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SPECIALISTS MANAGING THE EARTH

GEOTECHNICAL INVESTIGATION PROPOSED COMMERCIAL DEVELOPMENT 200 GEORGE STREET, SYDNEY

Mirvac Projects Pty Ltd

GEOTLCOV24518AA-AE
20 April 2012

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
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SPECIALISTS MANAGING THE EARTH

20 April 2012

Mirvac Projects Pty Ltd
Level 26, 60 Margaret Street
SYDNEY NSW 2000

Attention: David Chan

Dear David

RE: GEOTECHNICAL INVESTIGATION, PROPOSED COMMERCIAL DEVELOPMENT, 200 GEORGE STREET, SYDNEY

Coffey Geotechnics Pty Ltd is pleased to present the results of a geotechnical investigation carried out for the proposed redevelopment of 190 George Street, 200 George Street, and 4 Dalley Street to be known as 200 George Street. If you have any questions regarding our report please contact Dan Butterworth or the undersigned on 9911 1000.

For and on behalf of Coffey Geotechnics Pty Ltd



Peter Waddell

Principal Geotechnical Engineer

Distribution: Original held by Coffey Geotechnics Pty Ltd
1 copy held by Coffey Geotechnics Pty Ltd
3 hard copies and electronic copy to Mirvac Projects Pty Ltd

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1 INTRODUCTION

At the request of Mirvac Projects Pty Ltd (Mirvac), Coffey Geotechnics Pty Ltd (Coffey) has carried out a geotechnical investigation for the proposed redevelopment of 190 George Street, 200 George Street and 4 Dalley Street in Sydney CBD to a commercial development to be known as 200 George Street. The work was carried out in general accordance with our revised proposal; reference GEOTLCOV24518AA-AC, dated 26 March 2012.

The site is located towards the northern end of George Street and is currently occupied by two concrete frame office buildings on 190 and 200 George Street and a brick clad building on 4 Dalley Street. Telstra has a long term lease on part of 4 Dalley Street and current proposals call for the partial demolition of this building, retaining the Telstra lease area. The buildings on 190 and 200 George Street are to be demolished.

A Stage 1 DA has been granted, however, a design competition has been completed and a DA will be submitted with the design that will be developed by the design competition winner. It is likely that a 155m tall tower will be constructed over the 190 and 200 George Street footprints. No. 4 Dalley Street may be reduced in height. Beneath the tower up to three levels of basement will be excavated to a bulk excavation level of about RL-6.2m AHD.

The objectives of the investigation are to provide geotechnical recommendations for DA submission and to assist the structural engineer in detailed design of basements and footings systems. A desk study of available geotechnical information nearby to the site was completed prior to the completion of fieldwork (reference GEOTLCOV24518AA-AD, dated 4 April 2012). This report supersedes the desk study report.

2 METHOD OF INVESTIGATION

2.1 Fieldwork

Fieldwork for the geotechnical investigation was carried out between 3 and 13 April 2012, and comprised drilling eleven boreholes (BH1/MW1 to BH11) all of which were located within existing basements beneath 190 George Street, 200 George Street and 4 Dalley Street.

Of the eleven boreholes, six were cored into rock (BH1, BH2, BH3, BH5, BH6 and BH9) with standpipe piezometers installed in BH1, BH2 and BH9. The standpipes initially contained fluid from the drilling work which was later flushed with fresh water and then bailed out to draw water into the standpipe from the surrounding formation.

Figure 1 shows the borehole locations which were measured from site features. Reduced levels were interpolated from client supplied survey plans of the existing development/s.

All boreholes were drilled with a difficult access Komatsu 05 tracked drilling rig. Concrete coring of the existing basement floor slabs was undertaken using a 200mm diatube prior to augering. Upon completion of diatubing, boreholes were advanced using solid flight augers with a Tungsten Carbide (TC) drill bit until practical refusal on rock occurred with the exception of BH11 which terminated within concrete.

Following TC bit refusal, BH1, BH2, BH3, BH5, BH6 and BH9 were continued using NQ rock coring techniques to a maximum depth of 13.2m below the ground surface.

On completion, all boreholes were backfilled with cuttings and capped at ground level with a 200mm plug of concrete flush with the surrounding surface levels, with the exception of BH1, BH2 and BH9 where standpipe piezometers were installed. Excess cuttings and drilling fluids were disposed of offsite.

Borehole drilling was observed by a Coffey Geotechnical Engineer who was present throughout the drilling operations to undertake sampling and testing, record test results and log materials encountered. The Engineering Logs of the boreholes are presented in Appendix A, together with Coffey soil and rock explanation sheets which describe the terms and symbols used in log preparation.

2.2 Laboratory Testing

Following completion of fieldwork four samples were submitted to MGT Labmark Pty Ltd for Soil Aggressivity testing (pH, Sulphate and Chloride). Rock cores were photographed and Point Load Strength testing was undertaken at approximately 1m intervals to assess rock strength.

The results of Soil Aggressivity testing are presented in Appendix B. The Point Load Strength Index test results are shown on the borehole logs presented in Appendix A.

3 RESULTS OF INVESTIGATION

3.1 Site Description

Figure 1 shows the site footprint. The entire redevelopment area is covered by buildings. The ground elevation at the George Street boundaries of 190 and 200 George Street lies at about RL7.2m AHD. The properties 190 and 200 George Street and 4 Dalley Street also have boundaries with Underwood Street that lies at about RL3.5m AHD.

The basement of 190 George Street lies at RL1.7m AHD. The basement of 200 George Street has an elevation of RL3.8m AHD. No.4 Dalley Street has a basement level that lies at about RL2.5m AHD. The sections in Figure 2 show the various site levels.

3.2 Geology

Reference to the Sydney 1:100,000 Series Geological Sheet indicates that the site is underlain by Hawkesbury Sandstone, a medium to coarse grained quartz sandstone. Hawkesbury Sandstone was encountered in the main geotechnical boreholes drilled for this investigation.

Rock is likely to be relatively shallow in George Street, deepening to the east as the ground elevation falls into a valley formed by erosion associated with the Tank Stream that formerly flowed north into Sydney Harbour on an alignment to the east of the site.

From our experience in this area, a 2m to 4m wide dyke (igneous intrusion) runs roughly east west in the vicinity of Dalley Street. Such dykes are often deeply weathered to soil strength materials and they may also have changed the surrounding sandstone. Coffey has borehole information from an investigation at 8-16 Dalley Street where poor quality, altered sandstone was encountered. It is possible that the dyke or altered sandstone may extend under the 4 Dalley Street part of the site.

3.3 Subsurface Conditions

The geotechnical boreholes drilled for this investigation encountered concrete floor slabs underlain by a variable depth of fill, overlying sandstone bedrock. Figure 2 shows interpreted cross sections through the site.

In 200 George Street sandstone bedrock was observed at a relatively shallow depth of 0.7m in BH7 on the western side of the site deepening to 5.4m depth in BH6 on the eastern boundary.

As the boreholes were drilled from basement levels the nature of materials supported by retaining walls is not known. We recommend that it be assumed that retained material is soil strength and will be referred to as 'Fill'.

The sandstone encountered in the boreholes ranges from fine to coarse grained, although predominantly medium and coarse grained, and is generally high strength with Point Load Index strength test results greater than 1MPa. However, it is also notable that very high strength sandstone was encountered in BH2, with Point Load Index strength test results consistently greater than 3MPa.

Relatively few joints and bedding partings were encountered in the boreholes, with significant core lengths having defect spacing between 1m and 3m.

Rock quality has been assessed in accordance with the Sydney Sandstone Classification System presented in Pells 1998. The rock is generally Class I Sandstone with occasional Class IV and III bands in the upper 5m.

4 DISCUSSION AND RECOMMENDATIONS

4.1 Excavation Conditions

Excavation contractors should be provided with the core logs and photographs and be required to make their own assessment of the suitability and productivity of particular excavation plant.

The predominantly Class I high and very high strength sandstone, with widely spaced defects will be difficult to excavate. Ripping, is likely to be difficult and will require high powered excavation plant such as Class 300/400C dozers, Cat D10 (or equivalent) or larger. In confined spaces such plant may require the use of rock saws and impact hammers to assist by opening up trenches between which ripping could be attempted.

If practicable, ripping productivity rates in the high and very high strength sandstone will be low and may produce blocky material. If ripping proves to be impracticable rock saws impact hammers and milling machines could be considered for all bulk and detail excavation and trimming works.

4.2 Vibrations

We note that there may be sensitive vibration receptors in close proximity to the site including:

- telephony equipment in 4 Dalley Street;
- an electricity substation in 8-16 Dalley Street;
- an electricity cable tunnel that crosses the site;
- high rise buildings adjacent to the site.

It will be necessary to limit the size of excavation plant such as impact hammers and/or to limit the use of impact hammers within certain distances of vibration sensitive receptors. Rock saws should be used to saw the perimeter of excavations to reduce the lateral transmission of vibrations.

The vibration limits in Table 1 are commonly recommended to reduce the risk of vibration damage to sensitive receptors.

Table 1: Ground Vibration Limits for Various Types of Structures

Type of Structure	Peak Particle Velocity mm/s
Historic buildings or monuments	2
Residential or low rise buildings in good condition	10
Reinforced concrete commercial and industrial buildings in good condition	25

Dilapidation surveys should be carried out on neighbouring structures or sensitive services prior to commencing excavation. Vibration trials should be carried out to assess appropriate distances for the plant to be used on site to limit vibrations. Vibration monitoring should continue during site works to confirm that the limits are not exceeded.

4.3 Groundwater

The site lies on the western edge of a drainage path created by the Tank Stream. Groundwater is likely to be encountered within the adjacent Tank Stream alluvium and within fill that has been placed to raise site levels from what was probably low lying swampy ground. Groundwater is also likely to be encountered within joints and bedding partings in the bedrock, however, inflows are likely to be relatively low through the rock.

A groundwater level was monitored at 9.8m depth (about RL-8m AHD) in the borehole drilled in the basement of 190 George Street. Groundwater seepage was noted at 3.5m depth (about RL+0.3m AHD) in fill encountered in BH6 on the eastern side of 200 George Street. These groundwater observations may not be representative of stable groundwater levels in the area. We are unaware of the drainage details of the existing basement retaining walls. It would be useful to obtain information on the existing building drainage system and whether regular pumping occurs from sumps.

Groundwater levels may change over time and may occur as complex perched systems that respond differently to changing conditions such as rainfall events.

Provided an adequate cut-off wall is established where the site boundaries intersect any saturated soils such as may be associated with fill or alluvium associated with the Tank Stream, we would expect that long term groundwater inflows through the rock can be managed by a conventional drained basement system with provision for pumping from sumps. If a significant amount of water flows through fill or natural soils above the rock then it may be necessary to design a semi tanked basement, with retaining walls designed as tanked structures capable of resisting hydrostatic pressures.

With a proposed bulk excavation level of RL-6m AHD and the proximity of the site to Sydney Harbour, saline groundwater may flow into the site. The impacts of saline water on long term performance of the drainage system should be considered in design. It should be noted that discharge of water from basements is contingent on approvals from the relevant authorities to discharge to sewer or stormwater.

4.4 Excavation Support Requirements

4.4.1 Existing Retaining Walls

We understand that it is preferred to maintain the existing retaining walls, where possible. The nature of the materials retained by the walls is unknown. Without specific information the retained material should be assumed to be soil strength. In the existing basement for 190 George Street, rock was encountered at shallow depth below the basement floor slab and hence it is likely that the retaining walls are founded on rock.

In 200 George Street sandstone bedrock was shallow in BH7 on the western side of the site deepening to 5.4m depth in BH6 on the eastern boundary. Therefore, excavations on the southern and eastern sides of 200 George Street are likely to require construction of a retaining wall.

The nature of existing retaining wall footings in 190 George Street is unknown, although given the shallow depth to rock below the basement slab, strip footings bearing on rock are likely. Supplied drawings for 200 George Street indicate that the retaining walls are founded on strip footings. It is likely that the existing retaining walls rely on propping from floor slabs for support. With demolition and basement excavation this propping will be removed and alternative support in the form of internal props of anchors will be required.

Underpinning of existing retaining wall footings that bear on rock is unlikely to be required provided the rock is assessed by a geotechnical engineer. Support such as rock bolts should be installed to support potentially unstable blocks or wedges as required by the geotechnical engineer.

The permission of adjacent landowners will be required to install support such as rock anchors and rock bolts, where such support extends beyond the site boundaries.

We recommend that further investigations be undertaken as part of demolition works to assess the nature of the retaining wall footings and prior to any bulk basement excavation.

4.4.2 Retaining Wall Design Parameters

For the assessment of existing and new retaining walls the parameters in Table 2 should be adopted.

Table 2: Retaining Wall Design Parameters

Material Type	Bulk Density ($kN/m^{3)}$	Coefficient of Active Earth Pressure, Ka	Coefficient of Passive Earth Pressure, K_p
Fill	18	0.4	2.5
Class IV Sandstone or better (Note 1)	24	0.2	5

Note 1: Class IV or better sandstone will not need to be supported by a retaining wall. However, retaining wall footings that penetrate into rock will develop passive resistance in the rock sockets.

Retaining wall design involves complex soil structure interaction. Lateral displacements of retaining walls designed assuming 'active' earth pressures could be up to 1% of the retained height. If such movements cannot be tolerated then wall should be designed for higher earth pressures. Coffey has specialist capability on design of retaining walls and would be pleased to assist if the estimation and management of displacements is important to the specific design.

Retaining walls should be designed for appropriate surcharge loads.

We are unaware of the drainage details of the existing basement retaining walls. If significant amounts of water flow through fill or natural soils above the rock then it may be necessary to design a semi tanked basement, with new and existing retaining walls designed as tanked structures capable of resisting hydrostatic pressures.

4.4.3 Unsupported Rock Face Support

It is difficult to accurately assess rock support requirement from vertical boreholes. Hawkesbury Sandstone typically contains sub-vertical joints and bedding planes that can form potentially unstable blocks and wedges. However, given the relatively good quality sandstone encountered at the borehole locations, support is likely to be limited to isolated spot rock bolting of the basement faces. In some boreholes the upper few metres of rock was Class III and Class IV Sandstone which is more fractured and hence is more likely to require spot bolting or localised pattern bolting.

An experienced geotechnical engineer should be engaged to observe the excavation faces after each 2m depth of excavation to assess support requirements. Rock bolts should be 3m long double encapsulated rock bolts (CT bolt or equivalent) to provide long term support to blocks or wedges. We recommend allowance for a nominal number of rock bolts; say 40 for cost estimating purposes, with actual numbers to be specified during excavation works.

The permission of adjacent landowners will be required to install support such as rock anchors and rock bolts, where such support extends beyond the site boundaries.

4.5 Excavation Induced Ground Movements

Walls retaining soil strength material will laterally deflect up to 1% of the retained height, depending on the stiffness of the retaining wall system. Horizontal stress relief in the bedrock will result in additional movement.

Based on past excavation experience in Hawkesbury Sandstone in the Sydney CBD, typical lateral ground movements at the excavation face are of the order of 0.5mm to 2mm per metre depth of excavation, depending on rock quality and the presence of bedding.

The potentially damaging effects of stress redistribution in the vicinity of excavations should be assessed as part of the detailed design. Lateral displacements of retaining walls and due to stress redistribution may also result in settlements. For preliminary assessment of impacts we recommend that potential settlement be assumed to be equal to predicted lateral displacements.

Typically, ground movements (lateral displacement and settlement) are greatest at the excavation face and decrease to negligible values at a distance of 2 to 3 times the excavation depth.

For preliminary impact assessment purposes the above guidelines on displacements may be used. Depending on the specific retention system, basement excavation details and the nature of adjacent structures more detailed analysis may be required. Coffey has specialist capability in applying numerical modelling techniques to the estimation of ground movements. We would be pleased to prepare a scope of work for such as study to assist the structural engineers in the assessment of potential impacts on adjacent structures.

4.6 Foundations

Depending on bulk excavation levels, sandstone should be available to found strip and pad footings for the proposed development. We provide both working stress bearing pressures and ultimate limit state parameters in Table 3 for various classes of sandstone. The working stress values assume that settlements will be less than 1% of the footing width or pile diameter. If a limit state approach is adopted significantly higher capacities may be justified. Settlements must be analysed if a limit state approach is to be adopted and particularly if such an approach is adopted to allow higher end bearing values to be adopted.

Class I Sandstone is likely to be exposed if the bulk excavation extends to below RL-4m AHD. For shallower footings an assessment of the likely rock class as foundation level should be made during detailed design.

Table 3: Foundation Design Parameters

Rock Class	Working Stress Design	Limit State Design		
	Serviceability End Bearing Pressure (kPa)	Ultimate End Bearing Capacity (kPa)	Ultimate Shaft Adhesion (kPa) Note 1	Elastic Modulus (MPa)
Class IV Sandstone	1,000	4,000	250	100
Class III Sandstone	5,000	20,000	1,000	500
Class II Sandstone or better	10,000	40,000	2,000	1,000

Note 1: Shaft adhesion should be ignored for pad footings.

For limit states design a geotechnical strength reduction factor, φ_g, of 0.75 can be adopted for compression loads. For uplift loads a φ_g value of 0.6 should be adopted and ultimate shaft friction values should also be multiplied by an additional factor of 0.7.

All footing excavations should be observed by a geotechnical engineer to assess the foundation. Where serviceability end bearing pressures of greater than 2,000kPa or ultimate limit state bearing capacities greater than 3,500kPa are adopted, foundation defects should be assessed by cored boreholes or spoon testing in jackhammer holes and/or observation of rock exposures in lift wells (if available). The number of tests for verification will depend on the number and layout of footings, and the number of existing cored boreholes. For preliminary estimating purposes we recommend allowance for testing at least 30% of footing locations.

4.7 Soil Aggressivity

The results of the Soil Aggressivity testing were assessed in accordance with Australian Standard AS2159-1995 Piling – "Design and Installation". Chemical test results indicated non-aggressive ground conditions to buried steel and concrete structural elements.

4.8 Seismic Design Parameters

Based on AS1170.4-2007 the following parameters should be adopted for seismic design:

Seismic Hazard Factor (Z)	0.08
Sub-Soil Class	B_e

5 LIMITATIONS

This report is based on a limited number of boreholes at discrete locations. Subsurface conditions can change over relatively short distances. An experienced geotechnical consultant should be engaged to review detailed designs and during construction to undertake verification that exposed ground conditions are consistent with design assumptions.

The attached document entitled "Important Information about Your Coffey Report" presents additional information on the uses and limitations of this report.

For and on behalf of Coffey Geotechnics Pty Ltd



Peter Waddell

Principal

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Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

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Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

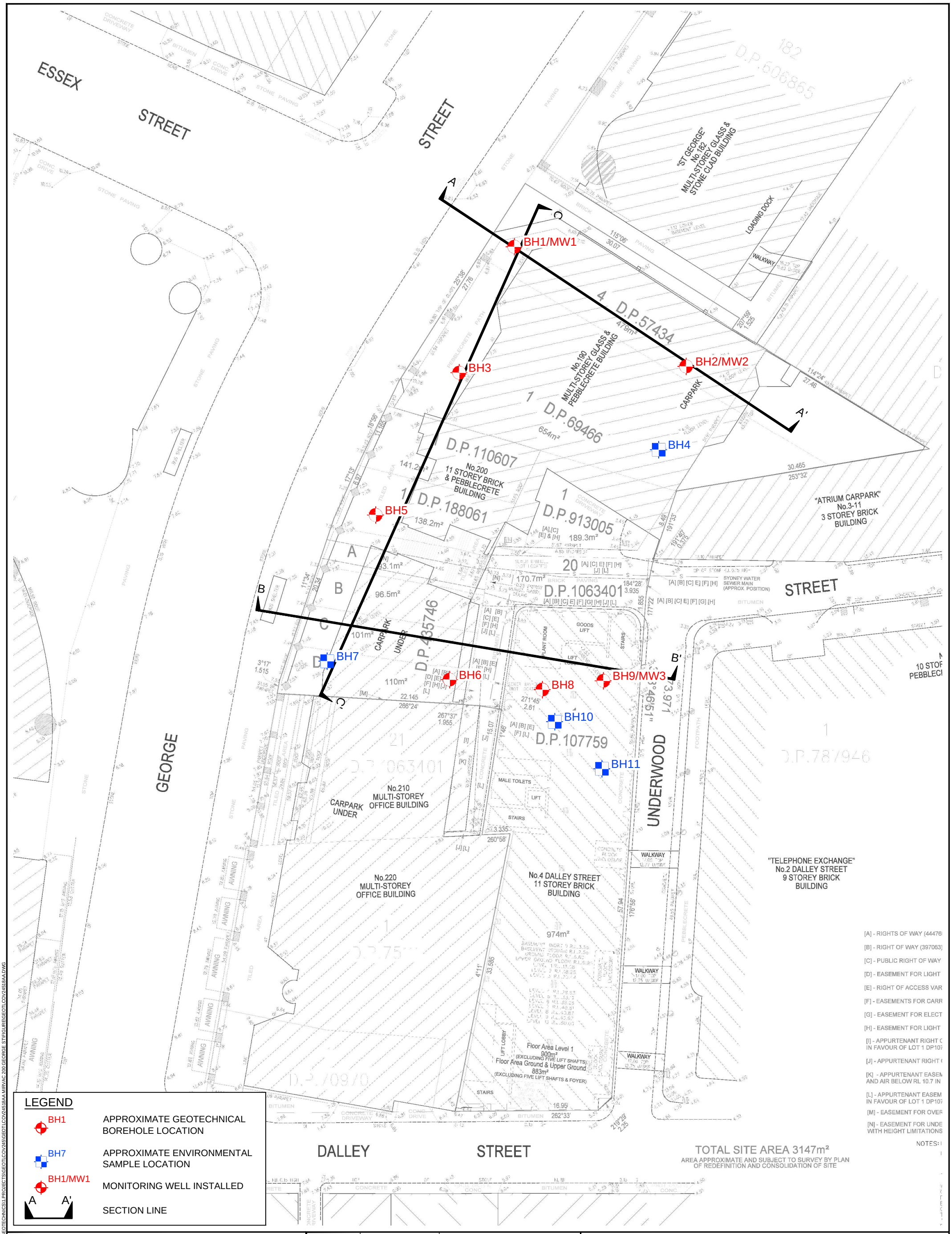
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures



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approved	PJW
date	18 / 04 / 12
scale	1:400
original size	A3

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client:	MIRVAC PROPERTIES PTY LTD
project:	GEOTECHNICAL INVESTIGATION 200 GEORGE STREET, SYDNEY
title:	BOREHOLE LOCATIONS PLAN
project no:	GEOTLCOV24518AA
figure no:	FIGURE 1

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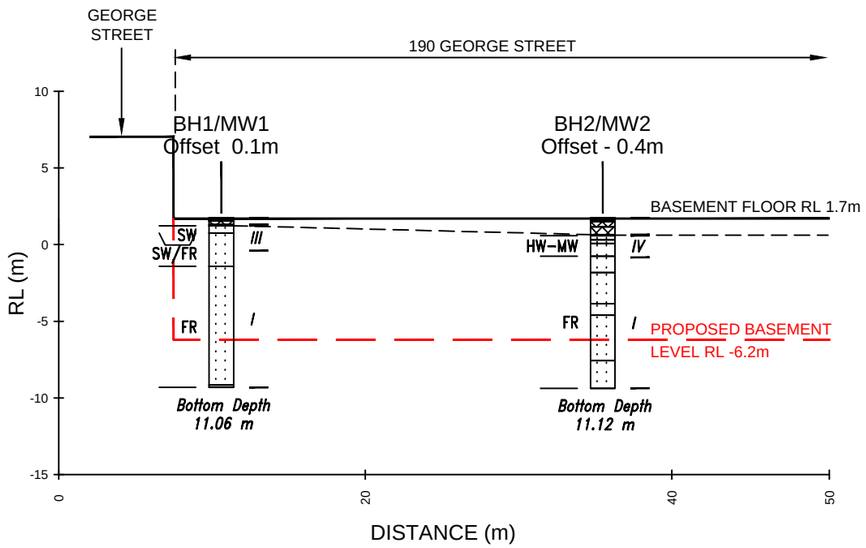

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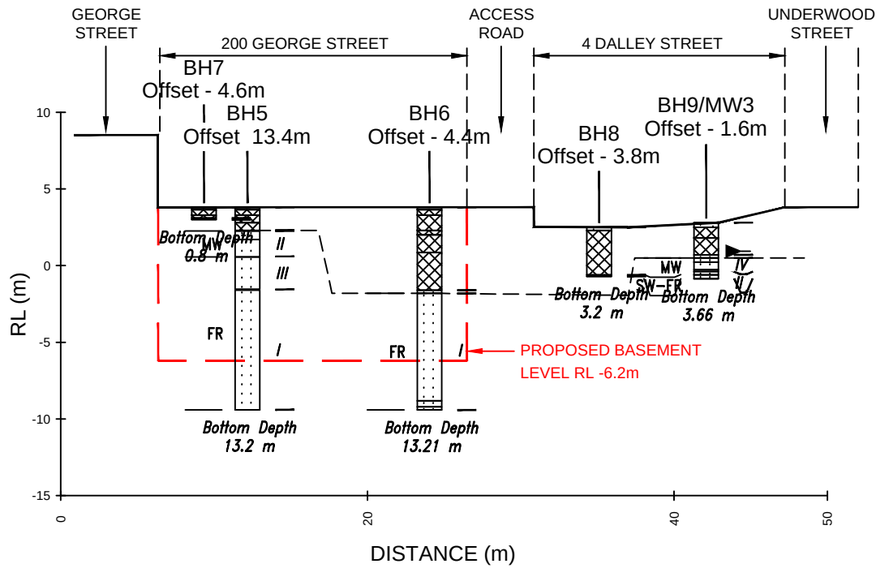

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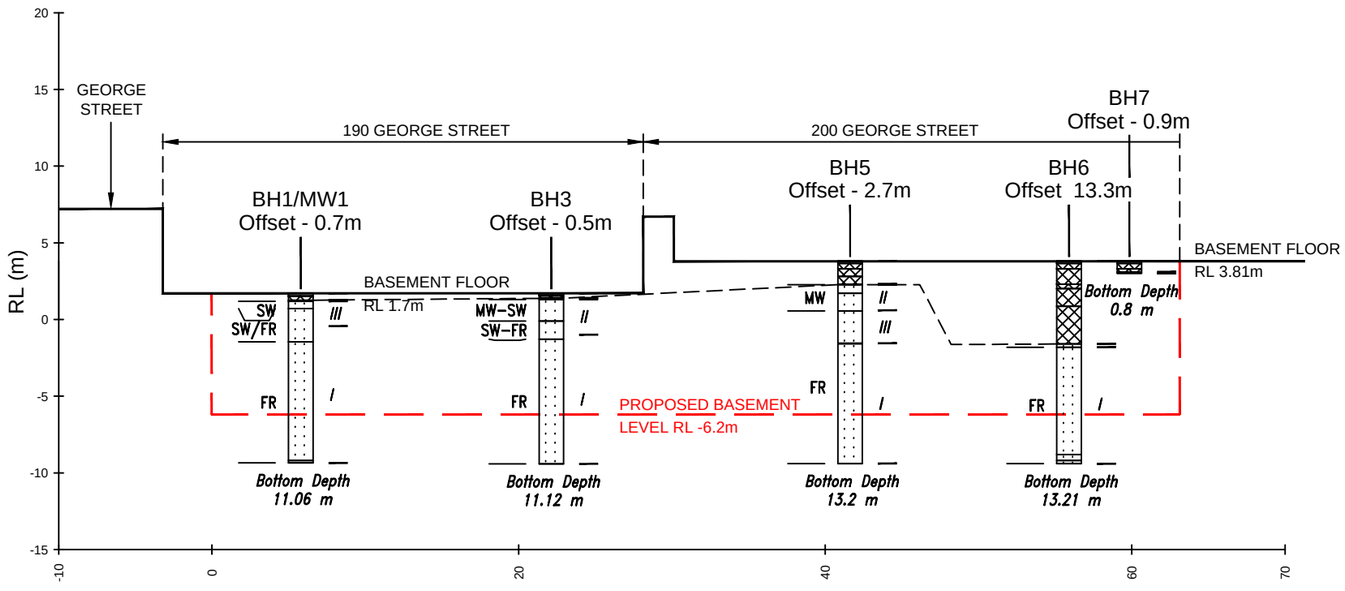

SECTION C-C'

LEGEND

- CONCRETE
- FILL
- SANDSTONE
- IV ROCK CLASSIFICATION (PELLS ET AL, 1998)
- DX WEATHERING (SEE EXPLANATION SHEETS)
- WATER LEVEL

revision	description	drawn	approved	date

Horizontal Scale (metres) 1:400

VerticalScale (metres) 1:400

drawn	PJW / MH
approved	PJW
date	18 / 04 / 12
scale	AS SHOWN
original size	A3

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client: MIRVAC PROPERTIES PTY LTD

project: GEOTECHNICAL INVESTIGATION
200 GEORGE STREET, SYDNEY

title: CROSS SECTION A-A', B-B' AND C-C'

project no: GEOTLCOV24518AA

figure no: FIGURE 2

PLOT DATE: 19/04/2012 11:57:04 AM DWG FILE: F:\GEOTECHNICS\51 PROJECTS\GEOTLCOV24\GEOTLCOV24518AA MIRVAC 200 GEORGE ST\FIGURE\GEOTLCOV24518AA.DWG

Appendix A

Engineering Logs, Core Photographs & and Explanation Sheets

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Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 μm to 2.36 mm
	medium	200 μm to 600 μm
	fine	75 μm to 200 μm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil 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.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

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Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)							USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.			GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.			GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)			GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)			GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes			SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.			SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).			SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.					
		SILTS & CLAYS Liquid limit less than 50	**DRY STRENGTH**	**DILATANCY**	**TOUGHNESS**			
			None to Low	Quick to slow	None		ML	SILT
			Medium to High	None	Medium		CL	CLAY
			Low to medium	Slow to very slow	Low		OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium		MH	SILT
			High	None	High		CH	CLAY
			Medium to High	None	Low to medium		OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.				Pt	PEAT

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

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Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME	Simple rock names are used rather than precise geological classification.
PARTICLE SIZE	Grain size terms for sandstone are:
Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm
FABRIC	Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:
Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbrev-iation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

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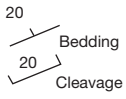
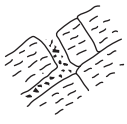
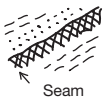
Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES Term	Definition	Diagram	Map Symbol	Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.			 (Note 2)
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.			 (Note 2)
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.			
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.			
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.			
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.			
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.			

DEFECT SHAPE TERMS	
Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS	
Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS	
Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS	
Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.

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Engineering Log - Borehole

Borehole No. **BH1/MW1**

Sheet 1 of 3

Project No: **GEOTLCOV24518AA**

Client: ***Mirvac Properties Pty Ltd***

Date started: ***4.4.2012***

Principal:

Date completed: ***4.4.2012***

Project: ***200 George Street Redevelopment***

Logged by: ***JW***

Borehole Location: ***190 George Street - See Figure 1***

Checked by: ***PJW***

drill model and mounting: Komatsu 05 Track Rig | Easting: 311.5204 | slope: -90° | R.L. Surface: 1.7

hole diameter: 80 mm | Northing 152.356 | bearing: N/A | datum: mAHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT DT		N		E					**CONCRETE:** 150mm with 30mm reinforcement				CONCRETE SLAB
				E					**FILL: Gravelly SAND:** Fine to coarse, black/dark grey, fine, angular gravel.	M			FILL No Odour observed
					1				**FILL: Sandy CLAY:** Medium plasticity, pale grey, mottled pale brown, fine to medium sand with a trace of fine, angular gravel.				BEDROCK
						1			**SANDSTONE:** Fine to medium, pale yellow to pale brown, grey, highly weathered, low to medium strength.				
					0				Borehole BH1/MW1 continued as cored hole				
						2							
					-1								
						3							
					-2								
						4							
					-3								
						5							
					-4								
						6							
					-5								
						7							
					-6								
						8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil

C casing

penetration 1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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Engineering Log - Cored Borehole

Borehole No. **BH1/MW1**
Sheet 2 of 3
Project No: **GEOTLCOV24518AA**

Client: ***Mirvac Properties Pty Ltd*** Date started: ***4.4.2012***

Principal: Date completed: ***4.4.2012***

Project: ***200 George Street Redevelopment*** Logged by: ***JW***

Borehole Location: ***190 George Street - See Figure 1*** Checked by: ***PJW***

drill model & mounting: Komatsu 05 Track Rig | Easting: 311.5204 | slope: -90° | R.L. Surface: 1.7

hole diameter: 80 mm | Drilling fluid: | Northing: 152.356 | bearing: N/A | datum: mAHD

drilling information					material substance						rock mass defects		
method	core-lift	water	RL	depth metres	graphic log core recovery	material: rock type; grain characteristics, colour, structure, minor components	weathering alteration	estimated strength VL L M H VH EH	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	defect spacing mm 30 100 300 1000 3000	defect description: type, inclination, planarity, roughness, coating, thickness — particular	general
						Continued from non-cored borehole							
NQ			1	1		**SANDSTONE:** Medium to coarse grained, yellow-brown, indistinctly bedded at 5°, with some dark grey laminations.	SW		D 0.98 A 0.88			PT, 0°, PL, SO, CO SILT	
						SANDSTONE: Coarse grained, pale grey indistinctly bedded at 10°, with some dark grey laminations.	SW/FR			92			
			0	2					D 1.14 A 1.4			SM, 0°, PL, clayey SAND (30mm) PT, 0°, PL, RO, CO clayey SAND PT, 0°, PL, RO, CN	
			-1	3					D 2.2 A 2.19	94			
						SANDSTONE: Fine to medium grained, grey/pale grey, massive.	FR					PT, 0°, PL, RO, CN	
			-2	4					D 2.08 A 1.73	100			
			-3	5					D 1.85 A 1.64				
			-4	6					D 1.75 A 3.97	100			
			-5	7					D 1.64 A 1.82	100			
		4/4/2012 at 3.30pm	-6	8					D A				

CORED BOREHOLE GEOTLCOV24518AA - GINT.GPJ COFFEY.GDT 4.18.12

Form GEO 5.5 Issue 3 Rev. 3

method

DT	diatube
AS	auger screwing
AD	auger drilling
RR	roller/tricone
CB	claw or blade bit
NMLC	NMLC core
NQ, HQ, PQ	wireline core

core-lift

casing used

barrel withdrawn

graphic log/core recovery

core recovered - graphic symbols indicate material

no core recovered

water

10/1/98 water level on date shown

water inflow

partial drill fluid loss

complete drill fluid loss

25 water pressure test result (lugeons) for depth interval shown

weathering

FR	fresh
SW	slightly weathered
MW	moderately weathered
HW	highly weathered
XW	extremely weathered
DW	distinctly weathered (covers MW and HW)

strength

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

defect type

JT	joint
PT	parting
SM	seam
SZ	sheared zone
SS	sheared surface
CS	crushed seam

planarity

PL	planar
CU	curved
UN	undulating
ST	stepped
IR	irregular

roughness

VR	very rough
RO	rough
SO	smooth
SL	slickensided

coating

CN	clean
SN	stained
VN	veneer
CO	coating

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Engineering Log - Cored Borehole

Borehole No. **BH1/MW1**
Sheet 3 of 3
Project No: **GEOTLCOV24518AA**

Client: ***Mirvac Properties Pty Ltd***
Date started: ***4.4.2012***
Principal:
Date completed: ***4.4.2012***
Project: ***200 George Street Redevelopment***
Logged by: ***JW***
Borehole Location: ***190 George Street - See Figure 1***
Checked by: ***PJW***

drill model & mounting: Komatsu 05 Track Rig | Easting: 311.5204 | slope: -90° | R.L. Surface: 1.7
hole diameter: 80 mm | Drilling fluid: | Northing: 152.356 | bearing: N/A | datum: mAHD

drilling information					material substance							rock mass defects			
method	core-lift	water	RL	depth metres	graphic log core recovery	material: rock type; grain characteristics, colour, structure, minor components	weathering alteration	estimated strength VL L M H VH EH	$Is_{(50)}$ MPa D- diametral A- axial	RQD %	defect spacing mm 30 100 300 1000 3000	defect description: type, inclination, planarity, roughness, coating, thickness — particular	general
NQ			-7	9		**SANDSTONE:** Fine to medium grained, grey/pale grey, massive. *(continued)*	FR		1.67 1.52 D A 1.39 1.67	100		PT, 10°, PL, RO, CN	
			-8	10					D A 4.58 1.77 D A 1.17 1.46	90		PT, 0°, PL, RO, CN PT, 5°, PL, RO, CN PT, 5°, PL, RO, CN PT, 5°, PL, RO, CN	
			-9	11		**INTERLAMINATED SHALE (70%) AND SANDSTONE (30%):** Grey to dark grey, sandstone is fine grained with some disturbed beds.			D A 0.73 0.47			PT, 0°, PL, RO, CN PT, 0°, PL, RO, CN SM, 5°, PL, CLAY (30mm)	
			-10	12		BH1/MW1 terminated at 11.06m							
			-11	13									
			-12	14									
			-13	15									
			-14	16									

method
DT diatube
AS auger screwing
AD auger drilling
RR roller/tricone
CB claw or blade bit
NMLC NMLC core
NQ, HQ, PQ wireline core

core-lift
casing used
barrel withdrawn

graphic log/core recovery
core recovered - graphic symbols indicate material
no core recovered

water
10/1/98 water level on date shown
water inflow
partial drill fluid loss
complete drill fluid loss
25 water pressure test result (lugeons) for depth interval shown

weathering
FR fresh
SW slightly weathered
MW moderately weathered
HW highly weathered
XW extremely weathered
DW distinctly weathered (covers MW and HW)

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

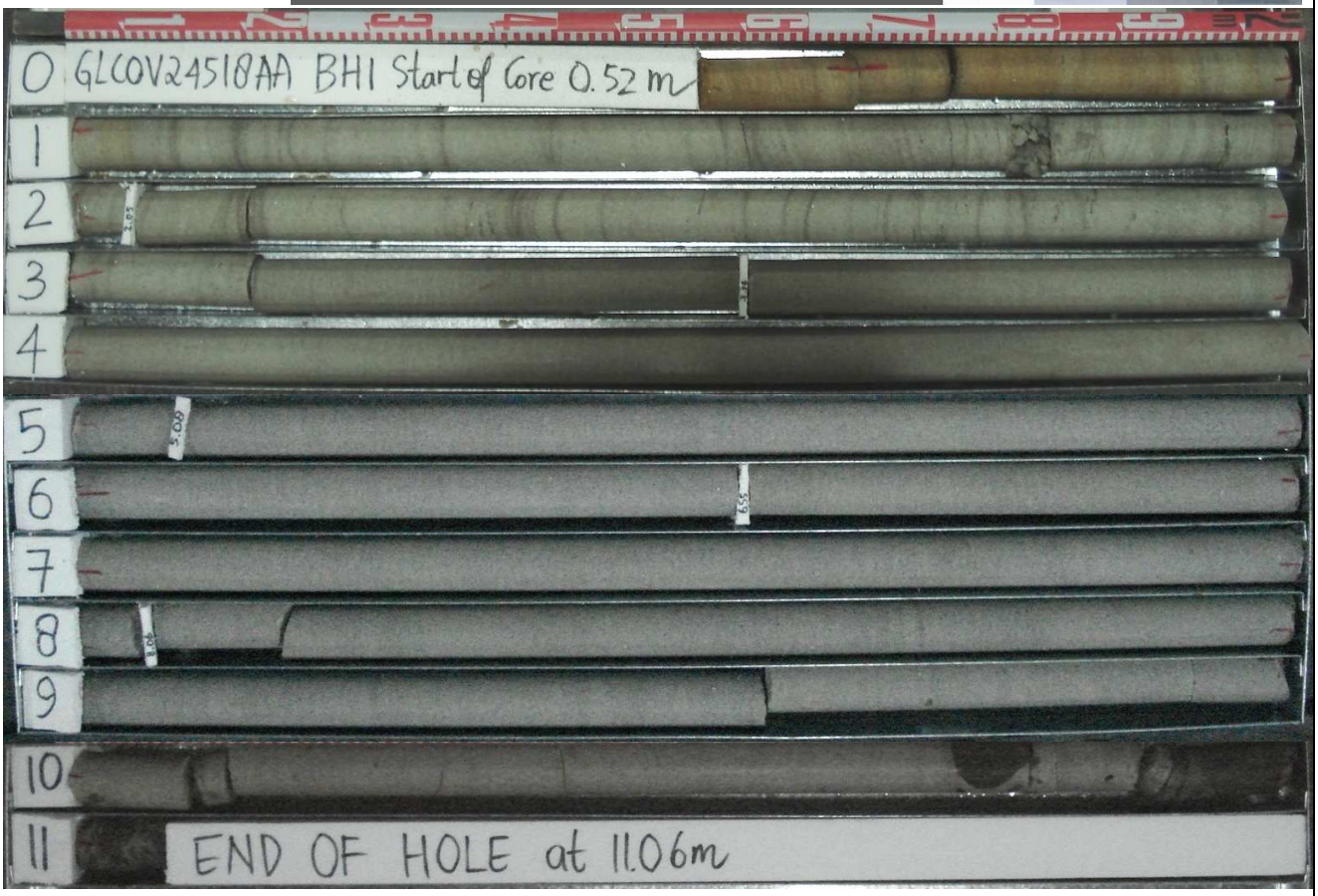
defect type
JT joint
PT parting
SM seam
SZ sheared zone
SS sheared surface
CS crushed seam

planarity
PL planar
CU curved
UN undulating
ST stepped
IR irregular

roughness
VR very rough
RO rough
SO smooth
SL slickensided

coating
CN clean
SN stained
VN veneer
CO coating

PROJECT No: GEOTLCOV24518AA
BH1 04/04/2012
DEPTH: 0.52 to 11.06m



drawn	**JW**		client: **Mirvac Properties Pty Ltd**	
approved	**DB**		project: **200 GEORGE STREET, SYDNEY**	
date	**16/4/2012**			
scale	**Not to scale**		title: **ROCK CORE PHOTOGRAPH – BH1**	
original size	**A4**		project no: **GEOTLCOV24518AA**	Photo no: **1 of 1**

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Engineering Log - Borehole

Borehole No. **BH2/MW2**

Sheet 1 of 3

Project No: **GEOTLCOV24518AA**

Client: ***Mirvac Properties Pty Ltd***

Date started: ***5.4.2012***

Principal:

Date completed: ***5.4.2012***

Project: ***200 George Street Redevelopment***

Logged by: ***JW***

Borehole Location: ***190 George Street - See Figure 1***

Checked by: ***PJW***

drill model and mounting: Komatsu 05 Track Rig | Easting: 331.9398 | slope: -90° | R.L. Surface: 1.7

hole diameter: 80 mm | Northing 138.1316 | bearing: N/A | datum: mAHD

drilling information | **material substance**

method	penetration 1 2 3	support	water	notes samples, tests, etc	RL	depth metres	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency/ density index	pocket penetro-meter kPa 100 200 300 400	structure and additional observations
ADT DT		N		E					**CONCRETE:** 150mm with 40mm reinforcement.				CONCRETE SLAB
				E					**FILL: Sandy CLAY:** Low to medium plasticity, pale Grey, fine sand.	<Wp M			FILL
					1	1			**FILL: Clayey SAND:** Fine to medium, pale grey, mottled pale brown, yellow-brown, trace fine to medium sub angulargravel.				No Odour Observed
									FILL: Gravelly SAND: Fine to medium, pale grey, fine to medium, sub angular gravel.				
		C							**SANDSTONE:** Medium grained, pale grey - pale yellow, highly to moderately weathered, low to medium strength.				BEDROCK
					0	2			Borehole BH2/MW2 continued as cored hole				
					-1	3							
					-2	4							
					-3	5							
					-4	6							
					-5	7							
					-6	8							

method

AS	auger screwing*
AD	auger drilling*
RR	roller/tricone
W	washbore
CT	cable tool
HA	hand auger
DT	diatube
B	blank bit
V	V bit
T	TC bit

*bit shown by suffix e.g. ADT

support

M mud N nil

C casing

penetration 1 2 3 4 — no resistance ranging to refusal

water

10/1/98 water level on date shown

water inflow

water outflow

notes, samples, tests

U_{50}	undisturbed sample 50mm diameter
U_{63}	undisturbed sample 63mm diameter
D	disturbed sample
N	standard penetration test (SPT)
N*	SPT - sample recovered
Nc	SPT with solid cone
V	vane shear (kPa)
P	pressuremeter
Bs	bulk sample
E	environmental sample
R	refusal

classification symbols and soil description based on unified classification system

moisture

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

consistency/density index

VS	very soft
S	soft
F	firm
St	stiff
VSt	very stiff
H	hard
Fb	friable
VL	very loose
L	loose
MD	medium dense
D	dense
VD	very dense

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