	8.0	5.4	
W46995	BH8	0.5-0.8	7.9	4.6	
W46996	BH9	0.5-0.95	6.9	6.1	

chris.lloyd@sgs.com
ABN: 44 000 964 278
ph: +61 (0)2 8594 0481
fx: +61 (0)2 8594 0499

TEST CERTIFICATE

SGS Australia Pty Ltd
PO Box 6432 Alexandria NSW 2015
Unit 15, 33 Maddox Street
Alexandria NSW 2015

Client:	Network Geotechnics Pty Ltd	Client Job No:	G09/1100 A
Order No:		Project:	Proposed Life City Wollongong
Tested Date:	17/12/2013	Location:	
SGS Job Number:	13-32-745	Sample No:	13-AC-5513
Lab:	Alexandria CMT	Sample ID:	BH2 0.70-0.95m

Emerson Class Number of a Soil

AS 1289.3.8.1

Emerson Class Number:	**5**
Soil Description:	SILTY CLAY:brown
Type of Water Used:	Distilled water at 20°C

Note: Sample supplied by client.

Approved Signatory: N O'Mahony (Niall O'Mahony.Senior Technical Officer) Date: 7/01/2014

Accredited for compliance with ISO/IEC 17025

TEST CERTIFICATE

ABN 44 000 964 278
ph: +61 (0)2 8594 0481
fax: +61 (0)2 8594 0499

SGS Australia Pty Ltd
Unit 15, 33 Maddox Street
(PO Box 6432)
Alexandria NSW 2015
Australia

PERCENT DISPERSION OF A SOIL

CLIENT: **Network Geotechnics Pty Ltd**
Unit 129-15 Gundah RoadMt Kuring_Gai NSW 2080
PROJECT: **Proposed Life City Wollongong (G09/1100 A)**
LOCATION:

Lab Number	Sample Source	Sample Description	% Passing 0.005mm without Dispersing Agent	% Passing 0.005mm with Dispersing Agent	Percent Dispersion (%)
13-AC-5513	BH2 0.70-0.95m	SILTY CLAY:brown	49	52	**94%**

NOTES TO TESTING

Test Procedure: AS1289 3.8.2 Determination of the percent dispersion of a soil

Sampled By: Client
Job Number: 13-32-745
Date Tested: 12/12/2013
Comments:

Approved Signatory: Chris Lloyd **Date:** 17/12/2013

Accredited for Compliance with ISO/IEC 17025

Accreditation No. 2418

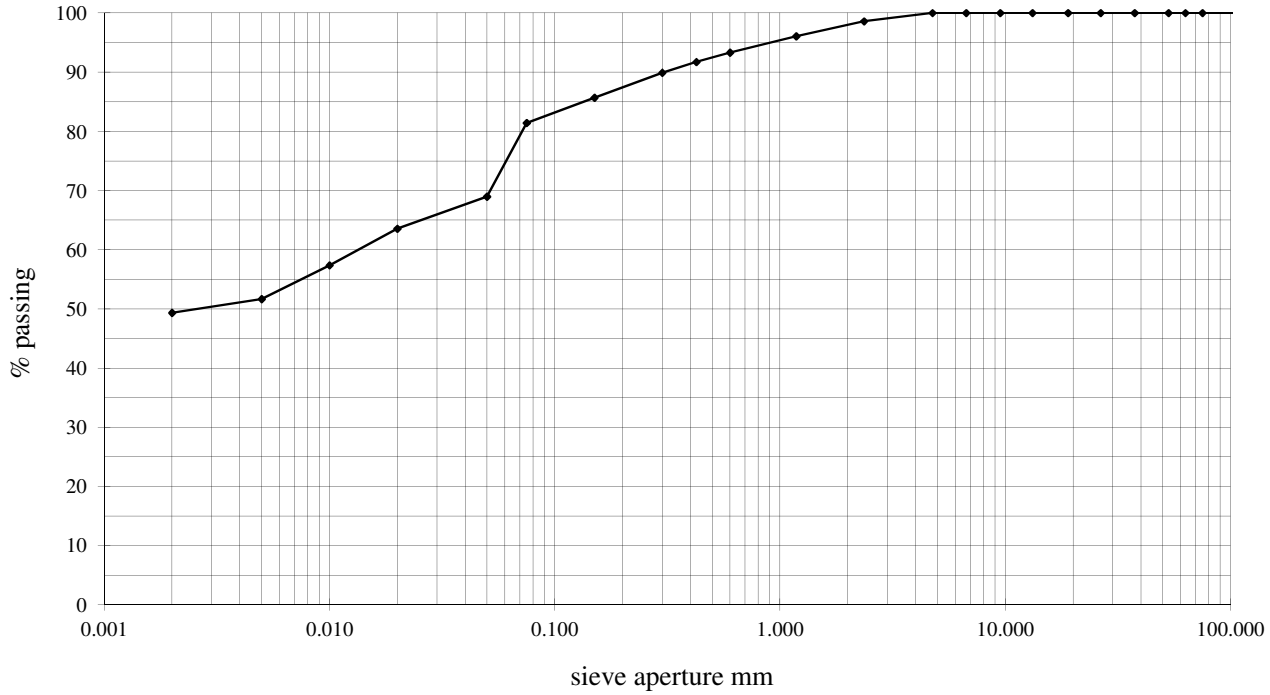
TEST CERTIFICATE

ABN 44 000 964 278
ph: +61 (0)2 8594 0481
fax: +61 (0)2 8594 0499

SGS Australia Pty Ltd
Unit 15, 33 Maddox Street
(PO Box 6432)
Alexandria NSW 2015
Australia

PARTICLE SIZE DISTRIBUTION

Client: **Network Geotechnics Pty Ltd**
Address: **Unit 129-15 Gundah RoadMt Kuring_Gai NSW 2080**
Project: **Proposed Life City Wollongong (G09/1100 A)**
Location:
Test Method: **AS 1289 3.6.1 / 3**
Job Number: 13-32-745
Sample Source: BH2 0.70-0.95m
Sampled By: Client
Lab Number: 13-AC-5513
Date Tested: 13/12/2013
Checked By: JL



Clay	Silt	Sand	Gravel

Sample Description: SILTY CLAY:brown

Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
150.0		1.18	**96**
75.0		0.600	**93**
63.0		0.425	**92**
53.0		0.300	**90**
37.5		0.150	**86**
26.5		0.075	**81**
19.0		0.050	**69**
13.2		0.020	**64**
9.5		0.010	**57**
6.7		0.005	**52**
4.75	**100**	0.002	**49**
2.36	**99**		

Hydrometer Type: **ASTM 152H**
Dispersant Type: **Sodium Hexametaphosphate**
Pretreatment: **None**
Loss on Pretreatment: **None**
Remarks:

Approved Signatory: Chris Lloyd Date: 17/12/2013

Accredited for Compliance with ISO/IEC 17025

TEST CERTIFICATE

ABN 44 000 964 278
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SGS Australia Pty Ltd
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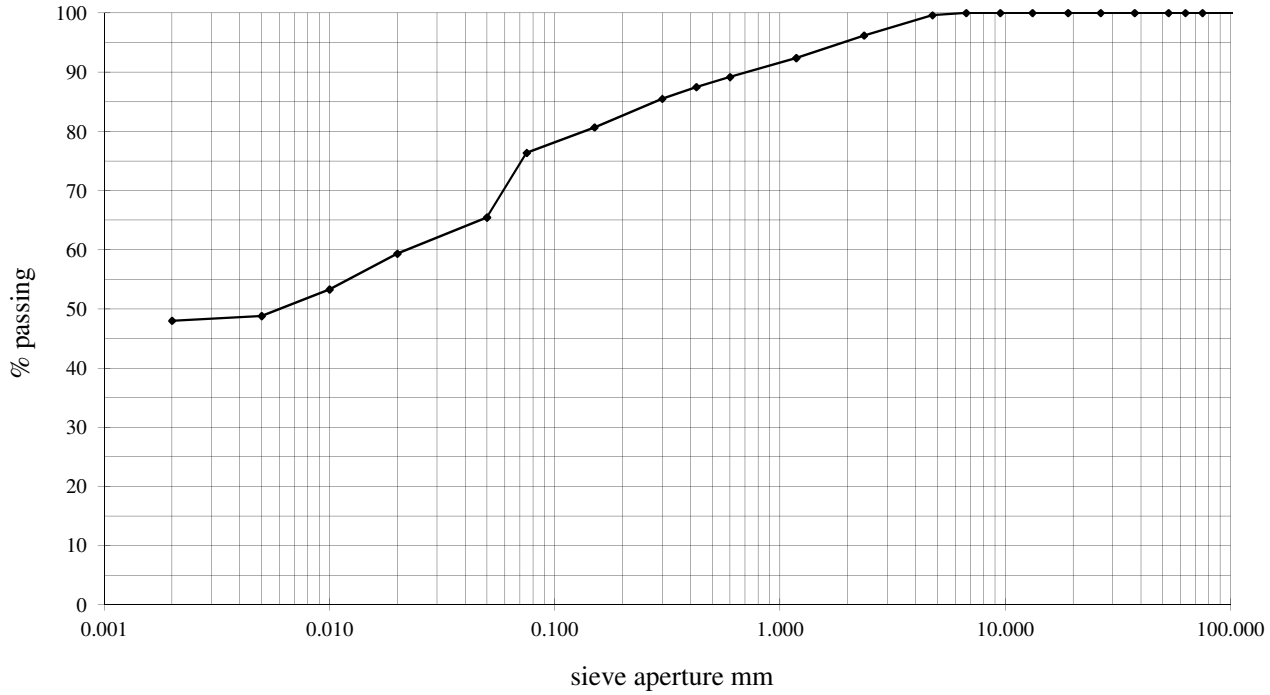
(PO Box 6432)
Alexandria NSW 2015
Australia

PARTICLE SIZE DISTRIBUTION

Client: **Network Geotechnics Pty Ltd**
Address: **Unit 129-15 Gundah RoadMt Kuring_Gai NSW 2080**
Project: **Proposed Life City Wollongong (G09/1100 A)**
Location:
Test Method: **AS 1289 3.6.1 / 3**
Job Number: 13-32-745
Sample Source: BH2 0.70-0.95m
Sampled By: Client
Lab Number: 13-AC-5513
Date Tested: 13/12/2013
Checked By: JL



Clay	Silt	Sand	Gravel

Sample Description: SILTY CLAY:brown

Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
150.0		1.18	**92**
75.0		0.600	**89**
63.0		0.425	**87**
53.0		0.300	**85**
37.5		0.150	**81**
26.5		0.075	**76**
19.0		0.050	**65**
13.2		0.020	**59**
9.5		0.010	**53**
6.7		0.005	**49**
4.75	**100**	0.002	**48**
2.36	**96**		

Hydrometer Type: **ASTM 152H**
Dispersant Type: **N/A**
Pretreatment: **None**
Loss on Pretreatment: **None**
Remarks:

Approved Signatory: Chris Lloyd Date: 07.01.14

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TEST CERTIFICATE

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Alexandria NSW 2015

Client:	Network Geotechnics Pty Ltd	Client Job No:	G09/1100 A
Order No:		Project:	Proposed Life City Wollongong
Tested Date:	17/12/2013	Location:	
SGS Job Number:	13-32-745	Sample No:	13-AC-5514
Lab:	Alexandria CMT	Sample ID:	BH4 1.65-1.85m

Emerson Class Number of a Soil

AS 1289.3.8.1

Emerson Class Number:	**5**
Soil Description:	SANDY SILTY CLAY:brown
Type of Water Used:	Distilled water at 20°C

Note: Sample supplied by client.

Approved Signatory: N O'Mahony (Niall O'Mahony.Senior Technical Officer) Date: 7/01/2014

Accredited for compliance with ISO/IEC 17025

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TEST CERTIFICATE

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Client:	Network Geotechnics Pty Ltd	Client Job No:	G09/1100 A
Order No:		Project:	Proposed Life City Wollongong
Tested Date:	17/12/2013	Location:	
SGS Job Number:	13-32-745	Sample No:	13-AC-5515
Lab:	Alexandria CMT	Sample ID:	BH5 1.50-1.95m

Emerson Class Number of a Soil

AS 1289.3.8.1

Emerson Class Number:	**2**
Soil Description:	SILTY CLAY:brown
Type of Water Used:	Distilled water at 20°C

Note: Sample supplied by client.

Approved Signatory: N O'Mahony (Niall O'Mahony.Senior Technical Officer) Date: 7/01/2014

Accredited for compliance with ISO/IEC 17025

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SGS Australia Pty Ltd
Unit 15, 33 Maddox Street
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Alexandria NSW 2015
Australia

PERCENT DISPERSION OF A SOIL

CLIENT: **Network Geotechnics Pty Ltd**
Unit 129-15 Gundah RoadMt Kuring_Gai NSW 2080
PROJECT: **Proposed Life City Wollongong (G09/1100 A)**
LOCATION:

Lab Number	Sample Source	Sample Description	% Passing 0.005mm without Dispersing Agent	% Passing 0.005mm with Dispersing Agent	Percent Dispersion (%)
13-AC-5515	BH5 1.50-1.95m	SILTY CLAY:brown	47	50	**94%**

NOTES TO TESTING

Test Procedure: AS1289 3.8.2 Determination of the percent dispersion of a soil

Sampled By: Client
Job Number: 13-32-745
Date Tested: 12/12/2013
Comments:

Approved Signatory: Chris Lloyd **Date:** 17/12/2013

Accredited for Compliance with ISO/IEC 17025

Accreditation No. 2418

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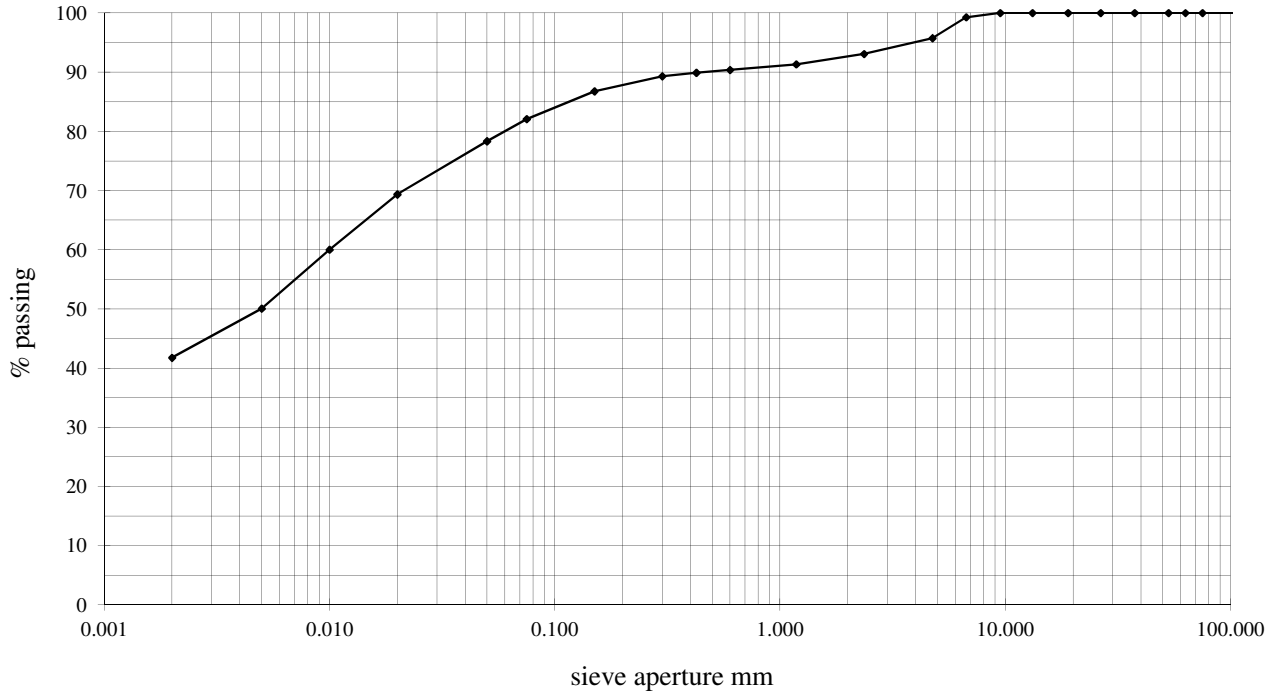
Alexandria NSW 2015
Australia

PARTICLE SIZE DISTRIBUTION

Client: Network Geotechnics Pty Ltd
Address: Unit 129-15 Gundah RoadMt Kuring_Gai NSW 2080
Project: Proposed Life City Wollongong (G09/1100 A)
Location:
Test Method: **AS 1289 3.6.1 / 3**
Job Number: 13-32-745
Sample Source: BH5 1.50-1.95m
Sampled By: Client
Lab Number: 13-AC-5515
Date Tested: 13/12/2013
Checked By: JL



Clay	Silt	Sand	Gravel

Sample Description: SILTY CLAY:brown

Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
150.0		1.18	**91**
75.0		0.600	**90**
63.0		0.425	**90**
53.0		0.300	**89**
37.5		0.150	**87**
26.5		0.075	**82**
19.0		0.050	**78**
13.2		0.020	**69**
9.5	**100**	0.010	**60**
6.7	**99**	0.005	**50**
4.75	**96**	0.002	**42**
2.36	**93**		

Hydrometer Type: **ASTM 152H**
Dispersant Type: **Sodium Hexametaphosphate**
Pretreatment: **None**
Loss on Pretreatment: **None**
Remarks:

Approved Signatory: Chris Lloyd Date: 17/12/2013

Accredited for Compliance with ISO/IEC 17025

TEST CERTIFICATE

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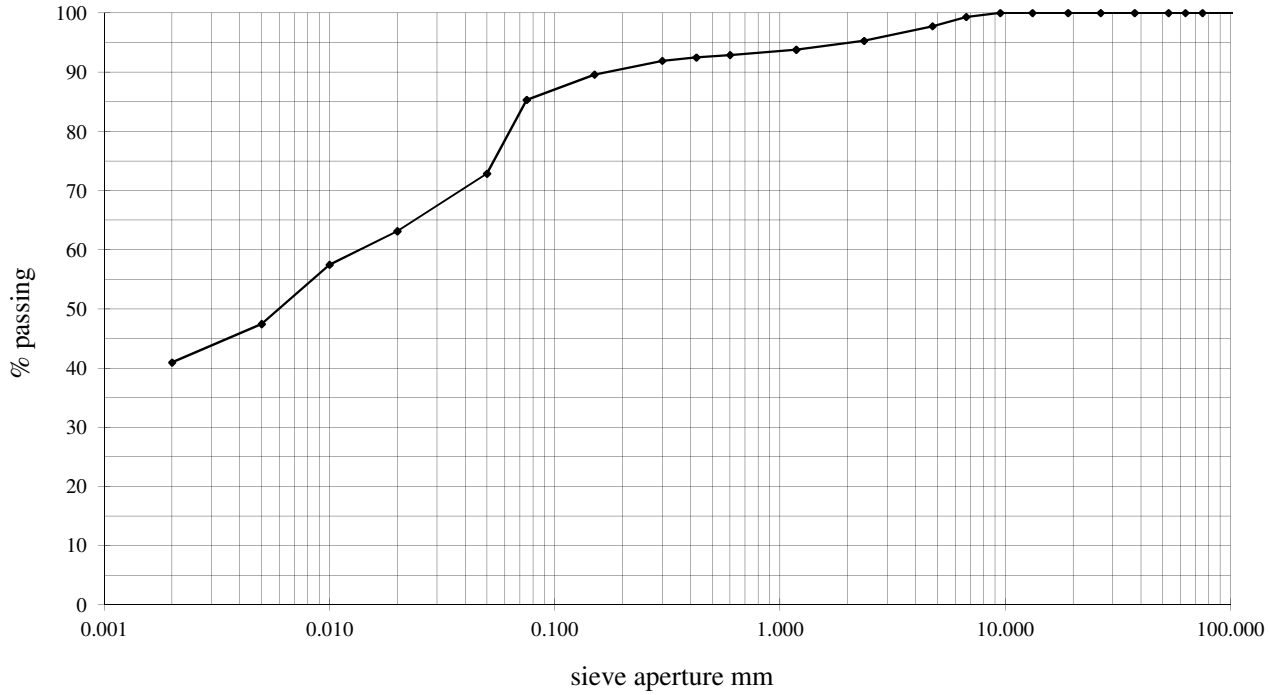
Alexandria NSW 2015
Australia

PARTICLE SIZE DISTRIBUTION

Client: Network Geotechnics Pty Ltd
Address: Unit 129-15 Gundah RoadMt Kuring_Gai NSW 2080
Project: Proposed Life City Wollongong (G09/1100 A)
Location:
Test Method: **AS 1289 3.6.1 / 3**
Job Number: 13-32-745
Sample Source: BH5 1.50-1.95m
Sampled By: Client
Lab Number: 13-AC-5515
Date Tested: 12/12/2013
Checked By: JL



Clay	Silt	Sand	Gravel

Sample Description: SILTY CLAY:brown

Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
150.0		1.18	**94**
75.0		0.600	**93**
63.0		0.425	**92**
53.0		0.300	**92**
37.5		0.150	**90**
26.5		0.075	**85**
19.0		0.050	**73**
13.2		0.020	**63**
9.5	**100**	0.010	**57**
6.7	**99**	0.005	**47**
4.75	**98**	0.002	**41**
2.36	**95**		

Hydrometer Type: **ASTM 152H**
Dispersant Type: **N/A**
Pretreatment: **None**
Loss on Pretreatment: **None**
Remarks:

Approved Signatory: Chris Lloyd Date: 17/12/2013

Accredited for Compliance with ISO/IEC 17025

Accreditation No. 2418

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TEST CERTIFICATE

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Alexandria NSW 2015

Client:	Network Geotechnics Pty Ltd	Client Job No:	G09/1100 A
Order No:		Project:	Proposed Life City Wollongong
Tested Date:	17/12/2013	Location:	
SGS Job Number:	13-32-745	Sample No:	13-AC-5516
Lab:	Alexandria CMT	Sample ID:	BH5 3.00-3.45m

Emerson Class Number of a Soil

AS 1289.3.8.1

Emerson Class Number:	**5**
Soil Description:	SILTY CLAY:brown
Type of Water Used:	Distilled water at 20°C

Note: Sample supplied by client.

Approved Signatory: N O'Mahony (Niall O'Mahony.Senior Technical Officer) Date: 7/01/2014

Accredited for compliance with ISO/IEC 17025

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Alexandria NSW 2015

Client:	Network Geotechnics Pty Ltd	Client Job No:	G09/1100 A
Order No:		Project:	Proposed Life City Wollongong
Tested Date:	17/12/2013	Location:	
SGS Job Number:	13-32-745	Sample No:	13-AC-5517
Lab:	Alexandria CMT	Sample ID:	BH8 1.50-1.95m

Emerson Class Number of a Soil

AS 1289.3.8.1

Emerson Class Number:	**2**
Soil Description:	SILTY CLAY:brown
Type of Water Used:	Distilled water at 20°C

Note: Sample supplied by client.

Approved Signatory: N O'Mahony (Niall O'Mahony.Senior Technical Officer) Date: 7/01/2014

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laboratory@netgeo.com.au

POINT LOAD STRENGTH INDEX TEST REPORT

Report Number: **G09/1100**

CLIENT: **TCG Planning** **Test Request Number:** **NA**

PROJECT: **Life of City**

LOCATION: **Between Warwick, Nottingham and York Street, Berkeley**

LAB. NO.	SAMPLE SOURCE	LITHOLOGY	PLATEN SEPARATION		TEST ORIENTATION	POINT LOAD STRENGTH	POINT LOAD STRENGTH
			DIAM (mm)	HEIGHT (mm)		I_s (MPa)	I_s 50 (MPa)
	BH3 4.46m-4.50m	SANDSTONE	52.3	 39.1	Diametral Axial	0.07 0.08	0.07 0.08
	BH3 5.61m-5.65m	SANDSTONE	52.1	 37.6	Diametral Axial	0.04 0.05	0.04 0.05
	BH3 6.72m-6.76m	SANDSTONE	52.4	 43.9	Diametral Axial	0.04 0.04	0.04 0.04
	BH3 7.22m-7.26m	SANDSTONE	51.8	 41.3	Diametral Axial	0.34 0.04	0.34 0.04
	BH4 4.81m-4.84m	SANDSTONE	52.3	 31.8	Diametral Axial	0.15 0.57	0.15 0.55
	BH4 5.20m-5.24m	SANDSTONE	52	 42.1	Diametral Axial	0.07 0.22	0.08 0.22
	BH4 6.40m-6.43m	SANDSTONE	51.9	0 33.4	Diametral Axial	1.02 1.41	1.04 1.37
	BH4 7.28m-7.32m	SANDSTONE	52.3	0 41.3	Diametral Axial	2.37 2.98	2.42 3.05

NOTES TO TESTING

Testing Device: ELE Point Load Tester

Sample History: Unsoaked

Sampled by: LT

Date Tested: 29/11/2013

Test method: AS 4133 4.1

Job Number: G09/1100

Approved Signatory

Date: 3rd December 2013

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025 **Mount Kuring-gai Laboratory 1318**

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POINT LOAD STRENGTH INDEX TEST REPORT

Report Number: **G09/1100**

CLIENT: **TCG Planning** **Test Request Number:** **NA**

PROJECT: **Life of City**

LOCATION: **Between Warwick, Nottingham and York Street, Berkeley**

LAB. NO.	SAMPLE SOURCE	LITHOLOGY	PLATEN SEPARATION		TEST ORIENTATION	POINT LOAD STRENGTH	POINT LOAD STRENGTH
			DIAM (mm)	HEIGHT (mm)		I_s (MPa)	I_s 50 (MPa)
	BH5 4.55m-4.58m	SANDSTONE	51.2	31.6	Diametral Axial	0.14 0.17	0.15 0.16
	BH5 5.48m-5.53m	SANDSTONE	51.1	49.5	Diametral Axial	0.34 0.47	0.34 0.50
	BH5 6.51m-6.56m	SANDSTONE	51.8	46.8	Diametral Axial	3.61 3.53	3.67 3.70
	BH6 2.80m-2.84m	SANDSTONE	52.3	40.1	Diametral Axial	0.22 0.16	0.23 0.16
	BH6 3.66m-3.70m	SANDSTONE	51.3	37.8	Diametral Axial	0.12 0.28	0.12 0.27
	BH6 4.40m-4.44m	SANDSTONE	51.4	39.5	Diametral Axial	0.30 0.56	0.30 0.57

NOTES TO TESTING

Testing Device: ELE Point Load Tester

Sample History: Unsoaked

Sampled by: LT

Date Tested: 29/11/2013

Test method: AS 4133 4.1

Job Number: G09/1100

Approved Signatory

Date: 3rd December 2013

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025 **Mount Kuring-gai Laboratory 1318**

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POINT LOAD STRENGTH INDEX TEST REPORT

Report Number: **G09/1100**

CLIENT: **TCG Planning** **Test Request Number:** **NA**

PROJECT: **Life of City**

LOCATION: **Between Warwick, Nottingham and York Street, Berkeley**

LAB. NO.	SAMPLE SOURCE	LITHOLOGY	PLATEN SEPARATION		TEST ORIENTATION	POINT LOAD STRENGTH	POINT LOAD STRENGTH
			DIAM (mm)	HEIGHT (mm)		I_s (MPa)	I_s 50 (MPa)
	BH31 4.45m-4.48m	SANDSTONE	51.7	32	Diametral Axial	0.14	0.14
	BH31 4.90m-4.93m	SANDSTONE	51.7	31	Diametral Axial	0.19 0.18	0.19 0.17
	BH32 1.52m-1.55m	SANDSTONE	51.7	29	Diametral Axial	0.76 1.20	0.77 1.13
	BH32 2.72m-2.75m	SANDSTONE	51.7	26.2	Diametral Axial	7.00	6.44
	BH32 3.79m-3.83m	SANDSTONE	51.2	36.2	Diametral Axial	2.39 3.54	2.42 3.50
	BH32 4.54m-4.58m	SANDSTONE	51.2	34.5	Diametral Axial	1.79 2.76	1.81 2.69

NOTES TO TESTING

Testing Device:	ELE Point Load Tester	Date Tested:	13/01/2014
Sample History:	Unsoaked	Test method:	AS 4133 4.1
Sampled by:	LT	Job Number:	G09/1100
		Approved Signatory	
		Date:	3rd December 2013

NATA ACCREDITED FOR TECHNICAL COMPETENCE

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POINT LOAD STRENGTH INDEX TEST REPORT

Report Number: **G09/1100**

CLIENT: **TCG Planning** **Test Request Number:** **NA**

PROJECT: **Life of City**

LOCATION: **Between Warwick, Nottingham and York Street, Berkeley**

LAB. NO.	SAMPLE SOURCE	LITHOLOGY	PLATEN SEPARATION		TEST ORIENTATION	POINT LOAD STRENGTH	POINT LOAD STRENGTH
			DIAM (mm)	HEIGHT (mm)		I_s (MPa)	I_s 50 (MPa)
	BH33 2.30m-2.34m	SANDSTONE	51.5	33.5	Diametral Axial	0.61	0.59
	BH33 2.93m-2.97m	SANDSTONE	51.5	34.1	Diametral Axial	3.04 1.66	3.08 1.62
	BH33 3.45m-3.47m	SANDSTONE	51.5	27.6	Diametral Axial	2.61 2.76	2.64 2.56
	BH33 4.00m-4.03m	SANDSTONE	51.5	26.6	Diametral Axial	1.32 4.09	1.34 3.77

NOTES TO TESTING

Testing Device:	ELE Point Load Tester	Date Tested:	13/01/2014
Sample History:	Unsoaked	Test method:	AS 4133 4.1
Sampled by:	LT	Job Number:	G09/1100
		Approved Signatory	
		Date:	13th January 2014

NATA ACCREDITED FOR TECHNICAL COMPETENCE

Accredited for compliance with ISO/IEC 17025 **Mount Kuring-gai Laboratory 1318**

LEGEND

O NETWORK GEOTECHNICS (NG) BOREHOLE 2013

Δ COFFEY GEOTECHNICS TEST PIT (CTP) 2012

□ CLEARSAFE CONTAMINATION SPOT (CCS) 2012

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Email southcoast@netgeo.com.au

NOT IN SCALE
DRAWING NO: G09/1100-1

CLIENT: TCG PLANNING

PROJECT: PROPOSED LIFE CITY PROJECT

LOCATION: WARWICK STREET, BERKELEY, NSW

APPROXIMATE TEST LOCATION PLAN