EMAG APARTMENTS PTY LTD

PROPOSED MULTI LEVEL DEVELOPMENT

2-18 STATION STREET, MARRICKVILLE, NSW

GEOTECHNICAL INVESTIGATION

Environmental Investigations

Report No. E1629.1 GA

21st June, 2012

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EI Ref: *E1629.1 GA*
Date: *21st June, 2012*

Mr Joseph Ghosn
Emag Apartments Pty Ltd
Suite 1, 32-34 Bunn Street
PYRMONT NSW 2009

RE: PROPOSED MULTI LEVEL DEVELOPMENT,
2-18 STATION STREET, MARRICKVILLE, NSW
GEOTECHNICAL INVESTIGATION

Environmental Investigations (EI) has pleasure in submitting this report on the Geotechnical Assessment of the above site.

This report was conducted on behalf of Environmental Investigations by Asset Geotechnical Engineering Pty Ltd to assess the surface and subsurface conditions of the site and to provide comments and recommendations relating to the current proposed development.

Should you require further information or clarification regarding any aspect of this report, please contact the undersigned.

For and on behalf of,
ENVIRONMENTAL INVESTIGATIONS

TONY GUIRGUIS
Project Manager

ASSET GEOTECHNICAL
geotechnical engineering consultants

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1892-A
21 June 2012

Environmental Investigations
17/1A Coulson Street
ERSKINEVILLE NSW 2043

Attention: Mr Tony Guirguis

Dear Sir,

PROPOSED MULTI LEVEL DEVELOPMENT, 2 – 18 STATION ST, MARRICKVILLE
GEOTECHNICAL INVESTIGATION

1. INTRODUCTION

1.1 General

This report presents the results of a geotechnical investigation for the above project. The investigation was commissioned by Mr Tony Guirguis of Environmental Investigations. The work was carried out in accordance with a proposal by Asset Geotechnical Engineering Pty Ltd dated 9/05/12, reference P2164.

We understand that the project involves construction of a building with a double basement car park with 9 levels aboveground. Excavation up to approximately 6m deep is anticipated.

Reference to the Sydney 1:100,000 Geological Map indicates that the site is underlain by Hawkesbury Sandstone. Alluvial sand, silt and clay is also shown near the eastern border of the site.

1.2 Scope of Work

The main objectives of the investigation were to assess the surface and subsurface conditions and to provide comments and recommendations relating to:

- Excavation conditions, methodology and monitoring requirements
- Shoring and retaining wall design requirements
- Batter slopes
- Subgrade preparation and earthworks
- Site Classification to AS2870 'Residential Slabs and Footings' 2011
- Suitable foundations
- Allowable bearing pressure

In order to achieve the project objectives, the following scope of work was carried out:

- A review of existing regional maps and reports relevant to the site, held within our files.
- Visual observations of surface features.
- Logging of two boreholes (BH1 and BH2), to sample and assess the nature and consistency of subsurface soils and bedrock (BH1) at accessible areas of the site.
- Carrying out laboratory tests on the rock samples to provide engineering data.
- Engineering assessment and reporting.

This report should be read in conjunction with the attached Information Sheets. Particular attention is drawn to the limitations inherent in site investigations and the importance of verifying the subsurface conditions inferred herein.

2. FIELDWORK AND LABORATORY TESTING

The fieldwork was undertaken on 24 May 2012. The test locations are shown on the attached Figure 2.

Borehole BH1 was auger drilled to refusal on rock at depth of 6.2m and then continued using NMLC rock coring to the final depth of 8.8m. The recovered rock core was photographed and sent to a NATA accredited laboratory for Point Load Strength Index Testing. Borehole BH2 was auger drilled to the target depth of 9.0m. On completion of logging and sampling, each borehole was backfilled with the spoil.

The test locations were set out by our engineer and were located relative to existing site features. The subsurface conditions encountered were recorded during the progress of the drilling and coring. Rock samples were retained for laboratory testing. Surface levels at the test locations were not determined.

Engineering logs and explanatory notes are attached to this report.

3. SITE DESCRIPTION

A number of single and multistorey residential and café buildings Nos. 2-18 are located along Station Street. Each of these allotments is located adjacent to each other with neighbouring walls or property boundaries. These developments are bounded by Station St and the multistorey apartment building to the southeast.

The overall slope of the natural ground surface surrounding the allotments slopes down at angles of 6 - 9° towards east.

There is little to no vegetation across the existing sites as buildings take up entire allotments. Where vegetation can be seen it is comprised of small trees and shrubs that are rooted into the slope and pose no threat to existing structures in their current condition.

The buildings vary with age but all appear to be in excess of 25 - 30 years. The majority of the buildings are comprised of brick that show minor cracking in the exteriors.

4. SUBSURFACE CONDITIONS

4.1 Geology

The 1:100,000 Sydney Geological Map indicates the site is underlain by Hawkesbury Sandstone, with Quaternary alluvium to the east. The sandstone rocks typically weather to form residual clay soils of medium plasticity and residual sandy soils.

4.2 Stratigraphy

The following summary description is provided for the conditions observed at the test locations for this investigation. The detailed conditions at each test location are recorded on the attached logs. For specific design input, reference should be made to the logs and/or the specific test results, in lieu of the following summary.

Table 1 – Generalised Subsurface Profile

Layer	Description	BH1 (m)	BH2 (m)
Pavement	CONCRETE (BH1) or ASPHALT (BH2)	0.0–0.2	0.0 – 0.1
Fill	Gravelly SAND, fine to medium grained, medium to low consistency	0.2–0.6	0.1–1.2
Alluvium	Sandy CLAY/ Clayey SAND/ Silty CLAY, medium to high plasticity clays, fine to medium sands, generally moist grading wet below about 4m to 5m depth, generally	0.6–6.2	1.2–9.0+
Bedrock	SANDSTONE, fine to medium grained, light grey to brown/red, medium to highly weathered, medium and high strength, defect spacing typically 60 to 200mm (assessed Class 4 / 3 Sandstone[1])	6.2–8.8	– –

4.3 Groundwater

Groundwater was observed in borehole BH1 during drilling to depth of 5.3m and in borehole BH2 to at a depth of 5.1m. Groundwater observations below this level were precluded due to the addition of drilling water.

It is noted that the groundwater observation may have been made before water levels had stabilised.

[1] Pells, P.J.N., Mostyn, G. & Walker, B.F., *Foundations on Sandstone and Shale in the Sydney Region*, Australian Geomechanics Journal, December 1998

4.4 Laboratory Test Results

The results from the laboratory Point Load Testing are attached, and presented graphically on the cored borehole logs. The testing indicated typically medium and high rock substance strength.

5. DISCUSSIONS & RECOMMENDATIONS

5.1 Earthworks

5.1.1 Excavation

The boreholes indicate that the excavation will be entirely within predominantly clay soils, and should be readily achievable using conventional earthmoving equipment (e.g. hydraulic excavator bucket).

It should be noted that vibrations that are below threshold levels for building damage may be experienced at adjoining developments.

5.1.2 Subgrade Preparation

The following general recommendations are provided for subgrade preparation for earthworks, pavements, slab-on-ground construction, and minor structures:

- Strip existing fill. Remove unsuitable materials from site (e.g. material containing deleterious matter). Stockpile remainder for re-use as landscaping material or remove from site.
- Excavate alluvial clayey and sandy soils and remove to spoil.
- Compact the upper 150mm depth to a dry density ratio (AS1289.5.4.1–2007) not less than 100% Standard. Areas which show visible heave under compaction equipment should be over-excavated a further 0.3m and replaced with approved fill compacted to a dry density ratio not less than 100%.

Further advice should be sought where the depth of filling beneath pavements and/or structures exceeds that noted above, or where filling is required to support major structures.

Any waste soils being removed from the site must be classified in accordance with current regulatory authority requirements to enable appropriate disposal to an appropriately licensed landfill facility. Further advice should be sought from a specialist environmental consultant if required.

Design of underpinning measures and/or excavation support must be carried out by a suitably experienced and qualified structural/civil engineer.

5.1.3 Filling

Where filing is required, place in horizontal layers not more than 0.3m loose thickness over prepared subgrade and compact to a dry density ratio not less than 95% Standard beneath pavements and 98% Standard beneath structures. The moisture content during compaction should be maintained at ±2% of Standard Optimum. Compact the upper 150mm of subgrade to a dry density ratio not less than 100% Standard.

Filling within 1.5m of the rear of retaining walls should be compacted using light weight equipment (e.g. hand-operated plate compactor or ride-on compactor not more than 3 tonnes static weight) in order to limit compaction-induced lateral pressures. The layer thickness should be reduced to 0.2m maximum loose thickness.

Any soils to be imported onto the site for the purpose of back-filling and re-instatement of excavated areas should be free of contamination and deleterious material, and should include appropriate validation documentation in accordance with current regulatory authority requirements which confirms its suitability for the proposed land use. Further advice should be sought from a specialist environmental consultant if required.

5.1.4 Batter Slopes

Recommended maximum slopes for permanent and temporary batters are presented in Table 2 below:

Table 2 – Recommended Maximum Batter Slopes

Unit	Maximum Batter Slope (H : V)	
	Permanent	Temporary
Alluvial soils	2 : 1	1 : 1

5.2 Footings

Bulk excavation to 6m depth will be about 0.2m above the top of the sandstone bedrock at the location of BH1, but at least 3m above the top of bedrock at BH2. Given that shoring will likely be part of the permanent structure and will likely extend below the bulk excavation level (and therefore into bedrock in at least some areas), it is recommended that all footings be founded on bedrock in order to reduce the risk of differential movement due to variable founding stratum.

Suitable footings might comprise strip and pad footings where rock is close to the base of the bulk excavation, and piles to rock elsewhere.

Edge beams for slab, pad footings and rock socketed piles may be designed for the parameters in Table 3 following.

Table 3 – Footing Design Parameters

Founding Stratum	Maximum allowable design values		
	End Bearing (kPa)	Shaft Friction – Compression (kPa)	Shaft Friction – Tension (kPa)
Alluvial clay (VSt or H)	200	–	–
Class 4 / 3 Sandstone	2,000	200	150

Settlements for footings on rock are anticipated to be about 1% of the pile diameter (for rock-socketed piles), and 1% of the minimum footing width for strip and pad footings.

Options for piles include:

Driven piles. Driven piles are not considered suitable because environmental factors including noise and vibration are likely to be unacceptable for the adjacent development.

Bored Piles. As noted above, groundwater was observed at about 5.1 m to 5.3 m depth in the boreholes during drilling, within alluvial soils. Bored piles are therefore not recommended in this area due to the possibility of collapse of the sidewalls and requirement for dewatering.

Continuous Flight Auger (CFA) Piles. CFA piles are constructed by drilling a hollow stemmed continuous flight auger to the required founding depth. Concrete is then injected under pressure through the auger stem as the auger is extracted from the soil. The reinforcing cage is then inserted upon completion of the concreting process. Pile diameters vary from 300mm to 1200mm. Drilled spoil is produced during CFA piling, and must subsequently be removed from site. CFA piles are considered non-displacement piles as defined in AS2159. Examples of CFA piles are Frankipile “Atlas” type piles, or Vibropile “Omega” type piles.

Steel Screw Piles. Hollow stemmed steel piles fitted with a single or double helix at the tip are installed using specially modified hydraulic excavators. Shaft diameters typically vary from 90mm to 220mm and helix diameters vary from 350mm to 600mm. Single pile capacities range from 2 to 65 tonnes. However, given the anticipated founding depths, steel screw piles are not likely to be the most practical or economical solution for this site.

It assessed that the construction of sockets would require the use of a truck mounted drilling rig. It is also assessed that the bored pile holes would not require liners to support the overburden soils, although some over break and minor fretting should be allowed for.

An experienced geotechnical engineer should review footing designs to check that the recommendations of the geotechnical report have been included, and should assess footing excavations to confirm the design assumptions.

Selection of a suitable piling system may also need to consider management of potential or actual acid sulfate soils that could be disturbed and brought to the surface during the piling operation.

5.3 Temporary Shoring and Permanent Retaining

Where temporary or permanent batter slopes cannot be accommodated in the development or are not desired, temporary shoring and/or permanent retaining will be required.

Design of retaining walls will need to consider both long–term (i.e. permanent) and short–term (i.e. during construction) loading conditions, as well as the possible impact on adjoining developments.

In the long–term, the ground floor slab will provide bracing at the top of the wall and the garage floor slab will provide bracing at the bottom of the wall. Therefore, the basement retaining wall should be designed as a braced wall for the long–term loading condition.

In the short–term (i.e. during construction), the design of the basement retaining wall will depend on the method of construction adopted. Two common construction techniques include top–down and bottom–up construction.

Top–down construction typically involves:

- construction of the perimeter wall as either contiguous bored piles or cast-insitu wall (e.g. Geocast) and internal columns as bored piles;
- pouring the ground floor slab;
- excavating to subgrade level; and
- pouring the basement floor slab.

Bottom–up construction typically involves:

- constructing the perimeter wall as either contiguous bored piles, cast–insitu wall (e.g. geocast), or conventional soldiers installed in concreted pile sockets;
- options for wall design include cantilever, anchored (“deadman”, soil, or rock anchors), and propped (internal props);
- excavating to basement subgrade level (installing horizontal walers and timber lagging if solider pile wall construction is adopted);
- pouring the ground floor slab and proceeding upwards.

In view of the proximity to adjacent structures and the rectangular nature of the development, we consider that top-down construction would be appropriate for this site. This would minimise the risk of lateral deflection of the wall and subsidence of adjacent ground, compared with bottom-up construction. If bottom-up construction is considered, we recommend the use of internal propped walls or anchored walls where the retained height is 2m or more, and either internal propped walls or cantilever walls where the retained height is less than 2m.

Cantilever retaining walls may be designed for a lateral earth pressure coefficient (K_a) of 0.3. Piles for cantilever walls should be socketed below bulk excavation level by a depth at least equal to the retained height.

Braced retaining walls may be designed for a uniform lateral earth pressure of 0.65 * γ * H * K_a where γ = unit weight of backfill (say 18kN/m^3), H = height of wall, and K_a = earth pressure coefficient (0.3). Piles for braced walls should be socketed at least 0.75m below basement subgrade level to provide toe "kick-in" resistance until the slab can be poured.

Where adequate subsoil drainage is provided behind walls, no allowance for groundwater is considered necessary. Appropriate surcharge loading at the finished surface level should also be adopted for design of the wall. Control of groundwater seepage through the basement wall should also be allowed for, unless a waterproof basement is designed and constructed.

6. LIMITATIONS

In addition to the limitations inherent in site investigations (refer to the attached Information Sheets), it must by pointed out that the recommendations in this report are based on assessed subsurface conditions from limited investigations. In order to confirm the assessed soil and rock properties in this report, further investigation would be required such as coring and strength testing of rock, and should be carried out if the scale of the development warrants, or if any of the properties are critical to the design, construction or performance of the development.

Specifically, it is noted that bedrock was only encountered in BH1. It is recommended that further investigation be carried out to confirm rock levels and rock quality at other locations. This could be done immediately after demolition when access is more readily available for a large truck-mounted drilling rig.

It is recommended that a qualified and experienced geotechnical engineer be engaged to provide further input and review during the design development; including site visits during construction to verify the site conditions and provide advice where conditions vary from those assumed in this report. Development of an appropriate inspection and testing plan should be carried out in consultation with the geotechnical engineer.

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Please do not hesitate to contact the undersigned if you have any questions regarding this report or if you require further assistance.

For and on behalf of
Asset Geotechnical Engineering Pty Ltd

Mark Bartel
BE MEngSc MIEAust CPEng GMQ
Director / Principal Geotechnical Engineer

Encl: Information Sheets (3 sheets)
Field Investigation Results (5 sheets)
Laboratory Test Results (1 sheet)
Figure 1 Site Locality
Figure 2 Test Locations
Figure 3 Core Photo (BH1)

Important Information

SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client and Asset Geotechnical Engineering Pty Ltd ("Asset"). The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

RELIANCE ON DATA

Asset has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. Asset has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, Asset will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Asset.

GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies.

The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. Asset should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, it is a condition of acceptance of the report that Asset be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

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 minimize the likelihood of misinterpretation from logs.

REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party. Asset assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of Asset or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

OTHER LIMITATIONS

Asset will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.

Abbreviations, Notes & Symbols

METHOD

borehole logs		*excavation logs*	
AS	auger screw *	NE	natural excavation
AD	auger drill *	HE	hand excavation
RR	roller / tricone	BH	backhoe bucket
W	washbore	EX	excavator bucket
CT	cable tool	DZ	dozer blade
HA	hand auger	R	ripper tooth
D	diatube		
B	blade / blank bit		
V	V-bit		
T	TC-bit		

* bit shown by suffix e.g. ADV

coring
NMLC, NQ, PQ, HQ

SUPPORT

borehole logs		*excavation logs*	
N	nil	N	nil
M	mud	S	shoring
C	casing	B	benched
NQ	NQ rods		

CORE—LIFT

casing installed

barrel withdrawn

NOTES, SAMPLES, TESTS

D	disturbed
B	bulk disturbed
U50	thin-walled sample, 50mm diameter
HP	hand penetrometer (kPa)
SV	shear vane test (kPa)
DCP	dynamic cone penetrometer (blows per 100mm penetration)
SPT	standard penetration test
N*	SPT value (blows per 300mm) * denotes sample recovered
Nc	SPT with solid cone
R	refusal of DCP or SPT

USCS SYMBOLS

GW	Well graded gravels and gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines.
GM	Silty gravels, gravel-sand-silt mixtures.
GC	Clayey gravels, gravel-sand-clay mixtures.
SW	Well graded sands and gravelly sands, little or no fines.
SP	Poorly graded sands and gravelly sands, little or no fines.
SM	Silty sand, sand-silt mixtures.
SC	Clayey sand, sand-clay mixtures.
ML	Inorganic silts of low plasticity, very fine sands, rock flour, silty or clayey fine sands.
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
OL	Organic silts and organic silty clays of low plasticity.
MH	Inorganic silts of high plasticity.
CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity.
PT	Peat muck and other highly organic soils.

MOISTURE CONDITION

D	dry
M	moist
W	wet
Wp	plastic limit
Wl	liquid limit

CONSISTENCY

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable

DENSITY INDEX

VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

GRAPHIC LOG

Soil

Fill
Peat, Topsoil
Clay
Silty Clay
Gravelly Clay
Sandy Clay
Silt
Sandy Silt
Clayey Silt
Gravelly Silt
Gravel
Sandy Gravel
Clayey Gravel
Silty Gravel
Sand
Gravelly Sand
Silty Sand
Clayey Sand

Rock

Sandstone
Shale
Clayey Shale
Siltstone
Conglomerate
Claystone
Dolerite, Basalt
Granite
Limestone
Tuff
Coarse grained Metamorphic
Medium grained Metamorphic
Fine grained Metamorphic
Coal

Other

Asphalt
Concrete
Brick

Water

Level
Inflow
Outflow (complete)
Outflow (partial)

Boundaries

known ——— probable – – – – – – possible .....

WEATHERING

XW	extremely weathered
HW	highly weathered
MW	moderately weathered
SW	slightly weathered
FR	fresh

STRENGTH

EL	extremely low
VL	very low
L	low
M	medium
H	high
VH	very high
EH	extremely high

RQD (%)

= $\frac{\text{sum of intact core pieces} > 2 \times \text{diameter}}{\text{total length of section being evaluated}} \times 100$

DEFECTS

type		*coating*	
JT	joint	cl	clean
PT	parting	st	stained
SZ	shear zone	ve	veneer
SM	seam	co	coating

shape		**roughness**	
pl	planar	po	polished
cu	curved	sl	slickensided
un	undulating	sm	smooth
st	stepped	ro	rough
ir	irregular	vr	very rough

inclination
measured above axis and perpendicular to core

AS1726-1993

Soils and rock are described in the following terms, which are broadly in accordance with AS1726-1993.

SOIL

MOISTURE CONDITION

Term	Description
Dry	Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through the hand.
Moist	Feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	As for moist, but with free water forming on hands when handled.

Moisture content of cohesive soils may also be described in relation to plastic limit (W_P) or liquid limit (W_L) [>> much greater than, > greater than, < less than, << much less than].

CONSISTENCY OF COHESIVE SOILS

Term	Su (kPa)	Term	Su (kPa)
Very soft	< 12	Very Stiff	100 – 200
Soft	12 – 25	Hard	> 200
Firm	25 – 50	Friable	–
Stiff	50 – 100		

DENSITY OF GRANULAR SOILS

Term	Density Index(%)	Term	Density Index (%)
Very Loose	< 15	Dense	65 – 85
Loose	15 – 35	Very Dense	>85
Medium Dense	35 – 65		

PARTICLE SIZE

Name	Subdivision	Size (mm)
Boulders		> 200
Cobbles		63 – 200
Gravel	coarse	20 – 63
	medium	6 – 20
	fine	2.36 – 6
Sand	coarse	0.6 – 2.36
	medium	0.2 – 0.6
	fine	0.075 – 0.2
Silt & Clay		< 0.075

MINOR COMPONENTS

Term	Proportion by Mass	
	coarse grained	fine grained
Trace	≤ 5%	≤ 15%
Some	5 – 2%	15 – 30%

SOIL ZONING

Layers	Continuous exposures.
Lenses	Discontinuous layers of lenticular shape.
Pockets	Irregular inclusions of different material.

SOIL CEMENTING

Weakly	Easily broken up by hand.
Moderately	Effort is required to break up the soil by hand.

USCS SYMBOLS

Symbol	Description
GW	Well graded gravels and gravel-sand mixtures, little or no fines.
GP	Poorly graded gravels and gravel-sand mixtures, little or no fines.
GM	Silty gravels, gravel-sand-silt mixtures.
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CH	Inorganic clays of high plasticity.
OH	Organic clays of medium to high plasticity.
PT	Peat muck and other highly organic soils.

ROCK

SEDIMENTARY ROCK TYPE DEFINITIONS

Rock Type	**Definition** (more than 50% of rock consists of …..)
Conglomerate	… gravel sized (>2mm) fragments.
Sandstone	… sand sized (0.06 to 2mm) grains.
Siltstone	… silt sized (<0.06mm) particles, rock is not laminated.
Claystone	… clay, rock is not laminated.
Shale	… silt or clay sized particles, rock is laminated.

LAYERING

Term	Description
Massive	No layering apparent.
Poorly Developed	Layering just visible. Little effect on properties.
Well Developed	Layering distinct. Rock breaks more easily parallel to layering.

STRUCTURE

Term	Spacing (mm)	Term	Spacing
Thinly laminated	<6	Medium bedded	200 – 600
Laminated	6 – 20	Thickly bedded	600 – 2,000
Very thinly bedded	20 – 60	Very thickly bedded	> 2,000
Thinly bedded	60 – 200		

STRENGTH

Term	Is50 (MPa)	Term	Is50 (MPa)
Extremely Low	<0.03	High	1.0 – 3.0
Very low	0.03 – 0.1	Very High	3.0 – 10.0
Low	0.1 – 0.3	Extremely High	>10.0
Medium	0.3 – 1.0		

NOTE: Is50 = Point Load Strength Index

WEATHERING

Term	Description
Residual Soil	Soil derived from weathering of rock; the mass structure and substance fabric are no longer evident.
Extremely …..	Rock is weathered to the extent that it has soil properties (either disintegrates or can be remoulded). Fabric of original rock is still visible.
Highly …..	Rock strength usually highly changed by weathering; rock may be highly discoloured.
Moderately …..	Rock strength usually moderately changed by weathering; rock may be moderately discoloured.
Slightly …..	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh	Rock shows no signs of decomposition or staining.

DEFECT DESCRIPTION

Type

Joint	A surface or crack across which the rock has little or no tensile strength. May be open or closed.
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub-parallel to layering/ bedding. May be open or closed.
Sheared Zone	Zone of rock substance with roughly parallel, near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects.
Seam	Seam with deposited soil (infill), extremely weathered insitu rock (XW), or disoriented usually angular fragments of the host rock (crushed).

Shape

Planar	Consistent orientation.
Curved	Gradual change in orientation.
Undulating	Wavy surface.
Stepped	One or more well defined steps.
Irregular	Many sharp changes in orientation.

Roughness

Polished	Shiny smooth surface.
Slickensided	Grooved or striated surface, usually polished.
Smooth	Smooth to touch. Few or no surface irregularities.
Rough	Many small surface irregularities (amplitude generally <1mm). Feels like fine to coarse sandpaper.
Very Rough	Many large surface irregularities, amplitude generally >1mm. Feels like very coarse sandpaper.

Coating

Clean	No visible coating or discolouring.
Stained	No visible coating but surfaces are discoloured.
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	Visible coating ≤1mm thick. Thicker soil material described as seam.

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BH no:	**BH1**
sheet:	1 of 3
job no.:	1892

Borehole Log

client:	ENVIRONMENTAL INVESTIGATIONS	**started:**	24.5.2012
principal:		**finished:**	24.5.2012
project:	PROPOSED MULTI-LEVEL DEVELOPMENT	**logged:**	SW
location:	2-18 STATION STREET, MARRICKVILLE	**checked:**	MAB
equipment:	TRACK-MOUNTED RIG	**RL surface:**	
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetro-meter kPa 100 200 300 400	structure and additional observations
ADT	NIL							CONCRETE	--	--		PAVEMENT
					0.2			Gravelly SAND, fine to medium grained, yellow	M	MD		FILL
					0.5							
					0.6		CL	Sandy CLAY, medium to high plasticity, light brown to red/brown		St		ALLUVIUM
					1.0							
					1.5							
					2.0							
					2.5							
					3.0							
					3.2		SC	Clayey SAND, fine to medium grained, brown/red		MD		
					3.4		CL	Sandy CLAY, medium to high plasticity, brown/red mottled with white		St		
					3.5							
					4.0							
					4.5							
					5.0							

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BH no:	**BH1**
sheet:	2 of 3
job no.:	1892

Borehole Log

client:	ENVIRONMENTAL INVESTIGATIONS	**started:**	24.5.2012
principal:		**finished:**	24.5.2012
project:	PROPOSED MULTI-LEVEL DEVELOPMENT	**logged:**	SW
location:	2-18 STATION STREET, MARRICKVILLE	**checked:**	MAB
equipment:	TRACK-MOUNTED RIG	**RL surface:**	
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT	NIL	▼					CL	Sandy CLAY, medium to high plasticity, brown/red mottled with white *(continued)*	M	St		
					5.3		CL	Silty CLAY, low plasticity, red/maroon	W	VSt		
					5.5							
					5.7		CL	Sandy CLAY, medium to high plasticity, red/brown to maroon				
					6.0							
								Borehole No: BH1 continued as cored hole from 6.2m				
					6.5							
					7.0							
					7.5							
					8.0							
					8.5							
					9.0							
					9.5							
					10.0							

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BH no:	**BH1**
sheet:	3 of 3
job no.:	1892

Cored Borehole Log

client:	ENVIRONMENTAL INVESTIGATIONS	**started:**	24.5.2012
principal:		**finished:**	24.5.2012
project:	PROPOSED MULTI-LEVEL DEVELOPMENT	**logged:**	SW
location:	2-18 STATION STREET, MARRICKVILLE	**checked:**	MAB
equipment:	TRACK-MOUNTED RIG	**RL surface:**	
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	

drilling information | **material information** | **rock mass defects**

method	support & core-lift	water	RL	depth metres	graphic log core recovery	rock substance description: rock type; grain characteristics, colour, structure, minor components	weathering	estimated strength MPa (EL 0.03, VL 0.1, L 0.3, M 1, H 3, VH 10, EH)	$Is_{(50)}$ MPa (D=diametral ×, A=axial o)	RQD %	defect spacing mm (20, 60, 200, 600, 2000)	defect description: type, inclination, thickness, shape, roughness, coating (specific / general)
		▼		5.3								
				5.5								
				5.7								
				6.0		Continued from non-cored borehole from 6.2m						
				6.2		SANDSTONE, fine to medium grained, dark red/ red and yellow, dark laminations, thinly laminated at 10°	HW	× o	D=1.01			JT, 0°, pl, ro, clean JT, 0°, pl, ro, clean
				6.5					A=1.31			BP, 10°, pl, ro, sandy clay infill 2mm
				6.62		SANDSTONE, fine to medium grained, light grey/ light brown, indistinct brown laminations, thinly laminated at 10°	MW					CLAY SEAM, 50mm
				7.0								
				7.1		No core 0.20m	--					JT, 85°, pl, ro, clay coating
				7.3		SANDSTONE, fine to medium grained, red and dark red with yellow mottle	HW	× o				XW SEAM BP, 0°, pl, ro, clean
				7.5					D=0.85			BP, 0°, pl, ro, clean
									A=1.16			
				8.0								
				8.14		SANDSTONE, fine to medium grained, light grey/ light brown, massive						JT, 0°, pl, ro, 30mm clay infill JT, 0°, pl, ro, clean
				8.28		SANDSTONE, fine to medium grained, red and light brown, with light grey mottle		× o	D=1.14			JT, 10°, pl, ro, clean
				8.5					A=1.78			
												BP, 10°, pl, ro, clay coating
												BP, 10°, pl, ro, clean FRACTURE SEAM
				8.8		BH1 terminated at 8.8m						
				9.0								
				9.5								
				10.0								

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BH no:	**BH2**
sheet:	1 of 2
job no.:	1892

Borehole Log

client:	ENVIRONMENTAL INVESTIGATIONS	**started:**	24.5.2012
principal:		**finished:**	24.5.2012
project:	PROPOSED MULTI-LEVEL DEVELOPMENT	**logged:**	SW
location:	2-18 STATION STREET, MARRICKVILLE	**checked:**	MAB
equipment:	TRACK-MOUNTED RIG	**RL surface:**	
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT	NIL							ASHPHALT	--	--		ROADBASE
					0.1		FILL	Gravelly SAND, fine to medium grained, yellow/brown	M	MD		FILL
					0.5							
					1.0							
					1.2		CL	Sandy CLAY, medium to coarse grained, low plasticity, orange to orange/red		F		ALLUVIUM
					1.5							
					1.8		CL	Sandy CLAY, medium to coarse grained, medium plasticity, orange to orange/red		F/Vst		
					2.0							
					2.5							
					2.9		SC	Clayey SAND, medium to coarse grained, red/orange to red		D		
					3.0							
					3.4		CL	Sandy CLAY, fine to medium grained, low to medium plasticity, yellow/brown		St		
					3.5							
					4.0							
					4.2		CL	Silty Sandy CLAY, fine to medium grained, low plasticity, white	W			
					4.5							
					4.5		SC	Clayey SAND, fine to coarse grained, white to white/maroon		MD		
					5.0							

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BH no:	**BH2**
sheet:	2 of 2
job no.:	1892

Borehole Log

client:	ENVIRONMENTAL INVESTIGATIONS	**started:**	24.5.2012
principal:		**finished:**	24.5.2012
project:	PROPOSED MULTI-LEVEL DEVELOPMENT	**logged:**	SW
location:	2-18 STATION STREET, MARRICKVILLE	**checked:**	MAB
equipment:	TRACK-MOUNTED RIG	**RL surface:**	
diameter:	100mm **inclination:** -90° **bearing:** --- **E:** **N:**	**datum:**	

drilling information | **material information**

method	support	water	notes samples, tests, etc	RL	depth metres	graphic log	USCS symbol	material description (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency/ density index	hand penetrometer kPa 100 200 300 400	structure and additional observations
ADT		Inferred from Materials ▼			5.5		SC	Clayey SAND, fine to coarse grained, white to white/maroon *(continued)*	W	MD		
					5.6		CL	Sandy CLAY,low plasticity, maroon mottled with pink/white	=Wp	St		
					6.0							
					6.5							
					7.0							
					7.2		SC	Silty Clayey SAND, fine grained, white	>>Wp	VSt		
					7.5							
					7.6		CL	Silty Sandy CLAY, low to medium plasticity, white/brown				
					8.0							
					8.5							
					8.8		CL	Sandy CLAY,medium plasticity, dark brown/white	Wp	VSt		
					9.0							
					9			Borehole No: BH2 terminated at 9m				Target Depth at 9m
					9.5							
					10.0					--		

TEST CERTIFICATE

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POINT LOAD STRENGTH INDEX

CLIENT: **Asset Geotechnical**
Suite 2.05 56 Delhi Road, North Ryde NSW 2113

PROJECT: **Multi Level Development - 2-18 Station St, Marrickville (1892)**

LAB. NO.	SAMPLE SOURCE	LITHOLOGY	PLATEN SEPARATION DIAM (mm)	PLATEN SEPARATION HEIGHT (mm)	TEST ORIENTATION	POINT LOAD STRENGTH Is (MPa)	POINT LOAD STRENGTH $Is_{(50)}$ (MPa)	Type OF FAILURE
72665	BH1 6.28-6.56m	Sandstone	51.5		Diametral	1.00	1.01	FOB
				34.7	Axial	1.34	1.31	FOB
72666	BH1 7.50-7.60m	Sandstone	51.6		Diametral	0.84	0.85	FOB
				29.2	Axial	1.23	1.16	FOB
72667	BH1 8.35-8.45m	Sandstone	51.6		Diametral	1.13	1.14	FOB
				38.4	Axial	1.78	1.78	FOB

NOTES TO TESTING

Testing Device	ELE Point Load Tester
Sample History	Unsoaked
Sampled By:	Client
Job Number:	1225962
Date Tested:	05.06.12
Test Method:	AS 4133.4.1 2007

Failure Type

FOB	Fracture through fabric of specimen oblique to bedding not influenced by weak planes
FB	Fracture along bedding
FIP	Fracture influenced by pre-existing plane, microfracture, vein, chemical alteration
CPF	Chip or partial fracture

Approved Signatory: Chris Lloyd **Date:** 05.06.12

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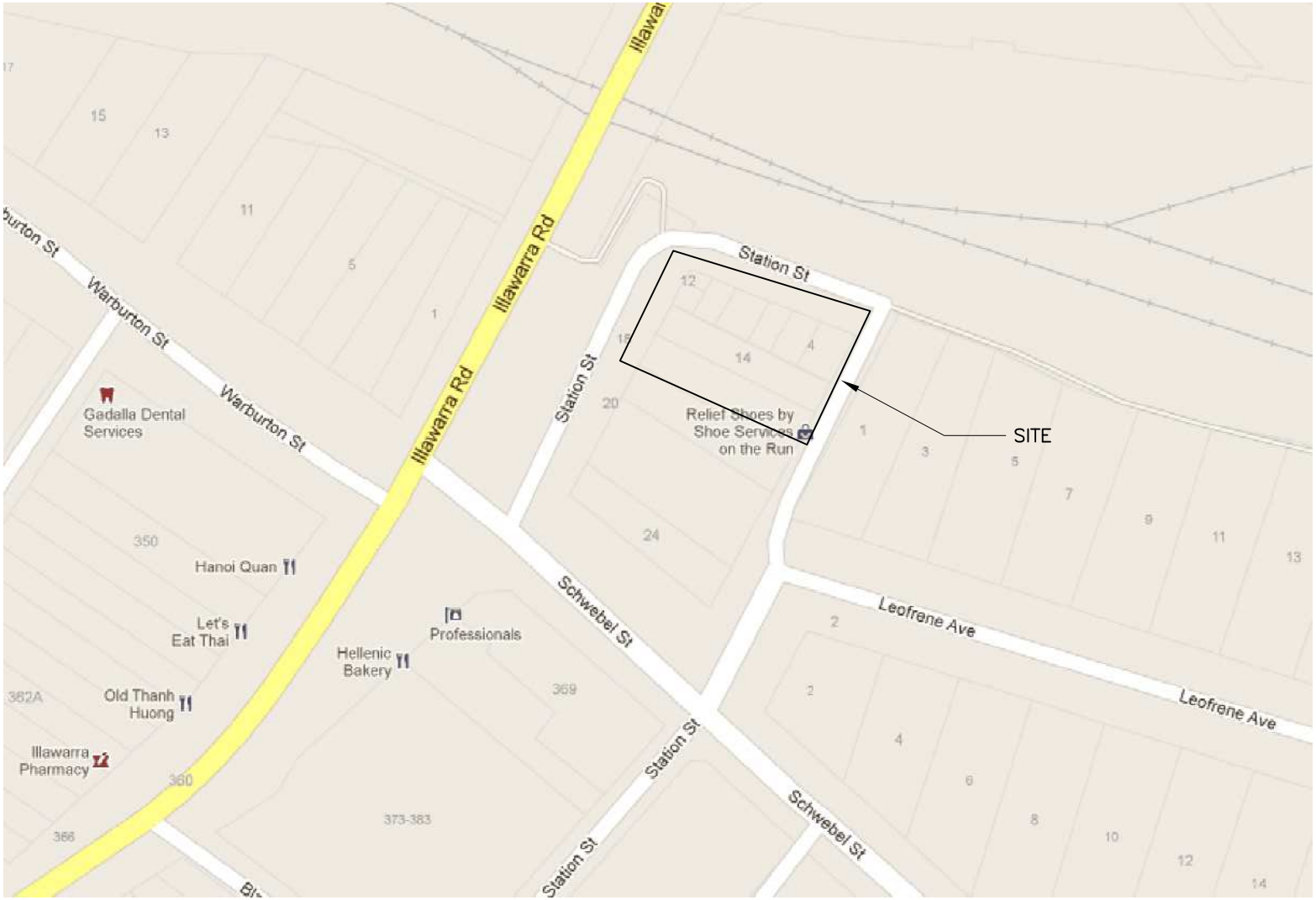
Accreditation No. 2418



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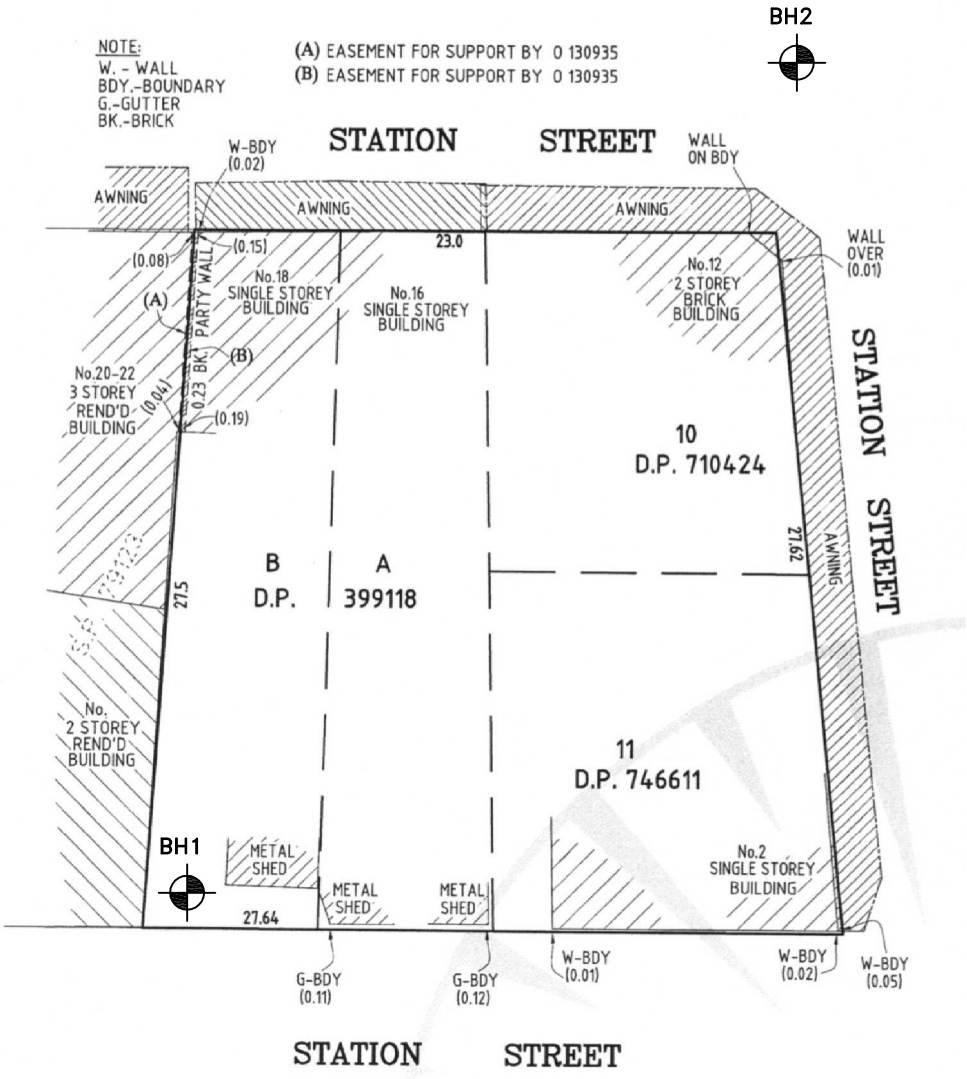
PROPOSED MULTI LEVEL DEVELOPMENT
2–18 STATION ST, MARRICKVILLE
for
ENVIRONMENTAL INVESTIGATIONS

SITE LOCALITY

drawn: XL
date: 20.6.12
checked: MAB
scale: 1:1,000 A4

job no.: 1892
fig: 1
issue: A



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PROPOSED MULTI LEVEL DEVELOPMENT
2–18 STATION ST, MARRICKVILLE
for
ENVIRONMENTAL INVESTIGATIONS

TEST LOCATIONS

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issue: A

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A	20.6.12	INITIAL ISSUE

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PROPOSED MULTI LEVEL DEVELOPMENT
2–18 STATION ST, MARRICKVILLE
for
ENVIRONMENTAL INVESTIGATIONS

CORE PHOTO (BH1)

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job no.: 1892
fig: 3
issue: A