Geotechnical Preliminary Pavement Assessment Report

Pakenham Transport Study

Prepared for: Cardinia Shire Council
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1.EXECUTIVE SUMMARY

This report presents the results of a Geotechnical Preliminary Pavement Assessment performed by SMEC Australia Pty Ltd (SMEC) across the proposed Pakenham East Precinct Structure Plan (PSP) area and the proposed Pakenham South PSP area.

The aim of the assessment was to provide a preliminary evaluation of subgrade conditions across the Pakenham East and Pakenham South areas in order to assess the implications on required pavement thicknesses across the two development areas

The assessment included a review of published information, available geotechnical reports and the drilling of boreholes across both PSP areas together with laboratory testing of recovered materials.

Both the Pakenham East PSP site and the Pakenham South PSP site are located within a low lying alluvial plain and as such the majority of both areas are underlain by alluvial deposits of sand, silt and clay. Devonian Granite comprising residual soils overlying granite rock extends across the elevated areas of both areas. The results of the investigation indicate that the upper soil profile, which provides the subgrade for pavements constructed at grade, generally comprises high plasticity clay across both the alluvial and granitic areas of the site.

Available geological maps indicate that the Devonian Granite has an isolated Tertiary Older Volcanics capping across parts of the Pakenham East PSP site. The Tertiary Older Volcanics were not encountered during the current investigation but typically comprise residual clay soil overlying basalt rock.

Current practice is to base pavement design on the laboratory 4 day soaked California Bearing Ratio (CBR) test to represent soil strength under poor pavement drainage conditions. Based on the results of the investigation the following CBR's are recommended for preliminary design of pavements for the various geological units;

Quaternary Alluvium

It is anticipated that the soaked CBR of Quaternary Alluvial soils across both the PSP East and PSP South areas would likely vary between about 1% and 4.5%.

Based on available information, a subgrade CBR of 2% is considered appropriate for the preliminary design of pavements underlain by Quaternary Alluvium. The Quaternary Alluvium should be considered expansive.

Residual Granite

It is anticipated that the soaked CBR of the residual granite soils across both the PSP East and PSP South areas would likely vary between about 1% and 8%. The higher values would be anticipated if and where sandier clay soils are encountered.

Based on available information, a subgrade CBR of 2% is considered appropriate for the preliminary design of pavements underlain by residual granitic clays. Design CBR values of up to 3.5% may be appropriate if and when sandier residual granitic clays are encountered. Residual granite clays should be considered expansive.

Residual Older Volcanics

It is anticipated that the soaked CBR of the residual older volcanic soils across both the PSP East and PSP South areas would likely vary between about 1.5% and 4%.

Based on available information, a subgrade CBR of 2% is considered appropriate for the preliminary design of pavements underlain by residual older volcanic soils. Residual older volcanic soils should be considered expansive.

Fill Embankments

The design of road pavements on fill embankments is dependent on the nature and thickness of the fill material used. Where natural onsite soils are reused as engineered fill, the design CBR and expansiveness would be as described above.

Preliminary pavement profiles are provided for design CBR values of 2% to 4% for Access Lanes, Access Streets and Connector Streets/Arterial Roads (i.e. road with varying traffic loads) so that the impact of geotechnical conditions on pavement profile can be assessed.

2.INTRODUCTION

2.1 General

This report presents the results of a Geotechnical Preliminary Pavement Assessment performed by SMEC Australia Pty Ltd (SMEC) across the proposed Pakenham East Precinct Structure Plan (PSP) area and the proposed Pakenham South PSP area.

The work was commissioned by Mr Scott Sibly of Cardinia Shire Council via email dated 16 September 2015 and was performed in general accordance with the SMEC proposal letter dated 1 September 2015 and email dated 15 September 2015.

The Geotechnical Preliminary Pavement Assessment forms part of transport studies being undertaken by SMEC for development of the Pakenham East Precinct Structure Plan and Pakenham South Precinct Structure Plan.

The aim of the Geotechnical Assessment was to provide a preliminary evaluation of subgrade conditions across the Pakenham East and Pakenham South areas in order to assess the implications on required pavement thicknesses across the two development areas.

The PSP East and PSP South areas are shown in green and in blue respectively in Figure 2-1

Figure 2-1: PSP East & PSP South Areas

2.2 Scope of Work

The scope of work for the Geotechnical Assessment comprised the following major elements:

- A desk top review of available information including;
    - Published geological maps
    - Victoria's Groundwater database
    - Previous reports within SMEC's archives
- An invasive geotechnical investigation across the two areas comprising;
    - 9 boreholes (6 across Pakenham East and 3 across Pakenham South) to a depth of 1.5m in the vicinity of likely intersection and road alignments to assess near surface subgrade conditions.
    - Laboratory testing of soil samples recovered from the boreholes to assist in the assessment of the engineering characteristics of the materials.

3.SITE DESCRIPTION

3.1 Pakenham East PSP

The Pakenham East PSP area measures about 635 hectares (Ha) in plan and is bound by the Princes Freeway/Pakenham Bypass to the south, Ryan Road to the west and Mount Ararat Road to the east. The Princes Highway passes east west through the northern part of the site. The Pakenham East PSP area lies to the east of the Pakenham Golf Club on the eastern edge of the Pakenham township.

The site lies towards the northern end of the Koo Wee Rup Plains, at the foothills of the Victorian high country which extend towards the north east. The area is currently used as open farm land and is generally flat with two north south trending ridgelines across the north of the site and across the eastern boundary of the site which extend up to approximately 50m above the surrounding landscape.

A series of local streams and channels drain runoff from the hills towards the north of the site to Western Port Bay, which lies approximately 15km to the south. These local streams and channels include Deep Creek which passes along the western boundary of the site and Hancocks Gully which passes across the eastern part of the site.

Figure 3-1: PSP East

3.2 Pakenham South PSP

The Pakenham South PSP area measures about 150 Ha in plan and is bound by McGregor Road in the west, Koo Wee Rup Road to the east and Greenhills Road to the north. The Pakenham South PSP area lies to the south of the Princess Freeway/Pakenham Bypass and south of the Pakenham township.

Like the Pakenham East PSP, the Pakenham South PSP lies within the Koo Wee Rup Plains and falls gently towards the south, with an elevated area towards the north of the site, and is currently used as open farmland.

A local drainage channel passes through the north west corner of the site and feeds into Toomuc Creek Drain to the south west. Another drainage channel passes along the eastern boundary of the site and feeds in to Deep Creek Drain at the southern boundary of the site.

Figure 3-2: PSP South

4.PUBLISHED GEOLOGICAL INFORMATION

4.1 Geological & Geomorphological Setting

Both the Pakenham East PSP and the Pakenham South PSP sites lie towards the northern end of the Koo Wee Rup plains at the foothills of the high country which extends to the north.

An extract of the Geological Survey of Victoria, Queenscliff Mapsheet (1:250,000 scale) to the west and the Warragul Mapsheet (1:250,000 scale) to the east, describing the geological setting of the general Pakenham area, is provided in Figure 4-1, below. Larger scale geological maps of the Pakenham East PSP area and the Pakenham South PSP area, obtained from the Victorian Department of Primary Industries GeoVic website are provided in Appendix A.

The Koo Wee Rup Plains are typically low lying and flat with only occasional ridges. The Plains are generally underlain by recent Quaternary aged alluvial deposits (Qra, green, in Figure 4-1) of sand, silt, clay and subordinate gravel associated with existing and former meanderings of local rivers and creeks. The central part of the Plains, formerly occupied by now artificially drained swamps, are underlain by lagoonal and swamp deposits of potentially soft, compressible clay and silt (Qrm, green, in Figure 4-1).

The alluvial sand, silt, clay and subordinate gravel deposits of the Koo Wee Rup Plains may occur in relatively thin layers or discontinuous lenses having been formed by the ongoing process of deposition and erosion which continues today. Rivers with meandering courses would deposit sand on the inside of the meander. Seasonal flooding of the rivers would then cause a very gradual build up of silt and clay across large areas of the plains. As sediments accumulated, the rivers would fan out across the plains by both gradual meandering and during flooding when a new channel may be incised into the landscape and an entirely new water course followed. The results of this shifting of the river channels was that older parts of the formation were constantly being eroded and new materials deposited making individual beds very discontinuous.

The elevated landscape to the north of the sites comprise Silurian aged marine mudstone and sandstone (S, pink, in Figure 4-1), Devonian aged intrusive granite (Dug, red, in Figure 4-1) and its associated hornfels aureole (Duh, purple, in Figure 4-1). The Devonian granite is capped in places by Tertiary aged Older Volcanics (Tvo, orange, in Figure 4-1).

The Devonian granite typically comprises a weathered clayey and sandy soil profile, overlying granite rock, whilst the Tertiary Older Volcanics typically comprises a high plasticity clay profile, overlying basalt rock.

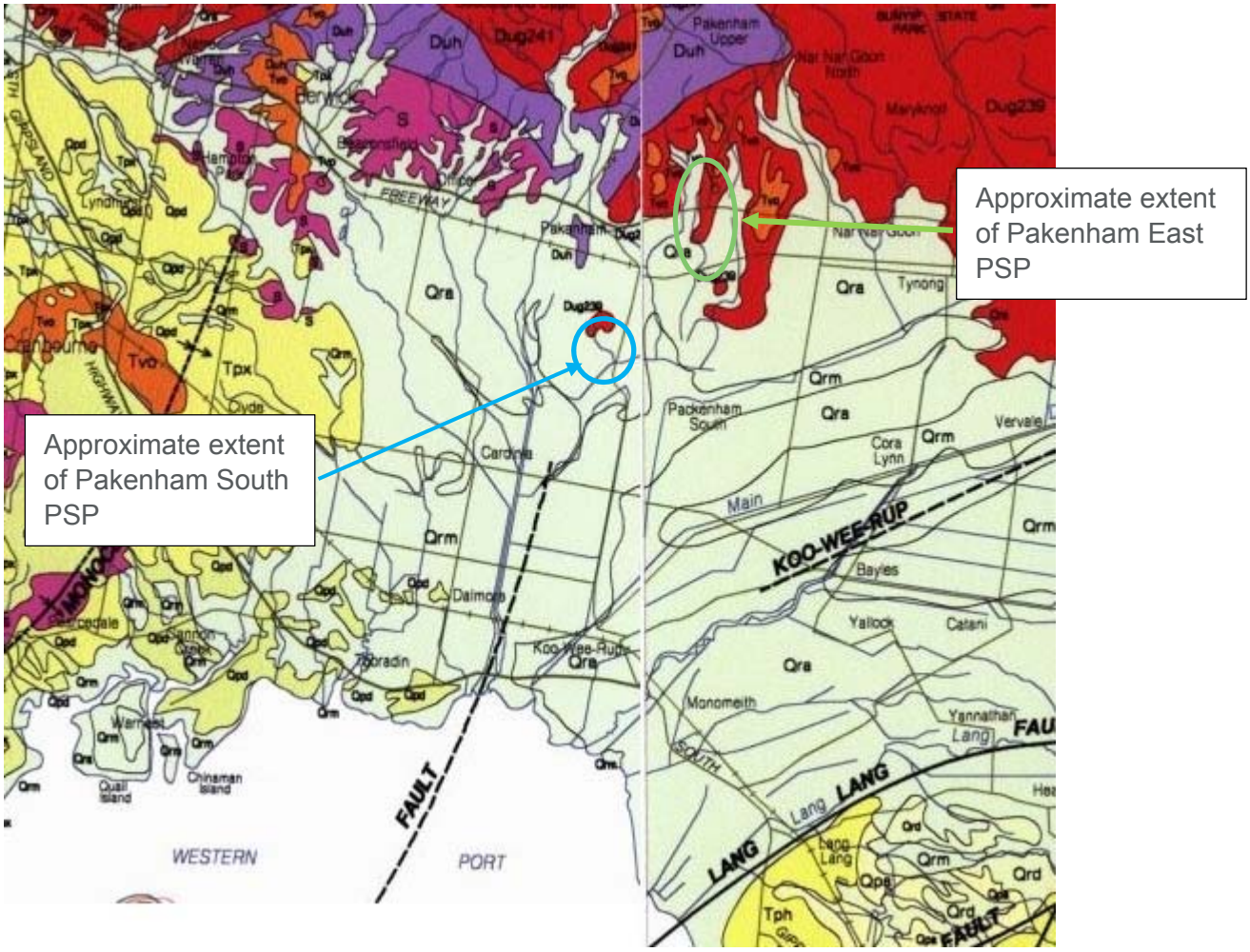

Figure 4-1: Geological Map

It is noted that some geological maps (Natural Resources and Environment, Victoria Geology, 1:500,000 scale) list the deposits across parts of the Koo Wee Rup plains, including the project area, as being of mixed alluvial and colluvial origin. Given the proximity of the site to the elevated areas north of the Koo Wee Rup Plains, the potential for colluvial deposits onsite cannot be eliminated. Colluvial deposits may comprise sediments ranging from clay to boulder size having been transported via gravity from the hill slopes above.

The site is located towards the northern end of a regional fault zone which comprises a series of faults (including the Tankerton Fault, Koo Wee Rup Fault and Lang Lang Fault) which generally trend in a north-north easterly direction across the Mornington Peninsula. It was movements along these fault lines from 60 million years ago to 2 million years ago which originally formed the low lying Western Port Bay and Koo Wee Rup Plains, which are collectively known as the Western Port Sunkland. The swamps across the Koo Wee Rup Plains were formed as a result of this land sinking and changes in the natural river system which occurred after the rise in sea level at the end of the last major ice age (about 10,000 years ago).

Local faulting has also resulted in warping and gentle folding of the parent rocks in this area. Small earthquakes recorded in very recent times indicate that, although slight, movements along the old fault lines can still occur. The presence of faults including the Koo Wee Rup Fault and the Tankerton Fault have been inferred, based on mapped changes in layer thicknesses and ages, about 10km south of the site.

4.2 Site Specific Geology

4.2.1 Pakenham East PSP

The geological map of the Pakenham East PSP area is shown in Appendix A and indicates that the majority of the site is underlain by Quaternary alluvial deposits of sand, silt and clay, with the elevated finger through the north of the site and towards the eastern boundary of the site underlain by Devonian Granite with isolated Tertiary Older Volcanics capping.

4.2.2 Pakenham South PSP

The geological map of the Pakenham South PSP area is shown in Appendix A and indicates that the site is underlain by Quaternary alluvial deposits, except for an isolated outcrop of Devonian Granite along Greenhills Road at the north of the site.

4.3 Victorian Groundwater Database

A search of lithological data on the Victorian Groundwater Database shows multiple boreholes across the Koo Wee Rup Plains, including both the Pakenham East and Pakenham South PSP areas. A summary of lithological bore data obtained from the Victorian Groundwater Database (Visualising Victoria Groundwater www.vvg.org.au) is provided in Appendix B. The lithological information indicates that the near surface soils generally comprise clays and sandy clays.

The groundwater table typically lies less than 5m below the alluvial plain across both the Pakenham East PSP and Pakenham South PSP areas and deeper below surface across the elevated sections of the two PSP areas.

4.4 Subgrade Conditions

Design of pavements is heavily dependent on geological conditions, specifically the California Bearing Ratio (CBR) and swell potential of the near surface, subgrade soils. It is noted that CBR can be measured in the field, on recompacted samples in the laboratory at a variety of moisture contents and/or can be correlated with field and laboratory tests.

Current VicRoads and Growth Areas Authority (of which Cardinia Shire Council is a signatory) practice is to base pavement design on the 4 day soaked CBR value which is measured in the laboratory on a sample of recompacted soil soaked for a period of 4 days. This is intended to represent soil strength under poor pavement drainage conditions.

'Roads & Subgrades' by Roger Olds, presented in 'Engineering Geology of Melbourne' (Peck, Neilson, Olds & Seddon eds, Balkema, 1992) presents data from VicRoads regarding CBR values for the different geological units across the Melbourne area. A summary of data presented by Olds is shown in Table 4-1, below.

Geological Unit/ Soil Description	Historical Design CBR (as measured using DCP/CBR correlation)	Soaked CBR
Quaternary Swamps of Silt & Clay	4% to 7%	-
Devonian Granite/ Residual Soils	8% to 10% (3 projects total)	3% to 12%
Older Volcanics/ Residual Clay	5% (2 projects) to 8% (1 project)	2% to 4% (based on Newer Volcanics Residual Clay)

Table 4-1 Summary of VicRoads CBR values

Soaked CBR data was not provided for either the Quaternary swamps or residual Tertiary Older Volcanic clays. The strength of the residual Older Volcanic clays would be similar to those of the Newer Volcanics for which Olds provides typical soaked CBR values of 2% to 4%.

This is generally consistent with the typical values provided by Austroads 'Guide to Pavement Technology' (AGPTO2-12, 2012) which recommends typical presumptive subgrade design CBR values of 2% to 4% for clays and sandy clays under poor drainage conditions and values of 4% to 6% for similar soils under good drainage conditions.

The residual clays of the Older Volcanics typically have high swell potential and may be subject to shrinking and swelling with variations in moisture content. High plasticity clays may also be encountered within the residual granitic soils and the Quaternary soil deposits and such materials may also have a large swell potential.

5.GEOTECHNICAL INVESTIGATION RESULTS

5.1 Previous Investigations

5.1.1 Ryans Road Branch Sewer

SMEC has previously performed a geotechnical investigation along Ryans Road and Deep Creek, south of the Princes Highway as part of design and construction of a new branch sewer. The investigation extended along part of the western boundary of the Pakenham East PSP area.

The results of the investigation revealed Quaternary clay and sandy clay deposits with occasional silt layers. Residual granitic soils, presenting as silty, sandy and gravelly clay were encountered underlying the alluvium towards the Princes Highway.

Onsite soils were generally moist, becoming wet with depth and were typically of stiff to very stiff consistency and occasionally firm, as indicated by SPT blow counts and pocket penetrometer test results.

Particle size distribution testing on 3 clay samples recovered during the investigation comprised 52% to 83% fines (clay and silt sized particles), 15% to 39% sand and 2% to 13% gravel. Atterberg Limits testing on 7 samples returned Liquid Limits of 55% to 96% and Plasticity Index values of 37% to 75%, corresponding with high plasticity materials. Atterberg Limits testing on 1 sample returned a Liquid Limit of 46% and a Plasticity Index of 30% corresponding to a medium plasticity clay.

Groundwater was measured in standpipes at depths of 1.4m to 2.5m below existing ground surface.

The investigation targeted the branch sewer only and as such CBR testing for use in pavement design was not performed. However, there are several methods available for correlating CBR to laboratory index tests, which were performed as part of the branch sewer investigation, including that presented in the National Association of Australia Road Authorities ‘Interim Guide to Pavement Thickness Design’ (NAASRA, 1979).

Based on the NAASRA 1979 methodology and the index laboratory testing performed during the branch sewer investigation, the unsoaked CBR of the recompacted onsite soils would be expected to vary between 2% and 5% for the more clay rich soils and between 6% and 9% for the sandier soils.

In accordance with Austroads AGPT02-12 guide to classification of expansive soils, available laboratory test results suggest that onsite soils would include materials with a moderate expansive nature (for sandier, less plastic soils) to materials with a high and very high expansive nature (for highly plastic clays with a low proportion of sand).

5.1.2 Estate Development

SMEC has also been involved in the development of a residential estate, located to the west of Deep Creek and north of the Princes Highway, approximately 1km west of the Pakenham East PSP area.

Geotechnical investigations for this estate revealed residual, high plasticity clays of the Older Volcanics and residual granitic soils which typically presented as an upper layer of clayey silt, overlying medium to high plasticity clay and sandy clay.

Four day soaked laboratory CBR testing returned CBR values of 3% to 8% for the residual granitic clays, with swells varying between 0% and 2.5% (7 samples). One residual volcanic clay sample only was tested which returned a CBR value of 1.5% and a swell value of 2%. Samples were compacted at 99% to 101% of Standard Maximum Dry Density, within 3% of optimum moisture content prior to testing and were tested under a 4.5kg surcharge. A summary of the CBR test results provided by the geotechnical consultant on this project is provided in Figure 5-1.

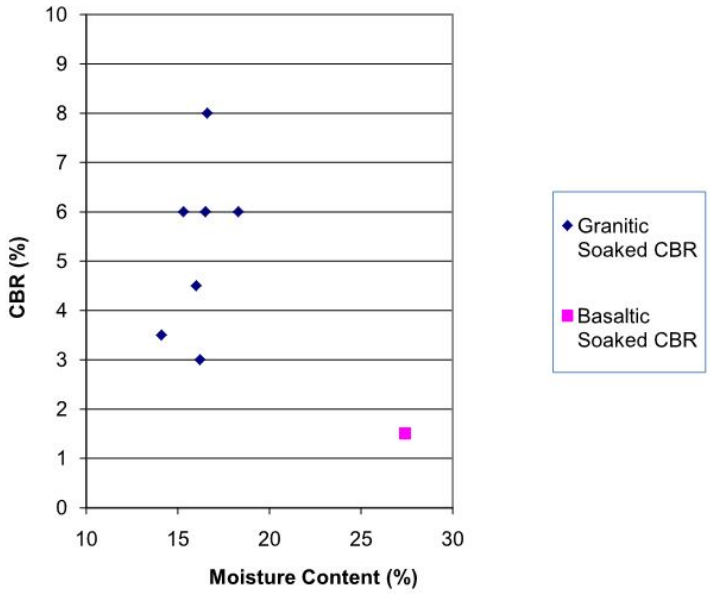

Figure 5-1 CBR Summary

VicRoads (RC500.22 Selection and Design of Pavements and Surfacings, 2013) requires that materials with swells greater than or equal to 2.5% to be considered expansive.

Based on the results of the investigation, design CBR values of 2% and 3.5% were recommended for the residual Older Volcanics and residual granite soils respectively. It was recommended that subgrade soils derived from the Older Volcanics and those derived from the Devonian Granite both be treated as expansive.

5.2 Current Investigation

5.2.1 Scope of Work

The scope of work for the current investigation comprised the drilling of 6 boreholes across the Pakenham East PSP area and 3 boreholes across the Pakenham South PSP area. The investigations were performed over two days on Tuesday 6 October and Thursday 8 October 2015.

The boreholes were positioned in paddocks at the approximate location of likely future intersections and roadworks and to target the different geological units anticipated across the two PSP areas.

The purpose of the investigation was to assess near surface subgrade conditions to ground truth data obtained from the desk top review.

The borehole locations are shown on the plans provided in Appendix C.

The boreholes were drilled to a depth of 1.5m using a 4WD mounted auger rig supplied and operated by Horizon Drilling Pty Ltd.

Dynamic Cone Penetrometer tests (DCP's) were performed adjacent to each borehole in general accordance with AS1289.6.3.2 to assess the insitu consistency of the subgrade materials.

The fieldwork was performed in the presence of a SMEC geotechnical engineer who positioned the boreholes, nominated sampling and testing and prepared borehole logs describing subsurface conditions encountered in general accordance with Australian Standard AS1726-1993 'Geotechnical Site Investigations.' The borehole logs, together with explanatory notes describing terms and symbols used in their preparation are provided in Appendix D.

Immediately upon completion the boreholes were backfilled with the excavated spoil and tamped in place from the surface.

Selected samples recovered from the boreholes were submitted to the NATA accredited laboratory of Civil Geotechnical Services (CGS) for CBR and index testing. CBR testing was performed on samples recompacted to nominal 98% of Standard Maximum Dry Density at ±2% of Standard Optimum Moisture Content, then soaked for a period of 4 days under a 4.5kg surcharge.

Laboratory test reports are provided in Appendix E.

5.2.2 Results

The results of the investigation are generally consistent with the information collated during the desk top review and revealed a layer of topsoil and silt 0.1m to 0.3m thick, overlying predominantly clay residual granite and alluvial soils. Sand and sandy clay layers were encountered towards the surface at some locations which graded quickly to clay within the 1.5m depth of investigation. Residual soils of the Older Volcanics were not encountered during the current investigation.

The residual granitic clays generally comprised a higher proportion of coarser grained sand/fine gravel (22% to 24% sand/fine gravel) when compared to the alluvial clays (5% to 8% sand/fine gravel with one outlier sandy clay with 32% sand/fine gravel). However, it is noted that the alluvial soils were generally derived from the pre-existing granodiorite landscape and as such a distinct difference in the composition of the soils could not always be made. Isolated coal fragments were recorded within the alluvium. The alluvial clays were generally grey and light brown/orange mottled whilst the residual granitic clays were similarly coloured with red mottles also noted.

The residual granitic clays and alluvial clays were both considered to be highly plastic, as indicated by Liquid Limit (LL) values of 49% to 66% and Plasticity Index (PI) values of 32% to 42% for the alluvial soils and LL values of 77% to 79% and PI values of 44% to 50% for the residual granitic clays.

Owing to the method of formation (i.e. residual soil derived from rock) and their location across the higher ground, the residual granite clays were consistently drier and harder than the

alluvial clays deposited across the low lying areas of the site. DCP test results typically varied between about 4 and 10 blows per 100mm penetration for the residual soils (i.e. very stiff to hard) and 2 to 6 blows (i.e. firm to very stiff) in the alluvial clays.

In accordance with Austroads AGPT02-12 Figure 5.3 the DCP test results correspond to insitu CBR values of 8% to 22% for the residual clays and 3% to 12% for the alluvial clays.

It is noted that borehole logs for the estate development to the west of the Pakenham East PSP area generally described the residual granite as a sandy clay, indicating that the material has a higher sand content than that typically encountered across the PSP East and PSP South areas during the current investigation. Particle size distribution testing was not performed during the investigation for the estate development however the laboratory CBR results for the estate (CBR values of 3% to 8%) are consistently higher than those obtained during the current investigation (CBR values of 1% to 3.5%) and percent swell values consistently lower (0% to 2.5% for the estate, 1% to 3.5% during the current investigation) which supports the contention that the residual soils encountered across the estate have a higher sand content than those encountered across the PSP East and PSP South areas.

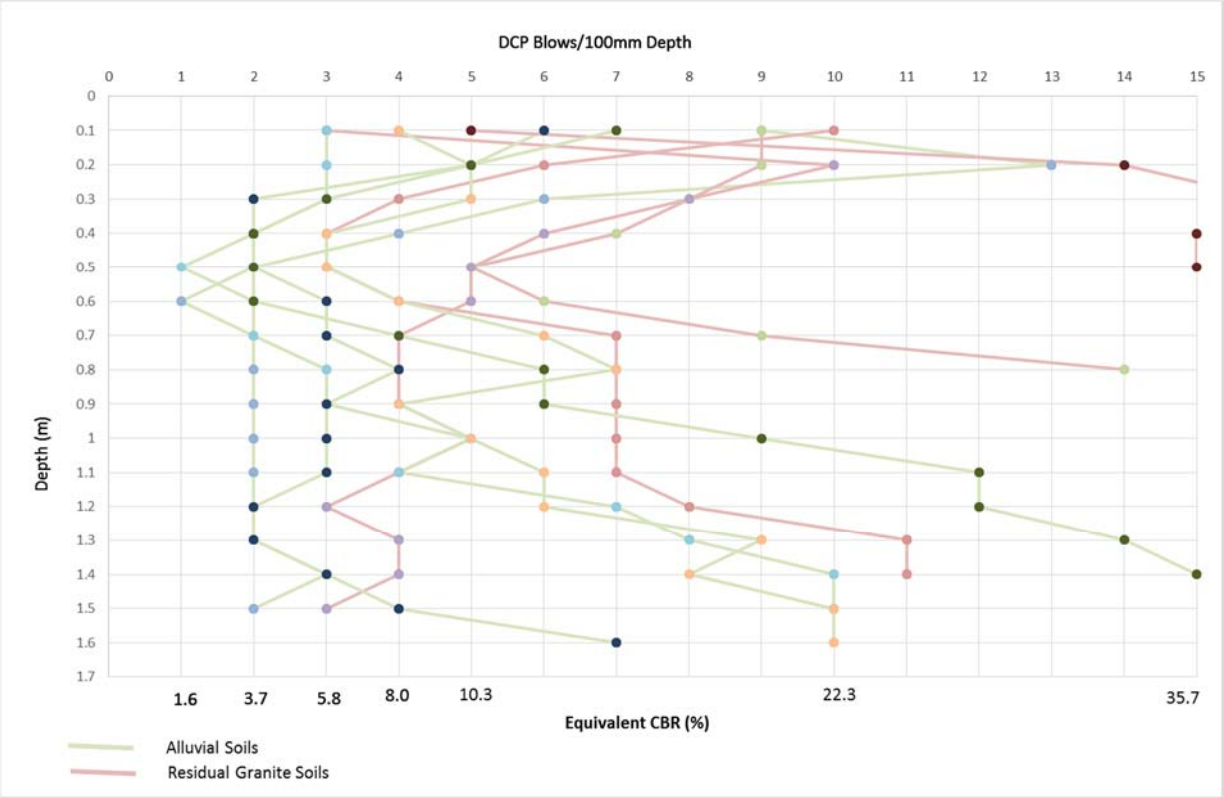

Figure 5-2 DCP Results Summary

A summary of available laboratory test results is provided in Table 5-1, below.

Borehole /Sample Depth	Geological Unit & Material Description	Field Moisture Content	Optimum Moisture Content	4 day soaked CBR	% Swell	LL/PI	% fines, sand & gravel
Pakenham East PSP area							
BH-E1/ 0.3m-0.9m	Inferred Quaternary Alluvium CLAY: high plasticity, grey and brown mottled	33.1%	26.5%	3%	3%	66% LL 42% PI	95% fines 4% sand 1% gravel
BH-E2/ 0.4m-0.8m	Inferred Residual Granite. Silty & Sandy CLAY: low plasticity, light brown and red, occurring in pockets	30.1%	28.5%	2%	2.5%		
BH-E3/ 1m-1.5m	Inferred Residual Granite. CLAY: medium to high plasticity, light brown and grey.	18.9%	18%	1%	3.0%		
BH-E4/ 0.7m-0.9m	Inferred Residual Granite. CLAY: high plasticity, grey and orange mottled.	26.2%	24.5%	3.5%	1.0%	77%LL 50% PI	76% fines 20% sand 4% gravel
BH-E5/ 0.5m-0.9m	Inferred Quaternary Alluvium. CLAY:high plasticity, grey and brown	23.9%	20.0%	3%	1.5%	49% LL 32%PI	92% fines 8% sand
BH-E6/ 0.9m-1.3m	Inferred Quaternary Alluvium. CLAY: medium to high plasticity, mottled grey and orange, trace coal fragments.	21.7%	18.5%	4.5%	0.5%		
Pakenham South PSP Area							
BH-S1/ 0.5m-1m	Inferred Quaternary Alluvium. CLAY: high plasticity, mottled grey and orange and dark grey, trace wood fragments.	25.5%	21.5%	2%	2.5%		
BH-S2/ 0.4m-0.9m	Inferred Residual Granite. CLAY: high plasticity, orange red and light brown, trace fine to medium grained sand	26.7%	28.5%	2.5%	3.5%	79% LL 44% PI	78% fines 18% sand 4% gravel
BH-S3/ 0.6m-1.1m	Inferred Quaternary Alluvium. Sandy CLAY: high plasticity, grey and orange mottled, some medium to coarse grained sand.	22.2%	19.0%	2%	1.5%	59% LL 40% PI	68% fines 31% sand 1% gravel
Other Investigations – New Estate Development (approx. 1km west of PSP East)							
1m-1.4m	Residual Granite. Sandy CLAY: medium plasticity, orange, brown, grey	22.6%	15.0%	8.0%	2.5%		

Borehole /Sample Depth	Geological Unit & Material Description	Field Moisture Content	Optimum Moisture Content	4 day soaked CBR	% Swell	LL/PI	% fines, sand & gravel
0.6m-0.9m	Residual Older Volcanics. Silty CLAY: brown, grey	32.2%	27.0%	1.5%	2.0%	61% LL 43% PI	
0.8m-1.1m	Residual Granite. Sandy CLAY: orange, brown, grey	20.7%	15.5%	3.0%	2.0%		
0.6m-0.9m	Residual Granite. Sandy CLAY: orange, brown, grey	19.7%	15.0%	4.5%	0.5%		
0.6m-0.9m	Residual Granite. Sandy CLAY: orange, brown, grey	19.3%	16.5%	6.0%	1.0%		
0.6m-0.9m	Residual Granite. Sandy CLAY: orange, brown, grey	13.8%	13.5%	6.0%	0.0%		
0.7m-1m	Residual Granite. Sandy CLAY: orange, brown, grey	13.4%	13.5%	3.5%	2.5%		
0.6m-1m	Residual Granite. Sandy CLAY: orange, brown, grey	19.5%	18.5%	6.0%	0.5%		

LL= Liquid Limit, PI = Plasticity Index, Fines = Clay and silt sized particles i.e. finer than 0.075mm

Table 5-1 Laboratory Test Results Summary

6. DISCUSSION

6.1 General

The design of pavements is dependent on subgrade conditions beneath road pavements. We are not aware of the subgrade levels of roads under consideration across the PSP East and PSP south although road pavements may potentially include areas of cut, areas of fill and areas at grade.

The investigation presented herein provides a preliminary assessment of near surface subgrade conditions only, which is considered relevant for pavements at grade and pavements on embankments constructed of near surface soils sourced from site.

Further investigation is required to target specific subgrade depths and areas once road alignments and levels are known.

6.2 Recommended Pavement Design Parameters

The results of the investigation indicate that the majority of both the PSP East area and PSP South area are underlain by alluvial clay and residual granite clay soils.

Isolated areas of residual Older Volcanic clays are also likely to be present but were not encountered during the current investigation.

DCP test results indicate that the insitu CBR of the alluvial clays vary from 3% to 12% whilst that of the residual clay soils vary from 8% to 22%. It is noted that the DCP/CBR correlation is highly dependent on soil moisture condition and lower results would be anticipated during wetter periods.

Current VicRoads and Growth Areas Authority (of which Cardinia Shire Council is a signatory) practice is to base pavement design on the laboratory 4 day soaked CBR test to represent soil strength under poor pavement drainage conditions.

VicRoads RC500.20 ‘Assignment of CBR and Percent Swell to Earthworks Fill and Pavement Materials (June 2013) presents methods for assigning CBR and percent swell values to materials used in highly trafficked roads or where there are more than 15000m^2 of new pavement represented by the testing (Scale A Assessment) and for lower trafficked and smaller road pavement projects (Scale B and Scale C Assessment). The approaches for assigning CBR and swell values for Scale A, B and C Assessments are summarised in Appendix F.

Table 6-1 summarises the relevant geological units, together with the recommended assigned CBR and percent swell values based on the VicRoads Scale A, B and C Assessment criteria.

	Lab Results Summary	Assigned Values Scale A Assessment*	Assigned Values Scale B Assessment*	Assigned Values Scale C Assessment*
Quaternary Alluvium	• 5 samples • CBR 2%-4.5% • Swell 0.5%-3%	• CBR 2% • Swell 2.5% (expansive)	• CBR 2% • Swell 2.75% (expansive)	• N/A
Residual Granite	**Current Investigation** • 4 samples • CBR 1%-3.5% • Swell 1%-3.5%	• CBR 2% • Swell 3% (expansive)	• CBR 1.5% • Swell 3.25% (expansive)	• N/A
	Estate Investigation • 7 samples • CBR 3%-8% • Swell 0%-2.5%	• CBR 3.5% • Swell 2.5% (expansive)	• CBR 3% • Swell 2.5% (expansive)	• N/A
	All combined • 11 samples • CBR 1%-8% • Swell 0%-3.5%	• CBR 2% • Swell 3% (expansive)	• CBR 1.5% • Swell 3.25% (expansive)	• N/A
Residual Older Volcanics	**Estate Investigation** • 1 sample • CBR 1.5% • Swell 2%	• N/A	• N/A	• CBR 1.5% to 4% • Swell >2.5% (expansive)

*Number of tests performed are not necessarily in accordance with VicRoads RC500.20 Scale A or Scale B Assessment as the assessment presented herein is preliminary only.

Table 6-1 Laboratory CBR Results & Assigned Values

Quaternary Alluvium

It is anticipated that the soaked CBR of Quaternary Alluvial soils across both the PSP East and PSP South areas would likely vary between about 1% and 4.5%.

Based on available information, a subgrade CBR of 2% is considered appropriate for the preliminary design of pavements underlain by Quaternary Alluvium. The Quaternary Alluvium should be considered expansive.

Residual Granite

It is anticipated that the soaked CBR of the residual granite soils across both the PSP East and PSP South areas would likely vary between about 1% and 8%. The higher values would be anticipated if and where sandier clay soils are encountered.

Based on available information, a subgrade CBR of 2% is considered appropriate for the preliminary design of pavements underlain by residual granitic clays. Design CBR values of up to 3.5% may be appropriate if and when sandier residual granitic clays are encountered. Residual granite clays should be considered expansive.

Residual Older Volcanics

It is anticipated that the soaked CBR of the residual older volcanic soils across both the PSP East and PSP South areas would likely vary between about 1.5% and 4%.

Based on available information, a subgrade CBR of 2% is considered appropriate for the preliminary design of pavements underlain by residual older volcanic soils. Residual older volcanic soils should be considered expansive.

Fill Embankments

The design of road pavements on fill embankments is dependent on the nature and thickness of the fill material used. Where natural onsite soils are reused as engineered fill, the design CBR and expansiveness would be as described above.

6.3 Implications on Pavement Profiles

As described previously, the structural design of road pavements is dependent on both traffic loads, subgrade strength and expansiveness.

VicRoads RC500.22 and the Growth Areas Authority ‘Engineering Design and Construction Manual’ (MPA 2011) require the use of a low permeability capping layer and/or minimum pavement thickness to reduce the potential for moisture variations and shrink/swell movements of an underlying expansive subgrade.

The Growth Areas Authority also requires the use of bitumen crumb rubber asphalt for all asphalt base courses for pavements on expansive subgrades. Crumb rubber asphalt has rubber particles added to the aggregate/bitumen mix and is generally more resistant to reflection cracking and any cracks are more liable to heal during the summer months.

In addition to subgrade conditions, pavement structural design is also dependent on anticipated traffic loads in terms of equivalent standard axles (ESA’s). Design traffic loads for the PSP East and PSP South areas are not known at present.

The following tables present a summary of pavement profiles required in accordance with MPA 2011 for different road types (i.e. with different traffic loads) and different subgrade strengths (i.e. design CBR 2%, 3% & 4%) to highlight the impact of subgrade strength on pavement thickness. The difference between the profiles are highlighted in red. All pavement profiles presented assume expansive subgrade conditions.

It is noted that the pavement profiles provided are presented for comparison purposes only and alternative pavement profiles, utilising different material types and thicknesses, may also be appropriate.

Street Type	Access Lane			
Assumed Traffic Load	3 x 10^4 ESA's, ~300 Average Annual Daily Traffic			
Subgrade Design Strength	CBR=2%	CBR=3%	CBR=4%	Material Description
Asphalt Wearing Course	20mm	20mm	20mm	Size 7 Type L Asphalt (Class 170 binder)
Asphalt Base Course	30mm	30mm	30mm	Size 10 Bitumen Crumb Rubber Asphalt
Prime or Primerseal	Yes	Yes	Yes	
Granular Base	140mm	185mm	185mm	20mm Class 2 Crushed Rock or Class CC2 crushed concrete
Upper Subbase	120mm	-	-	20mm Class 3 Crushed Rock or Class CC3 Crushed concrete or granular base quality material
Lower Subbase	-	-	-	Class 4 Crushed Rock or Class CC4 Crushed Concrete or upper subbase or base quality material.\
Capping	150mm	155mm	150mm	Type A Fill with assigned swell ≤1.5%, permeability ≤1x10^{-9}m/sec, CBR≥8%
Total Thickness	460mm	390mm	385mm	

Table 6-2 Access Lane Pavement Profiles

Street Type	Access Street			
Assumed Traffic Load	5 x 10^5 ESA's, ~2000 Average Annual Daily Traffic			
Subgrade Design Strength	CBR=2%	CBR=3%	CBR=4%	Material Description
Asphalt Wearing Course	30mm	30mm	30mm	Size 10 Type N Asphalt (Class 170 binder)
Asphalt Base Course	30mm	30mm	30mm	Size 10 Bitumen Crumb Rubber Asphalt
Prime or Primerseal	Yes	Yes	Yes	
Granular Base	130mm	130mm	130mm	20mm Class 2 Crushed Rock or Class CC2 crushed concrete
Upper Subbase	260mm	190mm	165mm	20mm Class 3 Crushed Rock or Class CC3 Crushed Concrete or granular base quality material
Lower Subbase	-	-	-	Class 4 Crushed Rock or Class CC4 Crushed Concrete or upper subbase or base quality material.\
Capping	150mm	150mm	150mm	Type A Fill with assigned swell ≤1.5%, permeability ≤1x10^{-9}m/sec, CBR≥8%
Total Thickness	600mm	530mm	505mm	

Table 6-3 Access Street Pavement Profiles

Street Type	Connector Street/ Arterial Road			
Assumed Traffic Load	5 x 10^6 ESA's, ~11,000 Average Annual Daily Traffic			
Subgrade Design Strength	CBR=2%	CBR=3%	CBR=4%	Material Description
Asphalt Wearing Course	40mm	40mm	40mm	Size 14 Type H Asphalt (Class 320 binder), or better
Asphalt Intermediate Course	75mm	75mm	70mm	Size 20 Type SI Asphalt (or Type SS)
Asphalt Base Course	75mm	75mm	75mm	Size 20 Type SI Asphalt (or Type SS)
Cemented Base	170mm	110mm	110mm	20mm Class 3 Crushed Rock or Class CC3 Crushed Concrete treated with 3% cement (E=500MPa)
Lower Subbase	150mm	150mm	150mm	Class 3 Crushed Rock or Class CC3 Crushed Concrete.
Capping	150mm	200mm	205mm	Type A Fill with assigned swell ≤1.5%, permeability ≤1x10^{-9}m/sec, CBR≥8%
Total Thickness	660mm	650mm	650mm	

Table 6-4 Connector Street/Arterial Road Pavement Profiles

6.4 Subgrade Treatment

When able to moisten and soften, onsite soils are likely to have poor workability, be difficult for construction equipment to traffic and may lack the necessary support for proper compaction of engineered fill and/or pavement layers.

Subgrades treatment may be required if wet and soft subgrade soils are encountered at the time of construction. Appropriate subgrade treatment measures may include over excavation and replacement, placement of a granular working platform and/or geogrid layer, or lime stabilisation.

Lime stabilised material with a swell ≤1.5%, a permeability ≤1x10-9m/sec and a CBR≥8% may be used in lieu of the capping layer in the pavement profiles described above.

Depending on the thickness/depth of lime stabilisation, a higher subgrade design CBR may be justifiable.

6.5 Other Considerations

Appropriate construction procedures and drainage measures are critical to the proper performance of road pavements.

Topsoil, organics, uncontrolled fill or otherwise deleterious material should be removed from areas beneath road pavements to expose the natural subgrade soils. Where soft spots are encountered at subgrade level, they should be over excavated and replaced with compacted fill or alternative engineering solutions, such as the use of geofabrics adopted. The subgrade should be shaped and earthworks planned to prevent infiltration of water into the subgrade.

Pavements should be provided with a minimum cross fall of 3% to ensure drainage of the asphalt surface. If kerb and channel is adopted, pavements should include 100mm diameter agricultural pipe subsurface drains along both sides of the pavement, installed within the capping layer. Where table drains are used, they should be designed and constructed such that the water level within the drains remains at least 250mm below subgrade level.

7.TECHNICAL REFERENCES

Australian Standard AS1726-1993 Geotechnical Site Investigations.

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Olds R.J., 'Roads & Subgrades' in 'Engineering Geology of Melbourne'Peck W.A., Neilson J.L., Olds R.J. and Seddon K.D. (eds), Balkema, 1992.

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Roberts D., 'From Swampland to Farmland – A History of the Koo Wee Rup Flood Protection District,' Water Commission of Victoria, South East Newspapers, 1985.

SMEC Report 'Ryan Road Branch Sewer, Pakenham, Geotechnical Investigation,' prepared on behalf of Peet Abrehart Road Pty Ltd, dated May 2013.

VicRoads Code of Practice for Assignment of CBR and Percent Swell to Earthworks Fill and Pavement Materials,' RC500.20, June 2013.

VicRoads Code of Practice for Selection and Design of Pavements and Surfacings, RC500.22, October 2013.

Victorian Department of Natural Resources and Environment, 'Victoria Geology 1:500000 scale'.

Victorian Groundwater Database at Visualising Victorias Groundwater, www.vvg.org.au.

Williams M.P.A., 'Quaternary Alluvial and Swamp Deposits' in 'Engineering Geology of Melbourne'Peck W.A., Neilson J.L., Olds R.J. and Seddon K.D. (eds), Balkema, 1992.

8.LIMITATIONS

8.1 Geotechnical Reports

The following notes have been provided to outline the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work, and is supplemented by knowledge of the local geology and experience of the range of properties that may exhibited by the materials present. For this reason geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (e.g. design of a three storey building), the information and interpretation may not be appropriate if the design is changed (e.g. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by SMEC in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities
- The actions of contractors responding to commercial pressures

If these occur, SMEC would be pleased to resolve the matter through further investigation, analysis or advice.

8.2 Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, SMEC should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

8.3 Subsurface Information

Logs of a borehole, recovered core, test pit, excavated face, or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling/observation spacing's and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume of material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements outside of specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localized perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures mask or prevent groundwater inflow.
- The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

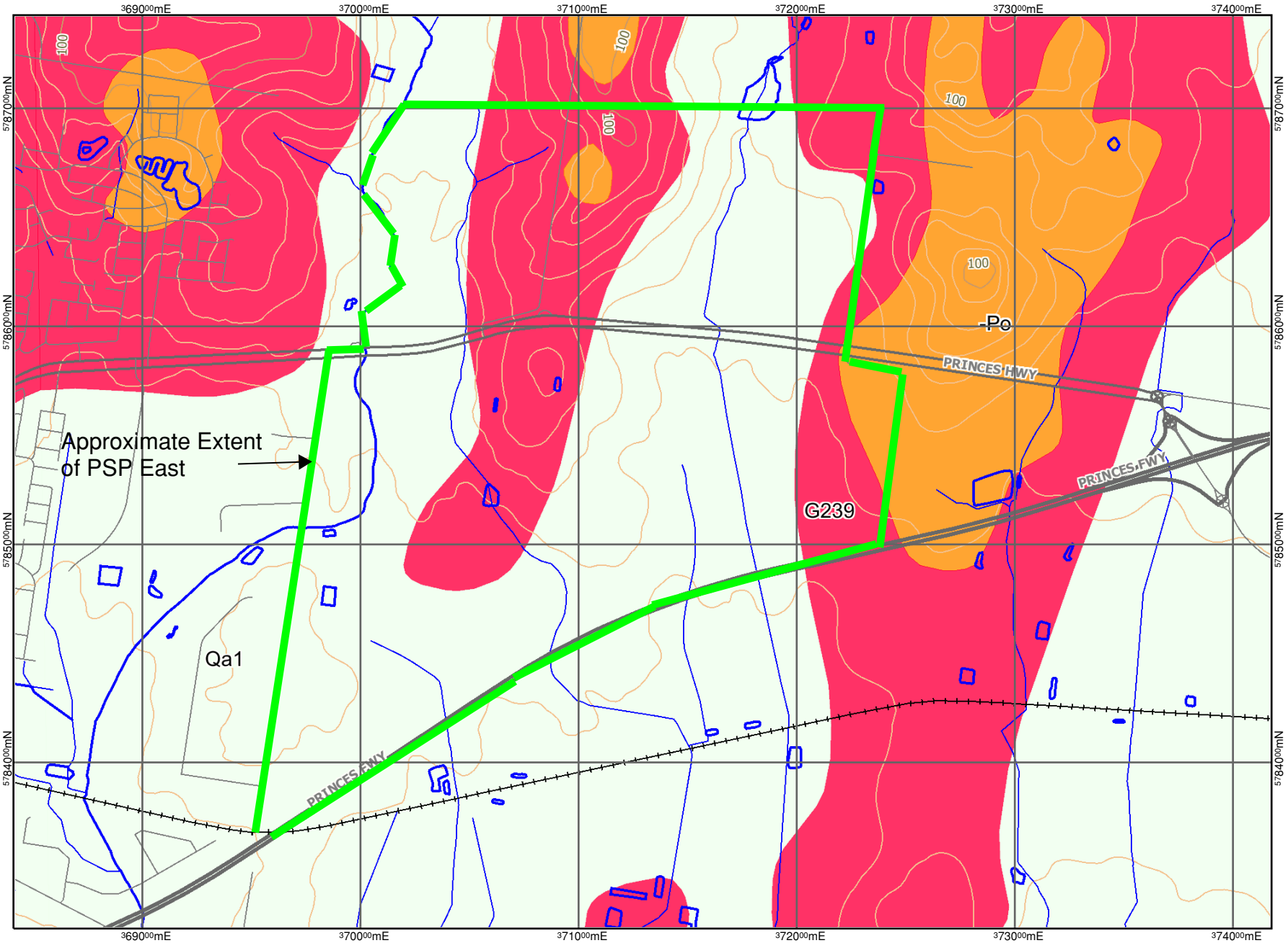
8.4 Supply of Geotechnical Information for Tendering Purposes

It is recommended tenderers are provided with as much geological and geotechnical information that is available. Where there are uncertainties regarding the ground conditions, prospective tenderers should be provided with comments discussing the range of likely conditions in addition to the investigation.

APPENDIX A: GEOLOGICAL MAPS

Department of Primary Industries

Map created Mon Sep 14 09:45:27 EST 2015



Legend

* Refer to page 2 for legend details

Map Server: P00403

Map Service: erd_geovic_v2_7

Generated at http://mapshare2.dse.vic.gov.au/MapShare2EXT/ from GeoVic

Produced on Mon Sep 14 09:45:43 EST 2015

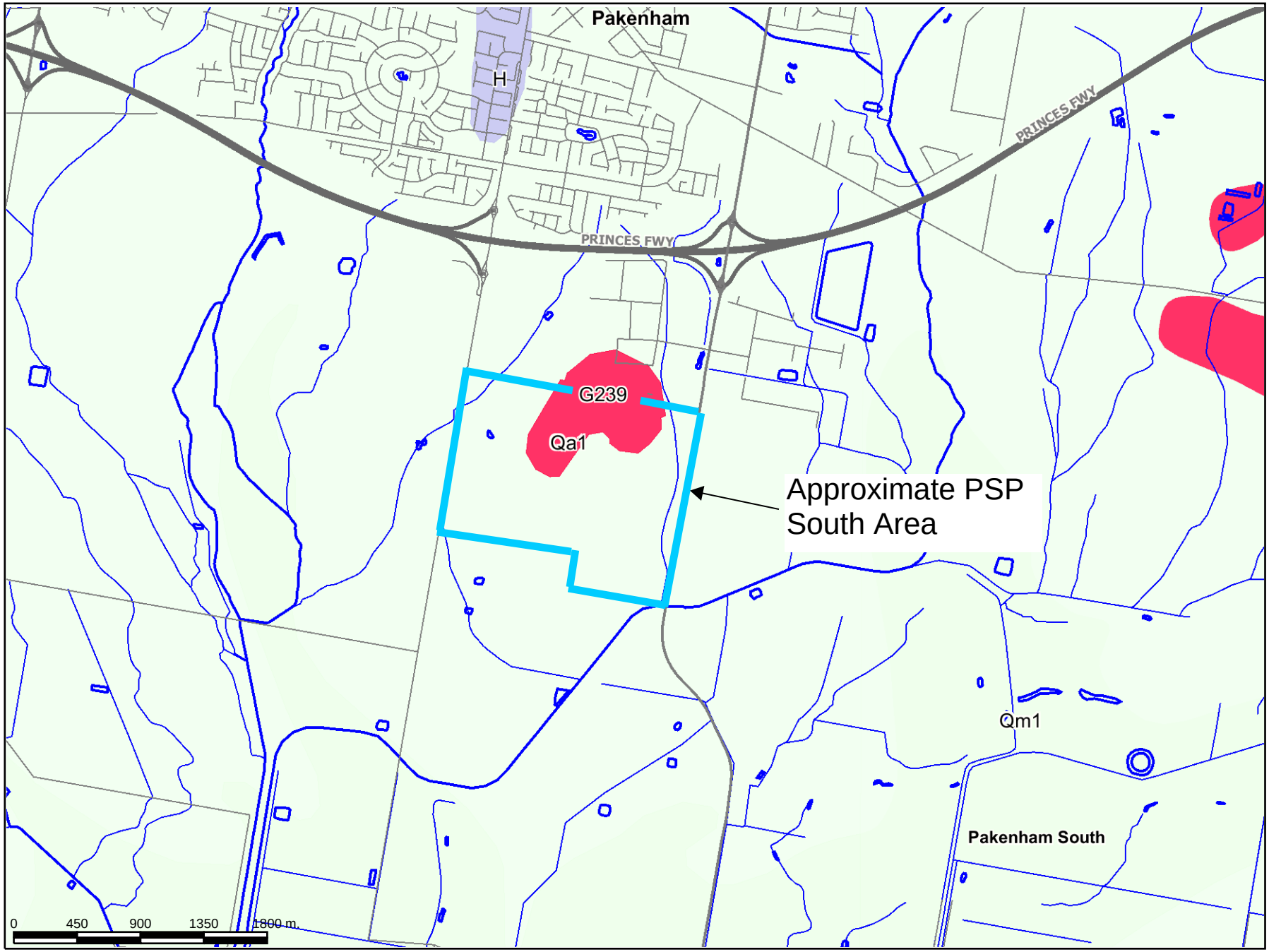
Map Scale 1:25,000

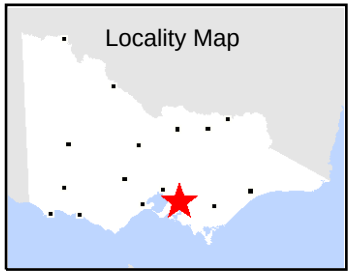
Projection: MGA_55

GDA

State Government Victoria

Department of Primary Industries





Legend

Towns (25K)

Roads (vmsimple)

Freeway

Highway

Main Road

Other

Lakes (vmhydro)

Watercourses (vmhydro)

Rivers

Creeks

Other

Contours (250K)

Contact Metamorphism Zones 250K

Geological Polygons 250K

GN

Qc3 Unnamed slump deposits

Qdl1 Unnamed coastal dune deposits

Qdi Unnamed inland dune deposits

Ql Unnamed lunette deposits

Qm1 Unnamed swamp and

Printed on 14 September 2015 9:52:26

Map Scale 1:37,937

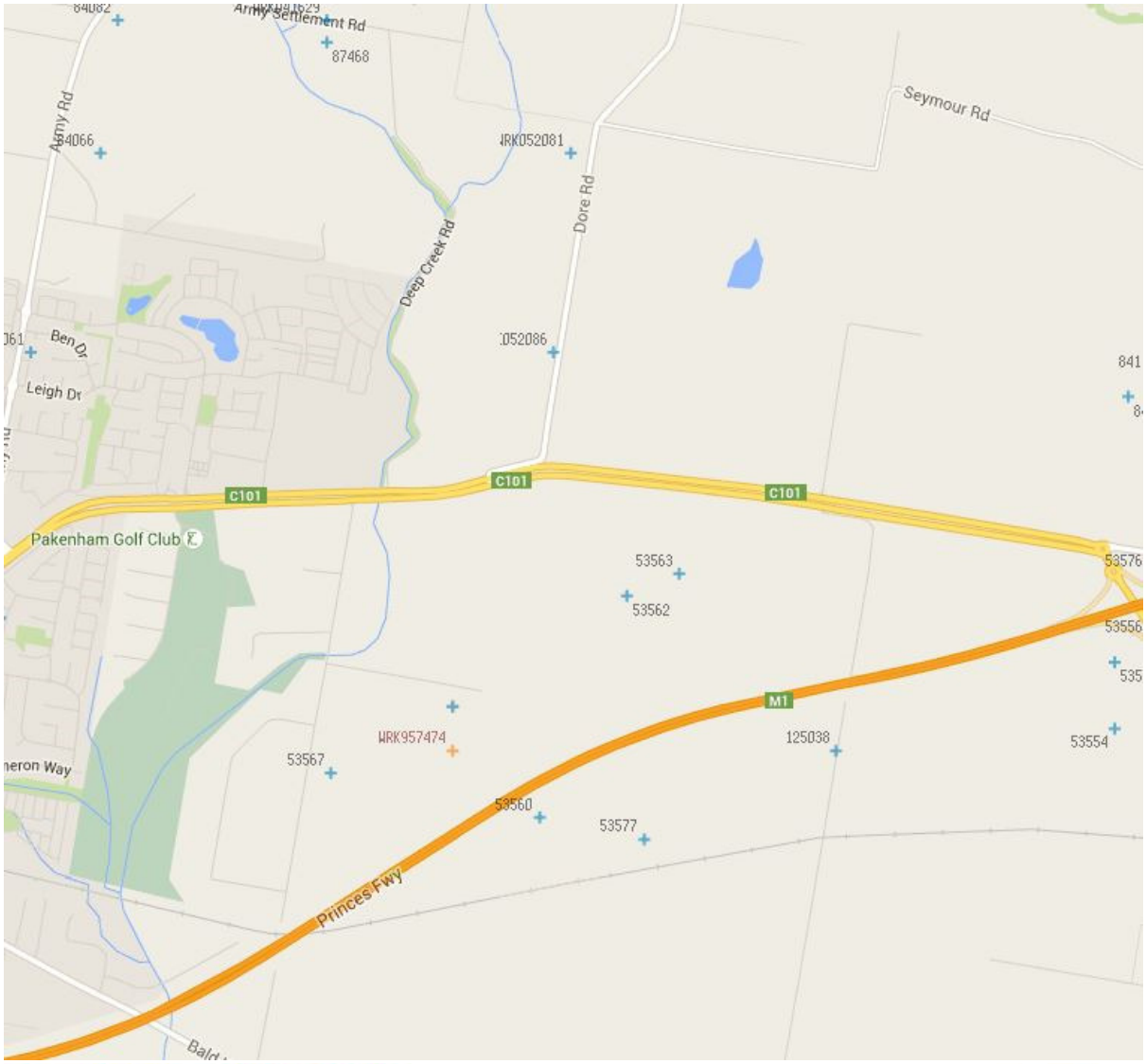
NOT FOR NAVIGATION

GDA

Vicgrid94

State Government Victoria

APPENDIX B:
VICTORIAN GROUNDWATER DATABASE SUMMARY



Bore Details:: WRK052081

Printable Version

BORE DETAILS | AQUIFER | MONITORING | CHEMISTRY | LITHOLOGY | STRATIGRAPHY | ATTACHMENTS

Lithology details for bore: WRK052081

Log Type	From (m)	To (m)	Description
Driller	0.00	5.00	top soil
Driller	5.00	8.00	brown clay

Federation UNIVERSITY • AUSTRALIA

Bore Details:: WRK052086

Printable Version

BORE DETAILS | AQUIFER | MONITORING | CHEMISTRY | LITHOLOGY | STRATIGRAPHY | ATTACHMENTS

Lithology details for bore: WRK052086

Log Type	From (m)	To (m)	Description
Driller	0.00	0.50	top soil
Driller	0.50	10.00	brown clay

Federation UNIVERSITY • AUSTRALIA

VVG Visualising Victoria's Groundwater

Bore Details:: WRK065763

Printable Version

BORE DETAILS | AQUIFER | MONITORING | CHEMISTRY | LITHOLOGY | STRATIGRAPHY | ATTACHMENTS

Lithology details for bore: WRK065763

Log Type	From (m)	To (m)	Description
Driller	0.00	0.25	TOP SOIL
Driller	0.25	3.00	ORANGE & GREY CLAY
Driller	3.00	6.00	RED; ORANGE & GREY CLAY
Driller	6.00	14.00	GREY CLAY
Driller	14.00	26.90	ORANGE & GREY SANDY CLAY
Driller	26.90	27.50	SANDY DRIFT
Driller	27.50	28.00	GRANIT CLAY

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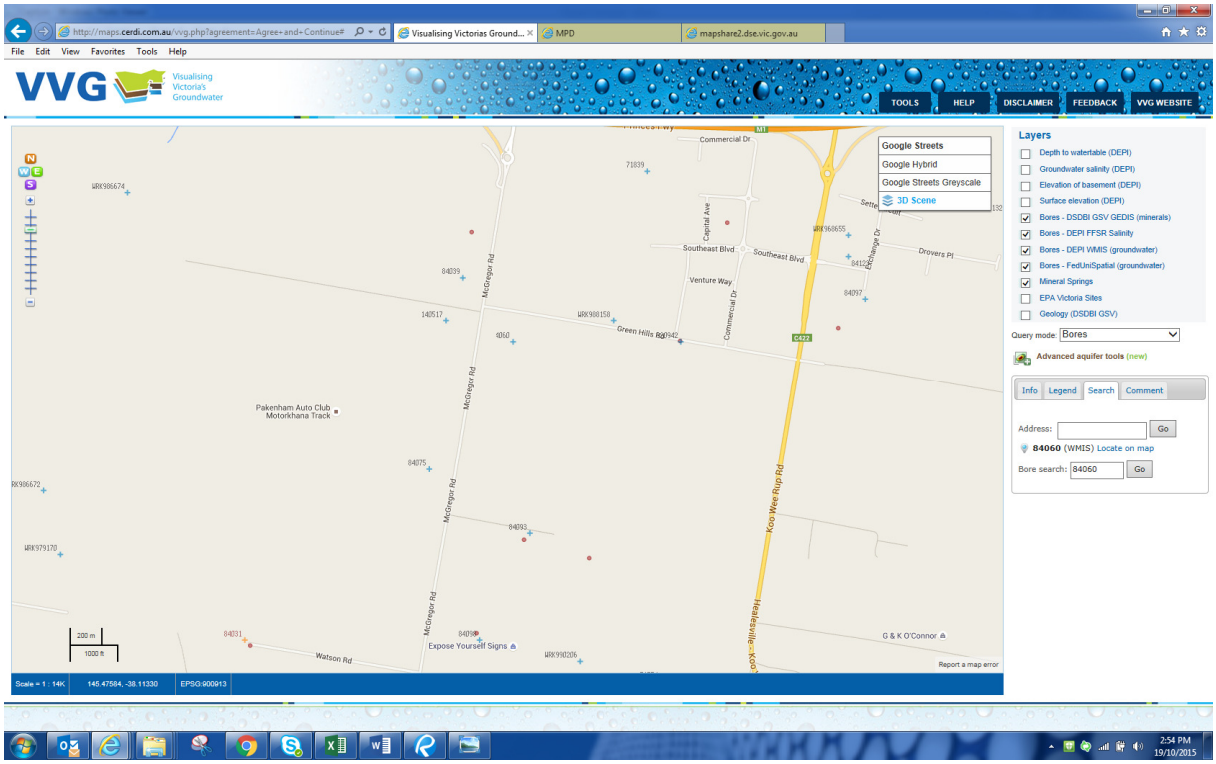

Bore Details:: 84060

Printable Version

BORE DETAILS | AQUIFER | MONITORING | CHEMISTRY | LITHOLOGY | STRATIGRAPHY | ATTACHMENTS

Lithology details for bore: 84060

Log Type	From (m)	To (m)	Description
Driller	0.00	1.22	GREY CLAYEY SAND
Driller	1.22	3.05	REDDISH BROWN AND GREY CLAY
Driller	3.05	4.57	BROWN AND GREY CLAY
Driller	4.57	10.67	DECOMPOSE GREY AND WHITE CLAY
Driller	10.67	12.19	BROWN AND REDDISH SANDY CLAY
Driller	12.19	15.84	DECOMPOSE GRANITE SAND

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Bore Details:: 84065

Printable Version

BORE DETAILS | AQUIFER | MONITORING | CHEMISTRY | LITHOLOGY | STRATIGRAPHY | ATTACHMENTS

Lithology details for bore: 84065

Log Type	From (m)	To (m)	Description
Driller	0.00	0.30	TOPSOIL
Driller	0.30	19.50	CLAY
Driller	19.50	0.00	BASALT

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Bore Details:: 84093

Printable Version

BORE DETAILS | AQUIFER | MONITORING | CHEMISTRY | LITHOLOGY | STRATIGRAPHY | ATTACHMENTS

Lithology details for bore: 84093

Log Type	From (m)	To (m)	Description
Driller	0.00	0.15	TOP SOIL
Driller	0.15	8.00	MOTTLED CLAY
Driller	8.00	9.50	DARK GREY CLAY
Driller	9.50	18.00	MOTTLED CLAY
Driller	18.00	22.00	GREY SANDY CLAY
Driller	22.00	27.00	MOTTLED CLAY
Driller	27.00	32.00	GREY SANDY CLAY
Driller	32.00	33.00	SAND
Driller	33.00	0.00	DECOMPOSED GRANITE

APPENDIX C:
BOREHOLE LOCATION PLANS

LEGEND

- Precinct Structure Plan
- Urban Growth Boundary
- Development Area

Movement Network

- Arterial Road (VicRoads)
- Connector Street
- Access Street - Level 2
- Access Place/Street - Level 1
- Traffic Management A - Signalised Intersection

Re:

Ac

Co

Op

Otl

- Farming Zone
- Existing Infrastructure to be retained
- Gas Transmission Pipeline

Baseplan drawing is being used to present borehole locations only. Other information shown on drawings may not be up to date

Summary Land Use Budget A -Net Developable Area Calculation

Description			
Total Precinct Area (Ha)		635.87	
		Area (Ha)	% Total Precinct Area
Land Outside Development Area			
	Electricity Easement	22.28	3.50%
	Farming Zone	21.44	3.37%
	Existing Road Reserves	0.47	0.07%
	Subtotal	**44.19**	**6.95%**
Development Area (Ha)		591.68	

nt

.82%
.93%
.74%
.27%
.18%
.44%
.89%
.57%
.42%
.99%
.67%
.83%
.50%
.88%
cinct
.79%
.19%
.98%

Summary Land Use Budget C - Preliminary Residential Yield Estimates

		Area (Ha)	Dwellings
Residential			
	Large Lot Residential^	24.38	171
	Low Density Residential^^	59.55	595
	Standard Density Residential^^^	278.87	4183
	Medium Density Residential^^^^	43.97	1099
Total		**406.78**	**6049**

Summary Land Use Budget D - Land Use Undefined

		Area (Ha)	% Total Precinct Area
	Existing Infrastructure to be retained	0.89	0.15%
Total		**0.89**	**0.15%**

Notes

^ - Based on an average of 7 lots per Hectare
^^ - Based on an average of 10 lots per Hectare
^^^ - Based on an average of 15 lots per Hectare
^^^^ - Based on an average of 25 lots per Hectare

1. Includes Deep Creek Road, Princes Highway, Ryan Road, Mount Ararat Road (north and south), Dore Road, Canty Lane

2. Indicative location and level of provision subject to refinement

BH N1

Borehole Location SMEC 2015

PAKENHAM EAST PSP FUTURE URBAN STRUCTURE

PAKENHAM EAST PSP

SMEC
Local People. Global Experience.

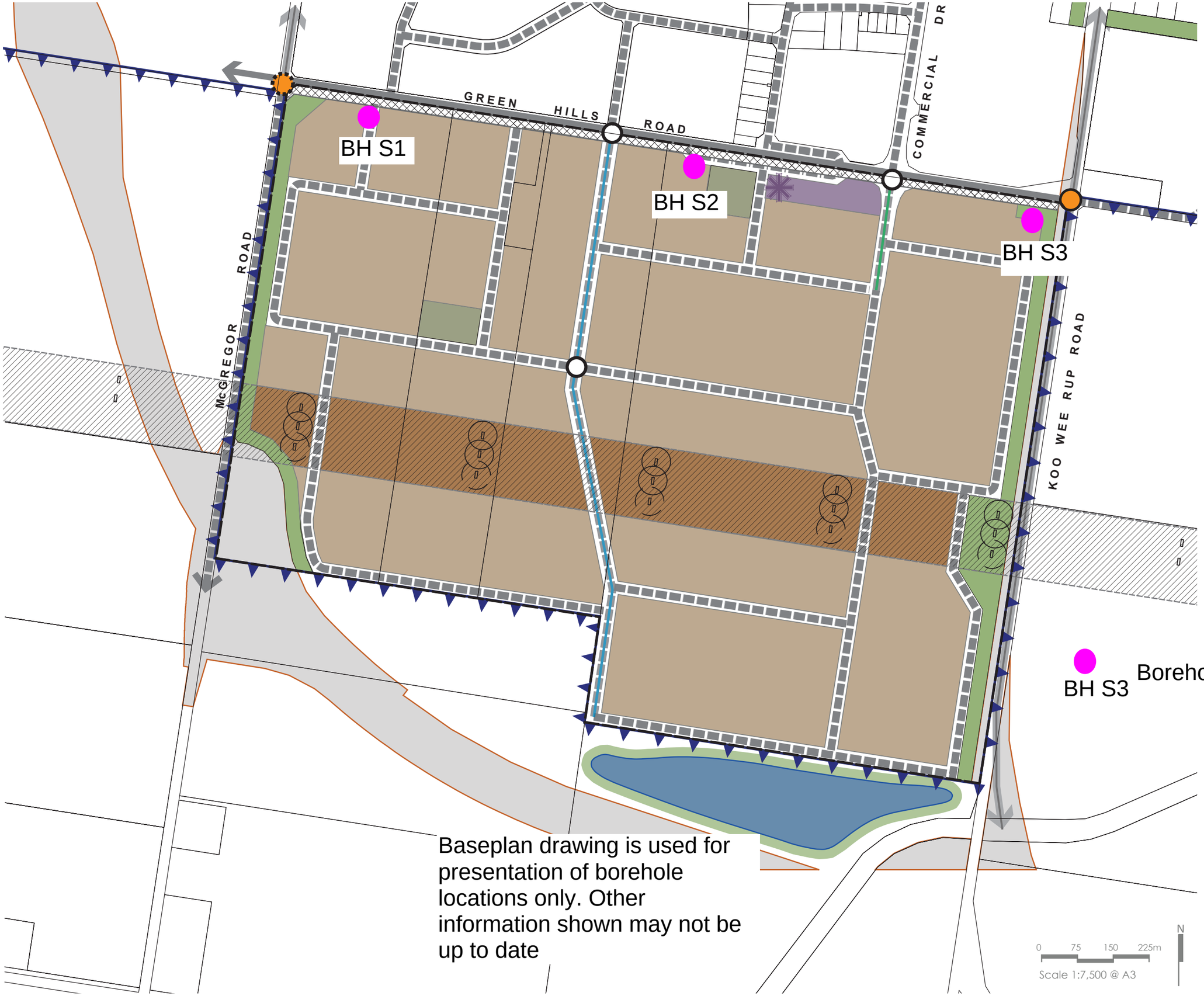
CONFIDENTIAL
DRAFT

Scale: 1:10,000 @ A1
0 100 200 300
0 200 400 600
Scale: 1:20,000 @ A3

ref.: 3410808U
date: 10 April 2015
rev.: K
drawn: FS
checked: CD

please note:
This plan is based on preliminary information only and may be subject to change as a result of formal Council/Authority advice, detailed site investigations and confirmation by survey

planning, urban design and landscape architecture
melbourne - tel 9514 1500
abn 47 065 475 149



Future Urban Structure
Pakenham South Employment Precinct (PSP06)

LEGEND

- Urban Growth Boundary
- Precinct Boundary
- Public Aquisition Overlay (PAO)
- Trans. Easement & Towers
- Green Hills Road Widening
- Prop. Water Bodies
- Prop. Drainage Lines
- Primary Arterial Roads (VicRoads)
- Local Arterial Road
- Industrial Road
- Industrial Road (with drainage requirements)
- Industrial Road (with meandering shared path)
- Industrial Service Road
- Future Signalised Intersection
- Signalised Intersection
- Traffic Control Device
- Potential Local Convenience Centre Location
- Commercial Land
- Industrial Land
- Industrial Land (Restricted Uses)
- Public Open Space (Encumbered)
- Public Open Space (Unencumbered)

0 75 150 225m
Scale 1:7,500 @ A3
N

Plan Ref: 15021_
Rev A

BH S3 Borehole Location SMEC 2015

Baseplan drawing is used for presentation of borehole locations only. Other information shown may not be up to date

Cardinia

UrbanDesign and management
Land Development | Project Management
Planning | Urban Design | Civil Engineering

APPENDIX D: BOREHOLE LOGS

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH E1

PROJECT : Pakenham Geotechnical Investigation
LOCATION : Pakenham
CLIENT : Cardinia Shire Council
FEATURE :
FILE / JOB NO : 30041261
SHEET : 1 OF 1

POSITION : E: 372226.000, N: 5785817.000 (55 MGA94) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig MOUNTING : 4WD UTE CONTRACTOR : Horizon Drilling DRILLER : JN

DATE STARTED : 6/10/15 DATE COMPLETED : 6/10/15 DATE LOGGED : 6/10/15 LOGGED BY : DK CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed	0.30m B	0.0		ML	**TOPSOIL: CLAYEY SILT:** low plasticity, brown, with rootlets to 100mm depth	M		0.00: DCP Test Results 0-0.1m 9 blows
								0.20m			0.10: 0.1-0.2m 13 blows
								CLAY: high plasticity, grey and brown mottled, *inferred alluvium*			0.20: 0.2-0.3m 6 blows
											0.30: 0.3-0.4m 4 blows
											0.40: 0.4-0.5m 2 blows
											0.50: 0.5-0.6m 1 blow
											0.60: 0.6-0.7m 2 blows
											0.70: 0.7-0.8m 2 blows
							CH		M	St	0.80: 0.8-0.9m 2 blows
				0.90m							0.90: 0.9-1m 2 blows
					1.0						1.00: HP In-situ = 200 kPa; 1-1.1m 2 blows
											1.10: 1.1-1.2m 2 blows
											1.20: 1.2-1.3m 2 blows
											1.30: 1.3-1.4m 3 blows
								1.50m			1.40: 1.4-1.5m 2 blows
								BOREHOLE BH E1 TERMINATED AT 1.50 m Target depth			
					2.0						
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH E2

PROJECT : Pakenham Geotechnical Investigation
LOCATION : Pakenham
CLIENT : Cardinia Shire Council
FEATURE :
FILE / JOB NO : 30041261
SHEET : 1 OF 1

POSITION : E: 372438.000, N: 5785275.000 (55 MGA94) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig MOUNTING : 4WD UTE CONTRACTOR : Horizon Drilling DRILLER : JN

DATE STARTED : 6/10/15 DATE COMPLETED : 6/10/15 DATE LOGGED : 6/10/15 LOGGED BY : DK CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed	0.40m B 0.80m	0.0		ML	**TOPSOIL: SANDY SILT:** low plasticity, dark grey brown 0.15m	D		0.00: DCP Test Results 0-0.1m 10 blows 0.10: 0.1-0.2m 6 blows
							SM	**SILTY SAND:** fine to coarse grained, dark grey brown 0.30m	D	MD	0.20: 0.2-0.3m 4 blows
					1.0		Cl	**SILTY and SANDY CLAY:** medium plasticity, light brown and red, occurring in variable pockets, sand is medium to coarse grained, *inferred residual granite* 1.50m	M	VSt	0.30: 0.3-0.4m 3 blows 0.40: 0.4-0.5m 3 blows 0.50: 0.5-0.6m 4 blows 0.60: 0.6-0.7m 7 blows 0.70: 0.7-0.8m 7 blows 0.80: 0.8-0.9m 7 blows 0.90: 0.9-1m 7 blows 1.00: 1-1.1m 7 blows 1.10: 1.1-1.2m 8 blows 1.20: 1.2-1.3m 11 blows 1.30: 1.3-1.4m 11 blows
					2.0			BOREHOLE BH E2 TERMINATED AT 1.50 m Target depth			
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH E3

PROJECT : Pakenham Geotechnical Investigation | CLIENT : Cardinia Shire Council | FILE / JOB NO : 30041261
LOCATION : Pakenham | FEATURE : | SHEET : 1 OF 1

POSITION : E: 370950.000, N: 5787074.000 (55 MGA94) | SURFACE ELEVATION : | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig | MOUNTING : 4WD UTE | CONTRACTOR : Horizon Drilling | DRILLER : JN

DATE STARTED : 6/10/15 | DATE COMPLETED : 6/10/15 | DATE LOGGED : 6/10/15 | LOGGED BY : DK | CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed		0.0		ML	**SILT:** low plasticity, brown, dry, powdery	D		0.00: DCP Test Results 0-0.1m 9 blows 0.10: 0.1-0.2m 9 blows
					0.20m		SP	**SAND:** predominantly medium to coarse grained, some fine grained, grey, becoming clayey with depth, *inferred residual granite*	M	D	0.20: 0.2-0.3m 8 blows 0.30: 0.3-0.4m 7 blows 0.40: 0.4-0.5m 5 blows
					0.50m		CI	**SANDY CLAY:** medium to high plasticity, grey and light brown, sand is medium to coarse grained	M	VSt - H	0.50: 0.5-0.6m 6 blows 0.60: 0.6-0.7m 9 blows 0.70: HP In-situ = 300 kPa; 0.7-0.8m 14 blows
				1.00m B	1.0						
					1.10m		CH	**CLAY:** hight plasticity, light brown and grey	M	VSt - H	1.40: HP In-situ = 380 kPa
				1.50m	1.50m			BOREHOLE BH E3 TERMINATED AT 1.50 m Target depth			
					2.0						
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH E4

PROJECT : Pakenham Geotechnical Investigation | CLIENT : Cardinia Shire Council | FILE / JOB NO : 30041261
LOCATION : Pakenham | FEATURE : | SHEET : 1 OF 1

POSITION : E: 370697.000, N: 5786155.000 (55 MGA94) | SURFACE ELEVATION : | ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig | MOUNTING : 4WD UTE | CONTRACTOR : Horizon Drilling | DRILLER : JN

DATE STARTED : 6/10/15 | DATE COMPLETED : 6/10/15 | DATE LOGGED : 6/10/15 | LOGGED BY : DK | CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed	0.70m B 0.90m	0.0		ML	**TOPSOIL: SANDY SILT:** low plasticity, brown 0.15m	D	MD	0.00: DCP Test Results 0-0.1m 3 blows 0.10: 0.1-0.2m 10 blows
							ML	**SILT:** low plasticity, brown, dry, powdery 0.30m	D	D	0.20: 0.2-0.3m 8 blows
							CI	**SANDY CLAY:** medium plasticity, dark orange-brown and grey, sand is coarse grained, *inferred residual granite* 0.70m	M	VSt	0.30: 0.3-0.4m 6 blows 0.40: 0.4-0.5m 5 blows 0.50: 0.5-0.6m 5 blow 0.60: 0.6-0.7m 4 blows
					1.0		CH	**CLAY:** high plasticity, grey and orange mottled, with some sand 1.50m	M	VSt	0.70: 0.7-0.8m 4 blows 0.80: HP In-situ = 300 kPa; 0.8-0.9m 4 blows 0.90: 0.9-1m 5 blows 1.00: 1-1.1m 4 blows 1.10: 1.1-1.2m 3 blows 1.20: HP In-situ = 300 kPa; 1.2-1.3m 4 blows 1.30: 1.3-1.4m 3 blows 1.40: 1.4-1.5m 3 blows
					2.0			BOREHOLE BH E4 TERMINATED AT 1.50 m Target depth			
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH E5

PROJECT : Pakenham Geotechnical Investigation
LOCATION : Pakenham
CLIENT : Cardinia Shire Council
FEATURE :
FILE / JOB NO : 30041261
SHEET : 1 OF 1

POSITION : E: 369929.000, N: 5784993.000 (55 MGA94) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig MOUNTING : 4WD UTE CONTRACTOR : Horizon Drilling DRILLER : JN

DATE STARTED : 6/10/15 DATE COMPLETED : 6/10/15 DATE LOGGED : 6/10/15 LOGGED BY : DK CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed	0.50m B 0.90m	0.0		ML	**TOPSOIL: CLAYEY SILT:** low plasticity, brown 0.15m	M		0.00: DCP Test Results 0-0.1m 3 blows 0.10: 0.1-0.2m 3 blows
							CH	**CLAY:** medium to high plasticity, grey and brown, becoming darker with depth, *inferred alluvium*	M	F - St	0.20: 0.2-0.3m 3 blows 0.30: 0.3-0.4m 2 blows 0.40: 0.4-0.5m 1 blow 0.50: 0.5-0.6m 2 blows 0.60: HP In-situ = 80 kPa; 0.6-0.7m 2 blows 0.70: 0.7-0.8m 3 blows 0.80: 0.8-0.9m 3 blows
					1.0					St - VSt	0.90: 0.9-1m 5 blows 1.00: 1-1.1m 4 blows 1.10: 1.1-1.2m 7 blows 1.20: 1.2-1.3m 8 blows 1.30: 1.3-1.4m 10 blows 1.40: HP In-situ = 120 kPa; 1.4-1.5m 10 blows
								1.50m BOREHOLE BH E5 TERMINATED AT 1.50 m Target depth			
					2.0						
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH E6

PROJECT : Pakenham Geotechnical Investigation
LOCATION : Pakenham
CLIENT : Cardinia Shire Council
FEATURE :
FILE / JOB NO : 30041261
SHEET : 1 OF 1

POSITION : E: 370489.000, N: 5784911.000 (55 MGA94) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig MOUNTING : 4WD UTE CONTRACTOR : Horizon Drilling DRILLER : JN

DATE STARTED : 6/10/15 DATE COMPLETED : 6/10/15 DATE LOGGED : 6/10/15 LOGGED BY : DK CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed		0.0		ML	**TOPSOIL: CLAYEY SILT:** low plasticity, grey brown	D	St	0.00: DCP Test Results 0-0.1m 4 blows
											0.10: 0.1-0.2m 5 blows
					0.15m		ML	**CLAYEY SILT:** low plasticity, grey	D	St	0.20: 0.2-0.3m 5 blows
					0.30m			**CLAY:** high plasticity, mottled grey and orange, trace coal fragments, *inferred alluvium*			0.30: 0.3-0.4m 3 blows
											0.40: 0.4-0.5m 3 blows
											0.50: 0.5-0.6m 4 blows
											0.60: 0.6-0.7m 6 blows
										St	0.70: 0.7-0.8m 7 blows
											0.80: HP In-situ = 150 kPa; 0.8-0.9m 4 blows
				0.90m B			CH		M		0.90: 0.9-1m 5 blows
					1.0						1.00: 1-1.1m 6 blows
											1.10: HP In-situ = 250 kPa; 1.1-1.2m 6 blows
				1.30m						VSt - H	1.20: 1.2-1.3m 9 blows
											1.30: 1.3-1.4m 8 blows
											1.40: 1.4-1.5m 10 blows
					1.50m			BOREHOLE BH E6 TERMINATED AT 1.50 m Target depth			1.50: 1.5-1.6m 10 blows
					2.0						
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH S1

PROJECT : Pakenham Geotechnical Investigation
LOCATION : Pakenham
CLIENT : Cardinia Shire Council
FEATURE :
FILE / JOB NO : 30041261
SHEET : 1 OF 1

POSITION : E: 365989.000, N: 5781900.000 (55 MGA94) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig MOUNTING : 4WD UTE CONTRACTOR : Horizon Drilling DRILLER : JN

DATE STARTED : 8/10/15 DATE COMPLETED : 8/10/15 DATE LOGGED : 8/10/15 LOGGED BY : DK CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed		0.0		CL	**TOPSOIL: SILTY CLAY:** low plasticity, brown, with rootlets	M	St	0.00: DCP Test Results 0-0.1m 6 blows 0.10: 0.1-0.2m 5 blows
					0.20m						
							CH	**CLAY:** high plasticity, grey, with some medium to coarse grained sand, *inferred alluvium*	M	F - St	0.20: 0.2-0.3m 2 blows 0.30: 0.3-0.4m 2 blows 0.40: 0.4-0.5m 2 blows
				0.50m B	0.50m						
							CH	**CLAY:** high plasticity, mottled grey and orange and dark grey, trace wood fragments	M	St - VSt	0.50: 0.5-0.6m 3 blows 0.60: HP In-situ = 100 kPa; 0.6-0.7m 3 blows 0.70: 0.7-0.8m 4 blows 0.80: 0.8-0.9m 3 blows 0.90: 0.9-1m 3 blows 1.00: 1-1.1m 3 blows 1.10: 1.1-1.2m 2 blows 1.20: HP In-situ = 200 kPa; 1.2-1.3m 2 blows 1.30: 1.3-1.4m 3 blows 1.40: 1.4-1.5m 4 blows
				1.00m	1.0						
					1.50m			BOREHOLE BH S1 TERMINATED AT 1.50 m Target depth			1.50: 1.5-1.6m 7 blows
					2.0						
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH S2

PROJECT : Pakenham Geotechnical Investigation
LOCATION : Pakenham
CLIENT : Cardinia Shire Council
FEATURE :
FILE / JOB NO : 30041261
SHEET : 1 OF 1

POSITION : E: 366684.000, N: 5781790.000 (55 MGA94) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig MOUNTING : 4WD UTE CONTRACTOR : Horizon Drilling DRILLER : JN

DATE STARTED : 8/10/15 DATE COMPLETED : 8/10/15 DATE LOGGED : 8/10/15 LOGGED BY : DK CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed		0.0		ML ML	**TOPSOIL: CLAYEY SILT:** low plasticity, brown, rootmat to 0.1m depth	D	H	0.00: DCP Test Results 0-0.1m 5 blows
								CLAYEY SILT: low plasticity, brown, with some fine grained sand, dry	D	H	0.10: 0.1-0.2m 14 blows 0.20: 0.2-0.3m 16 blows 0.30: 0.3-0.4m 15 blows
				0.40m B				0.35m **CLAY:** high plasticity, orange, red and light brown, some fine to medium grained sand, *inferred residual granite*			0.40: 0.4-0.5m 15 blows 0.50: 0.5-0.6m 16 blows
				0.90m	1.0		CH		D - M	H	
					2.0			1.50m BOREHOLE BH S2 TERMINATED AT 1.50 m Target depth			
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

NON-CORE DRILL HOLE - GEOLOGICAL LOG

HOLE NO : BH S3

PROJECT : Pakenham Geotechnical Investigation
LOCATION : Pakenham
CLIENT : Cardinia Shire Council
FEATURE :
FILE / JOB NO : 30041261
SHEET : 1 OF 1

POSITION : E: 367387.000, N: 5781694.000 (55 MGA94) SURFACE ELEVATION : ANGLE FROM HORIZONTAL : 90°

RIG TYPE : Auger Rig MOUNTING : 4WD UTE CONTRACTOR : Horizon Drilling DRILLER : JN

DATE STARTED : 8/10/15 DATE COMPLETED : 8/10/15 DATE LOGGED : 8/10/15 LOGGED BY : DK CHECKED BY : AG

DRILLING						MATERIAL					
PROGRESS: DRILLING & CASING	PROGRESS: WATER	DRILLING PENETRATION	GROUND WATER LEVELS	SAMPLES & FIELD TESTS	ELEVATION (RL) / DEPTH (m)	GRAPHIC LOG	CLASSIFICATION SYMBOL	MATERIAL DESCRIPTION Soil Type, Plasticity or Particle Characteristic, Colour Secondary and Minor Components	MOISTURE CONDITION	CONSISTENCY RELATIVE DENSITY	STRUCTURE & Other Observations
AD/V	N/A	E	Not Observed		0.0		CL	**TOPSOIL: SILTY CLAY:** low plasticity, grey brown	M	St	0.00: DCP Test Results 0-0.1m 7 blows 0.10: 0.1-0.2m 5 blows
				0.60m B	0.20						
							CH	**SANDY CLAY:** high plasticity, grey and orange mottled, sand is medium to coarse grained reducing with depth, *inferred alluvium derived from granitic source*	M	F - St	0.20: 0.2-0.3m 3 blows 0.30: 0.3-0.4m 2 blows 0.40: 0.4-0.5m 2 blows 0.50: 0.5-0.6m 2 blows 0.60: 0.6-0.7m 4 blows
				1.10m	1.0					VSt - H	0.70: HP In-situ = 200 kPa; 0.7-0.8m 6 blows 0.80: 0.8-0.9m 6 blows 0.90: 0.9-1m 9 blows 1.00: 1-1.1m 12 blows 1.10: 1.1-1.2m 12 blows 1.20: 1.2-1.3m 14 blows 1.30: 1.3-1.4m 15 blows
					1.50			BOREHOLE BH S3 TERMINATED AT 1.50 m Target depth			1.50: HP In-situ = 210 kPa
					2.0						
					3.0						

See Explanatory Notes for details of abbreviations & basis of descriptions.

SMEC AUSTRALIA

GEOTECHNICAL LOG OF BOREHOLE AND EXCAVATION

(These notes explain the terms and abbreviations used on the log sheets)

GENERAL

Information obtained from drilling investigations is recorded on log sheets. The "*Geotechnical Log of Borehole*" presents data from drilling operations where a core barrel has not been used to recover material and information is based on a combination of regular sampling and in-situ testing. The "*Geotechnical Log of Excavation*" presents data obtained on the subsurface profile from observations of excavations, either natural or man made.

The heading of the log sheets contains information on client and project identification, hole or pit identification, location and elevation. Details of the drilling contractor, equipment, drilling or excavation dates, and of the personnel responsible for the preparation of log, are given at the bottom of the sheet. The main section of the log contains information on drilling or excavation methods and conditions, material substance description, details of in-situ tests and additional observations, presented as a series of columns plotted with reference to length in metres below the ground surface.

As far as is practicable the data contained on the log sheets is factual. Some interpretation is inevitable in the assessment of conditions between samples and of the origin of the materials. Material description and classification is generally based on AS1726-1993 Geotechnical Site Investigations.

DRILLING OR EXCAVATION METHOD

B	Rubber tyred backhoe
H	Hand Excavation
EE	Existing excavation
EX	Excavator
HA	Hand auger
AS	Auger screwing
AV	Auger drilling with V-bit
ATC	Auger drilling with TC bit
WR	Washbore drilling with roller bit
WD	Washbore drilling with drag or blade
RC	Reverse circulation

SUPPORT

The measures used to support the hole or excavation during logging and the extent of those measures are described in the support column

WATER

- ▼ Groundwater level with date.
- ▸ Drilling fluid loss at level marked.
- ◂ Groundwater inflow at the level marked.

CLASSIFICATION SYMBOL

Standard symbol in accordance with the Unified Soil Classification System.

MATERIAL DESCRIPTION

Term	Grain Size (mm)
Boulders	>200
Cobbles	60 - 200
Gravel	2 - 60
Sand	0.06 - 2
Silt	0.002 - 0.06
Clay	<0.002

DESCRIPTIVE TERMS FOR MATERIAL PROPORTIONS

Coarse Grained Soils		Fine Grained Soils	
% Fines	Term	% Coarse	Term
≤ 5	trace	≤ 15	trace
> 5 ≤ 12	with some	> 15 ≤ 30	with some
> 12	Prefix silty / clayey	> 30	Prefix sandy / gravelly

MOISTURE

D Dry
M Moist - no free water on remoulding
W Wet - free water on remoulding

DENSITY

(Non-cohesive soil only)

Symbol	Term	SPT N Value	Density Index
VL	very loose	0 - 4	< 15%
L	loose	4 - 10	15 - 35%
MD	medium dense	10 - 30	35 - 65%
D	dense	30 - 50	65 - 85%
VD	very dense	>50	> 85%

CONSISTENCY

(Cohesive soil only)

Symbol	Term	Cone Resistance	Undrained Shear Strength
VS	very soft	0-180 kPa	< 25 kPa
S	soft	180-375 kPa	25 – 50 kPa
F	firm	375-750 kPa	50 – 100 kPa
St	stiff	750-1500 kPa	100 – 200 kPa
VSt	very stiff	1500-3000 kPa	200 – 400 kPa

Symbol	Term	Cone Resistance	Undrained Shear Strength
H	hard	>3000 kPa	> 400 kPa
Fr	friable	n/a	

SAMPLE

Sections sampled bounded by lines across column

D Disturbed sample
B Bulk disturbed sample
S Standard penetration test sample
U50 Undisturbed sample (50 mm diameter)
U75 Undisturbed sample (75 mm diameter)

TEST TYPE

S Standard penetration test
V Vane shear
PP Pocket penetrometer
P Pressuremeter
W Permeability
MC Field moisture content
LL Liquid limit
PL Plastic limit
PI Plasticity index
LS Linear shrinkage
UC Unconfined compression

OTHER OBSERVATIONS

Information on the structure of the material and an assessment of the inferred origin of the material.

RESIDUAL SOIL: Soil essentially in-situ and derived from weathering and degradation of the underlying bedrock

ALLUVIUM: Soil transported by river or stream processes and deposited remote from the parent material.

COLLUVIUM: Soil transported down slope by a process of creep and/or landslide activity.

BEDROCK: In-situ rock (excludes transported boulders or boulders underlain by soil)

TALUS: Rock fragments deposited from rock fall landslides

FILL: Material placed by human activities

APPENDIX E:
LABORATORY TEST REPORTS

PARTICLE SIZE DISTRIBUTION

AS 1289.3.6.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

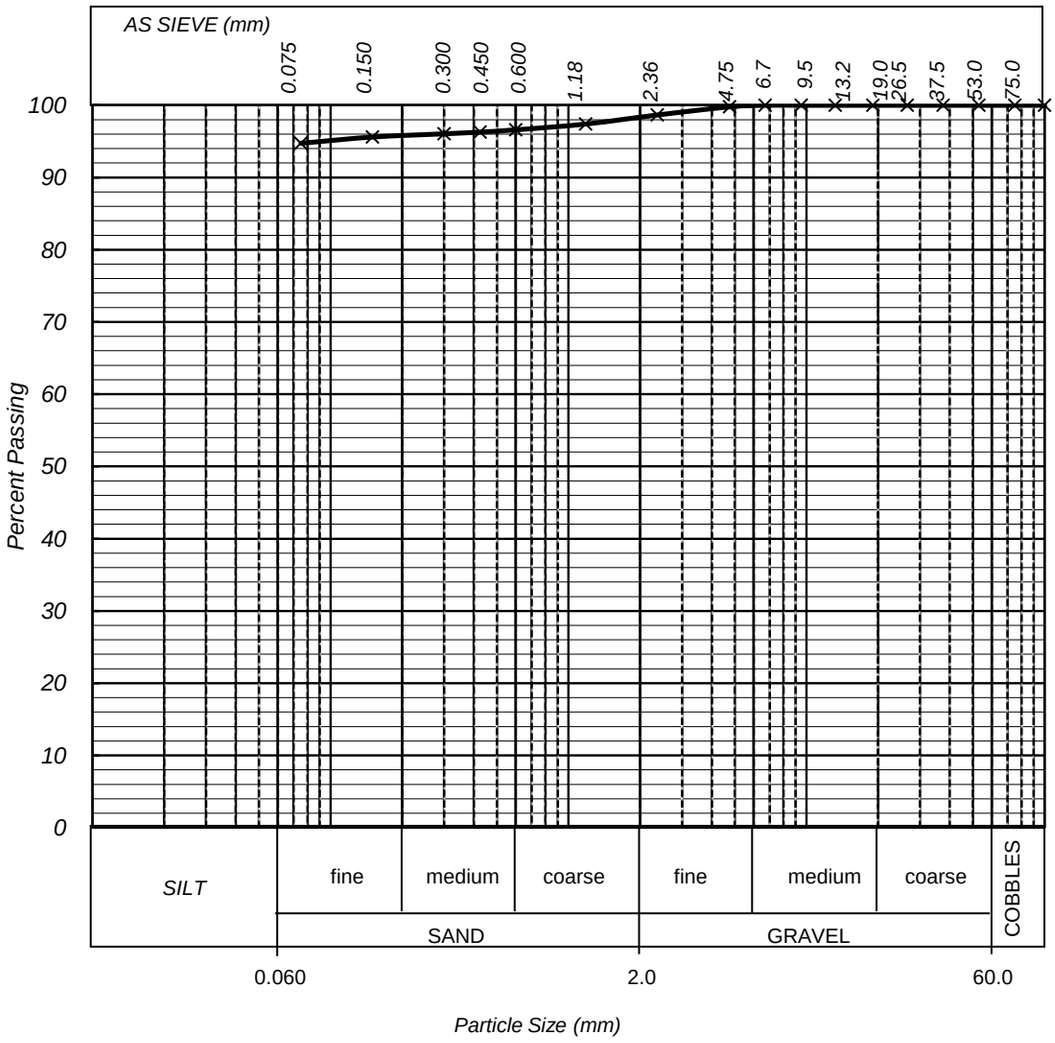
Job No	15048		
Report No	15048/R088		
Date of Issue	21/10/15		
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E1 0.3 - 0.9m	*Sample No*	15048096
Sampling method	By Client	*Sampled by*	Client
		Sampling date	2015

Sample Description

CLAY, high plasticity, brown and grey

Particle Size Distribution

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	100
2.36	99
1.18	97
0.600	97
0.425	96
0.300	96
0.150	96
0.075	95



Gravel		*Sand*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	1.8%	*Gravel*	1.7%
medium	0.1%	*medium*	0.8%	*Sand*	3.6%
fine	1.6%	*fine*	1.0%	*Fines*	94.7%
Total	1.7%	*Total*	3.6%	*Total*	100.0%

Approved Signatory : Peter Fry

PARTICLE SIZE DISTRIBUTION

AS 1289.3.6.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

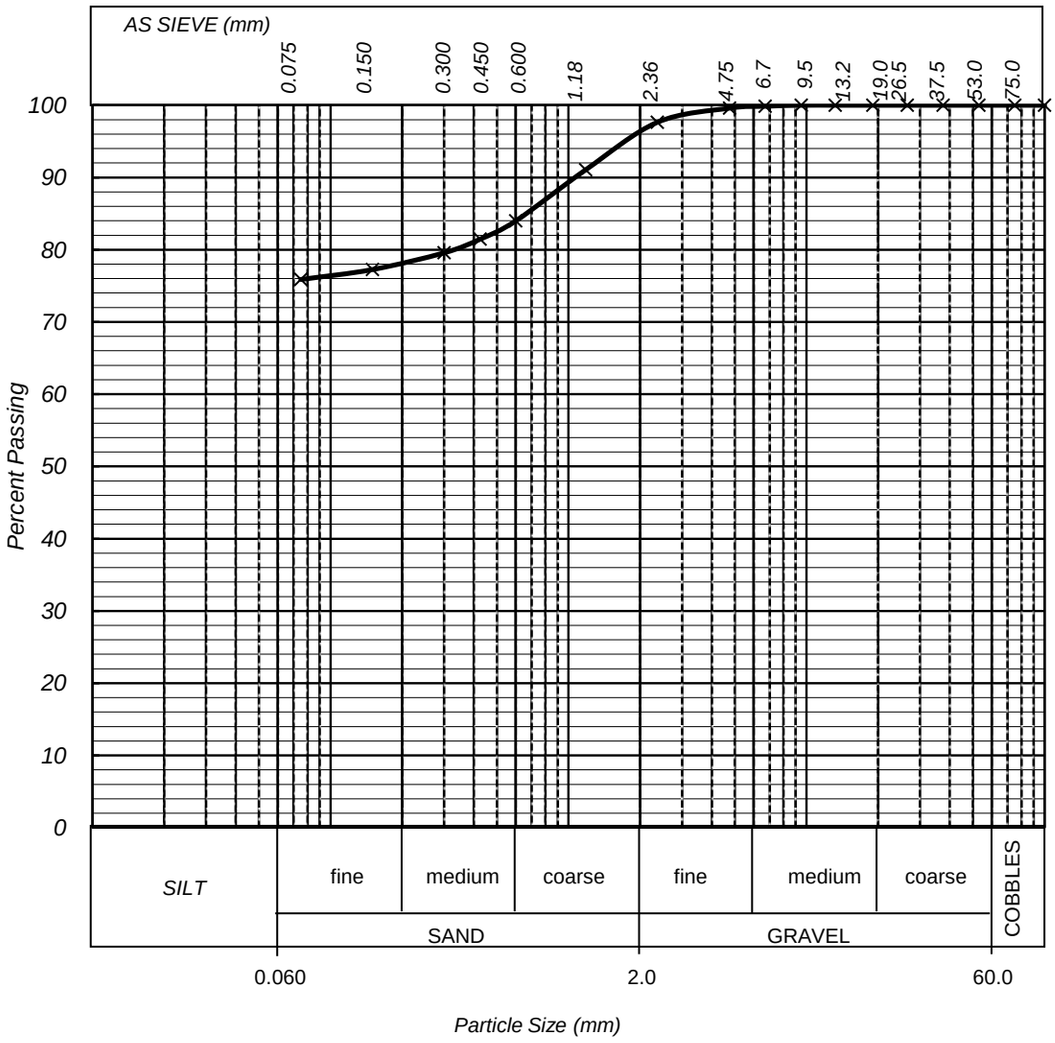
		Job No	15048
		Report No	15048/R089
		Date of Issue	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E4 0.7 - 0.9m	*Sample No*	15048099
Sampling method	By Client	*Sampled by*	Client
		Sampling date	2015

Sample Description

CLAY, high plasticity, brown, grey and orange-brown, with fine to coarse sand

Particle Size Distribution

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	100
2.36	98
1.18	91
0.600	84
0.425	81
0.300	80
0.150	77
0.075	76



Gravel		*Sand*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	12.1%	*Gravel*	3.9%
medium	0.2%	*medium*	5.8%	*Sand*	20.2%
fine	3.7%	*fine*	2.3%	*Fines*	75.9%
Total	3.9%	*Total*	20.2%	*Total*	100.0%

Approved Signatory : Peter Fry

PARTICLE SIZE DISTRIBUTION

AS 1289.3.6.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

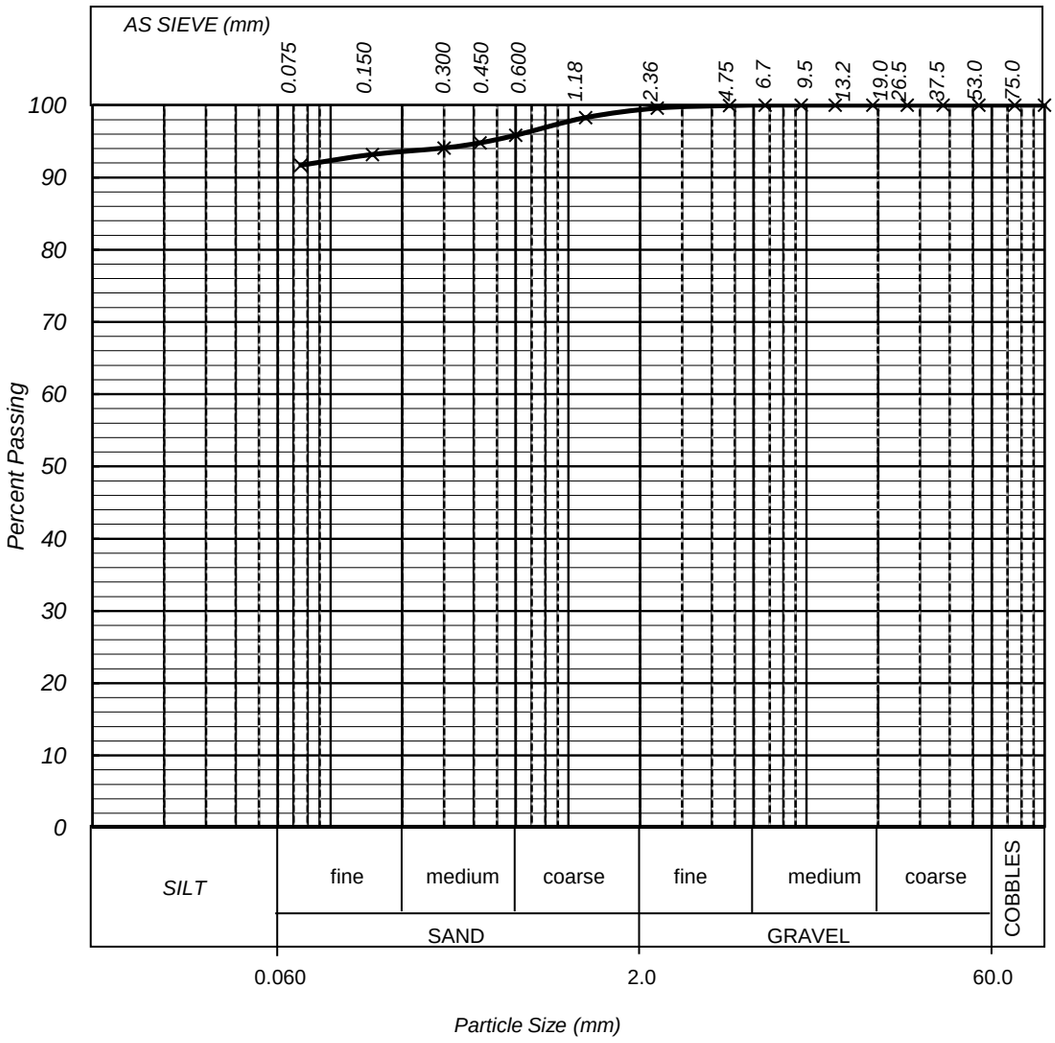
Job No	15048		
Report No	15048/R090		
Date of Issue	21/10/15		
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E5 0.5 - 0.9m	*Sample No*	15048100
Sampling method	By Client	*Sampled by*	Client
		Sampling date	2015

Sample Description

CLAY, medium plasticity, brown and grey, trace of fine to coarse sand

Particle Size Distribution

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	100
2.36	100
1.18	98
0.600	96
0.425	95
0.300	94
0.150	93
0.075	92



Gravel		*Sand*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	3.4%	*Gravel*	0.7%
medium	0.0%	*medium*	2.3%	*Sand*	7.6%
fine	0.7%	*fine*	1.9%	*Fines*	91.7%
Total	0.7%	*Total*	7.6%	*Total*	100.0%

Approved Signatory : Peter Fry

PARTICLE SIZE DISTRIBUTION

AS 1289.3.6.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

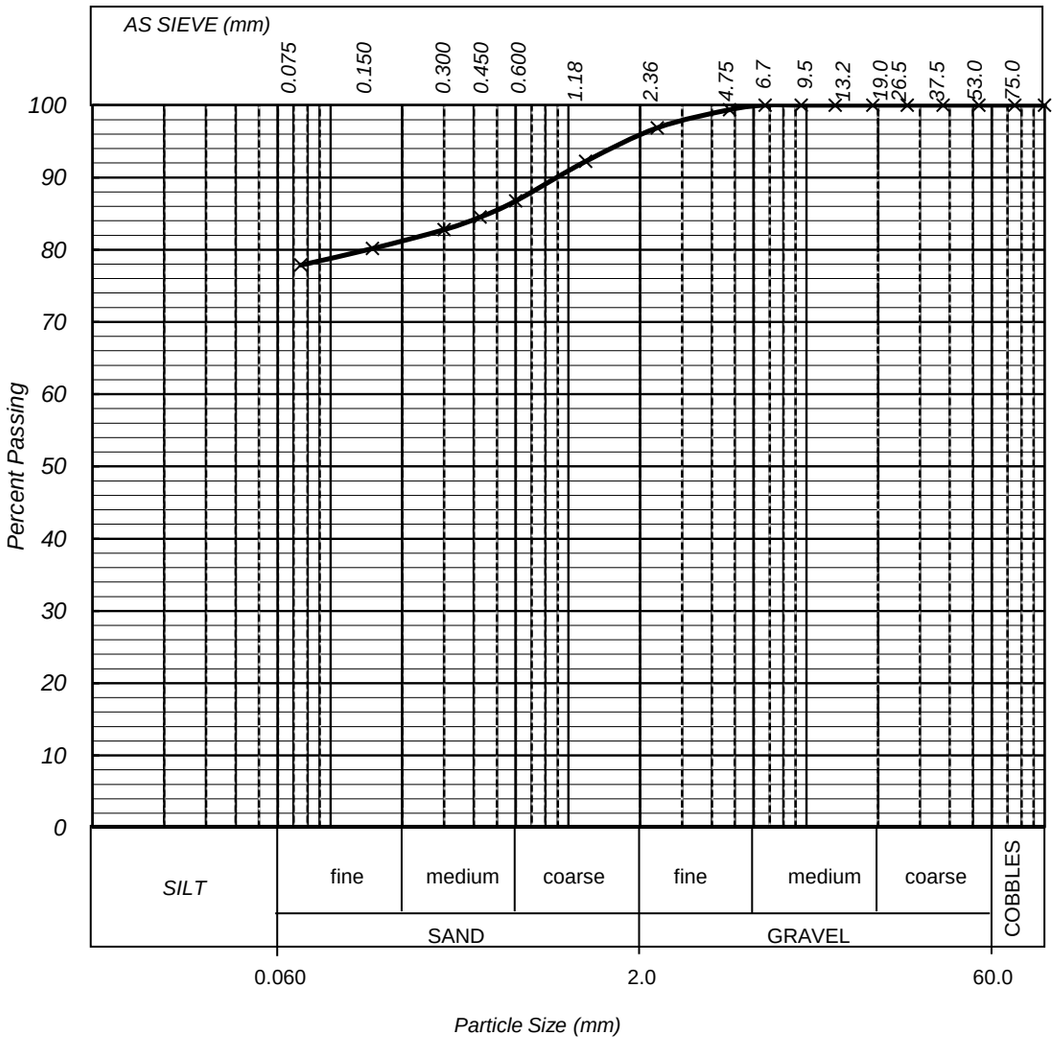
		Job No	15048
		Report No	15048/R091
		Date of Issue	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	01/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-S2 0.4 - 0.9m	*Sample No*	15048103
Sampling method	By Client	*Sampled by*	Client
		Sampling date	2015

Sample Description

silty CLAY, high plasticity, brown, red-brown and white, with fine to coarse sand

Particle Size Distribution

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	99
2.36	97
1.18	92
0.600	87
0.425	85
0.300	83
0.150	80
0.075	78



Gravel		*Sand*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	9.0%	*Gravel*	4.2%
medium	0.2%	*medium*	5.5%	*Sand*	17.9%
fine	4.0%	*fine*	3.4%	*Fines*	77.9%
Total	4.2%	*Total*	17.9%	*Total*	100.0%

Approved Signatory : Peter Fry

PARTICLE SIZE DISTRIBUTION

AS 1289.3.6.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

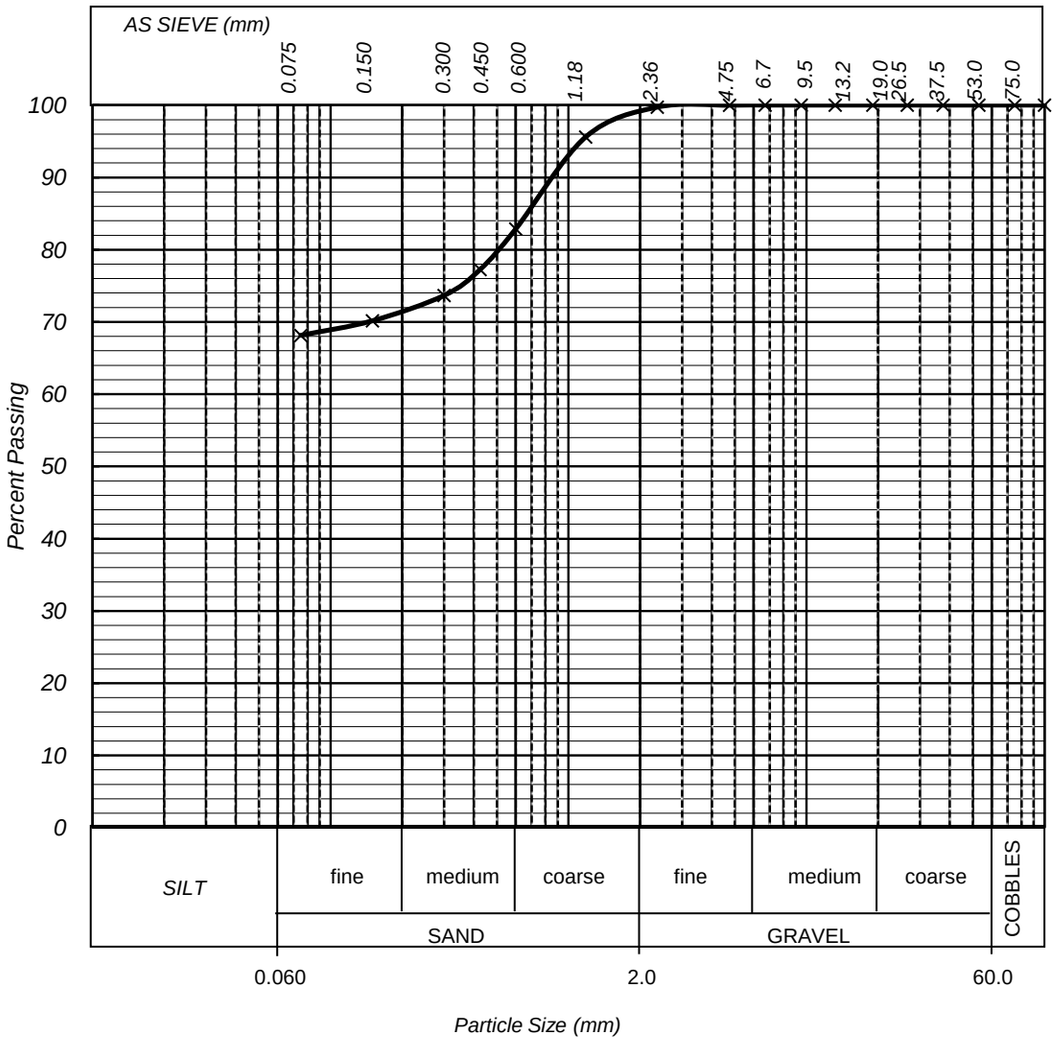
		Job No	15048
		Report No	15048/R092
		Date of Issue	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-S3 0.6 - 1.1m	*Sample No*	15048104
Sampling method	By Client	*Sampled by*	Client
		Sampling date	2015

Sample Description

sandy CLAY, high plasticity, brown and grey, fine to coarse sand

Particle Size Distribution

Particle Size (mm)	*Percent Passing*
100.0	100
75.0	100
53.0	100
37.5	100
26.5	100
19.0	100
13.2	100
9.5	100
6.7	100
4.75	100
2.36	100
1.18	96
0.600	83
0.425	77
0.300	74
0.150	70
0.075	68



Gravel		*Sand*		*Cobbles*	0.0%
coarse	0.0%	*coarse*	15.9%	*Gravel*	1.3%
medium	0.0%	*medium*	11.3%	*Sand*	30.6%
fine	1.3%	*fine*	3.4%	*Fines*	68.1%
Total	1.3%	*Total*	30.6%	*Total*	100.0%

Approved Signatory : Peter Fry

STANDARD COMPACTION

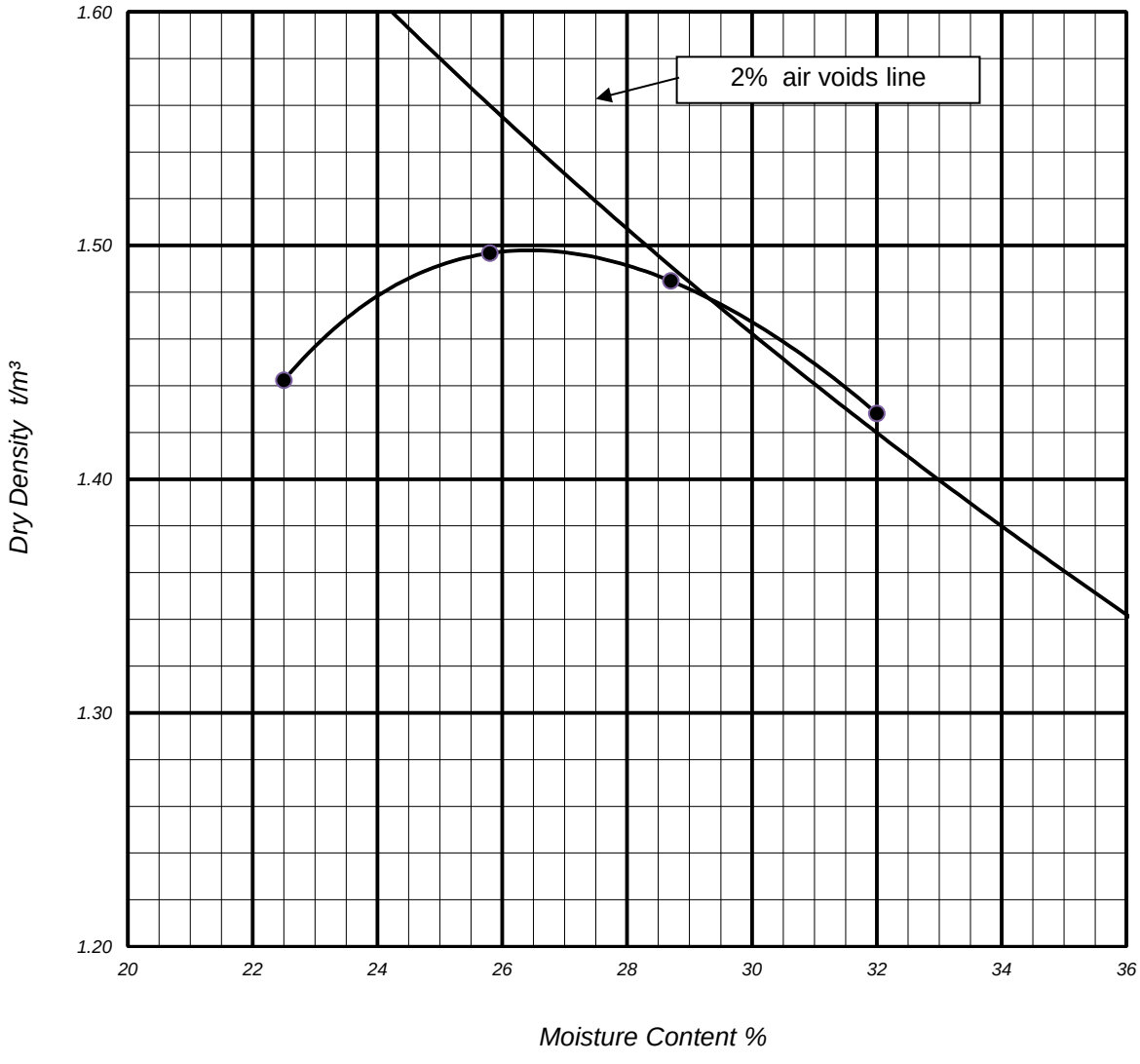
AS 1289.5.1.1

		Job No	15048
CIVIL GEOTECHNICAL SERVICES		*Report No*	15048/R093
6 - 8 Rose Avenue, Croydon 3136		*Date of Issue*	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E1 0.3 - 0.9m	*Sample No*	15048096
Sample Description		*Sampled by*	Client
CLAY, high plasticity, brown and grey		*Sampling date*	2015

Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.50 *t/m³*	*Optimum Moisture Content*	26.5 %

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.70 *t/m³*



Approved Signatory : Peter Fry

SOAKED C.B.R. TEST

AS 1289.6.1.1

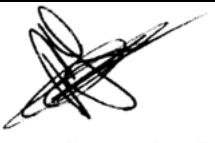
CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No	15048
Report No	15048/R094
Date of Issue	21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048096
Sample identification		BH-E1 0.3 - 0.9m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	33.1
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R093
Maximum Dry Density	t/m³	1.50
Optimum Moisture Content	%	26.5
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.47
Moisture content	%	25.9
Laboratory moisture ratio	%	98
Laboratory density ratio	%	98
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.43
Moisture content	%	29.7
Laboratory moisture ratio	%	112
Laboratory density ratio	%	95
Test details		
Moisture content top 30mm	%	32.4
Surcharge mass	kg	4.5
Swell	%	3.0
C.B.R. VALUE	**%**	**3**
Penetration	mm	2.5
Sample description		CLAY, high plasticity, brown and grey



Approved Signatory : Peter Fry

STANDARD COMPACTION

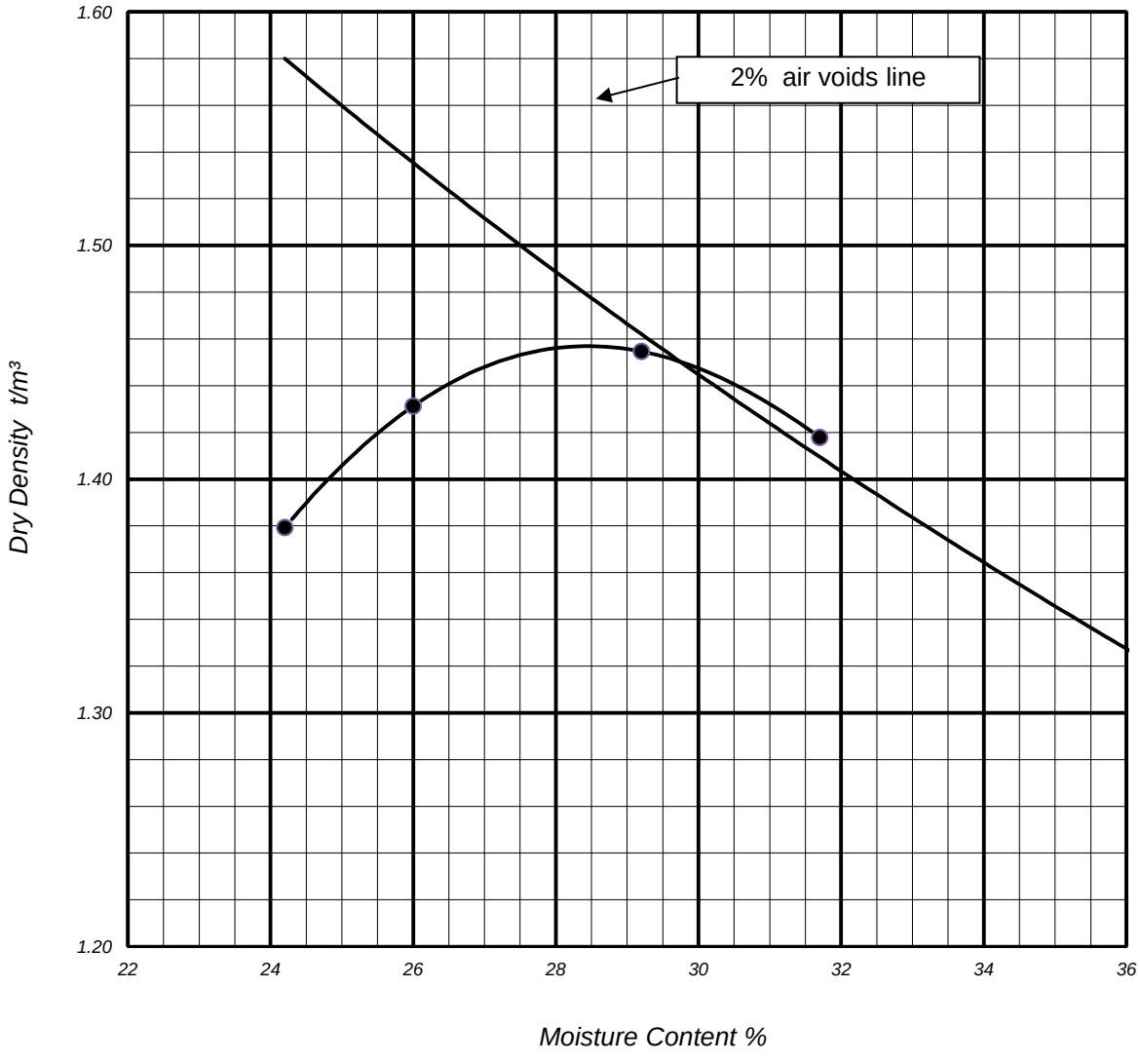
AS 1289.5.1.1

		Job No	15048
CIVIL GEOTECHNICAL SERVICES		*Report No*	15048/R095
6 - 8 Rose Avenue, Croydon 3136		*Date of Issue*	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E2 0.4 - 0.8m	*Sample No*	15048097
Sample Description		*Sampled by*	Client
CLAY, high plasticity, brown, orange-brown, red and grey		*Sampling date*	2015

Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.46 *t/m³*	*Optimum Moisture Content*	28.5 *%*

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.64 *t/m³*



AS512-R8-MAR 13

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Approved Signatory : Peter Fry

SOAKED C.B.R. TEST

AS 1289.6.1.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No 15048
Report No 15048/R096
Date of Issue 21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048097
Sample identification		BH-E2 0.4 - 0.8m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	30.1
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R095
Maximum Dry Density	t/m³	1.46
Optimum Moisture Content	%	28.5
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.42
Moisture content	%	29.3
Laboratory moisture ratio	%	103
Laboratory density ratio	%	97
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.38
Moisture content	%	33.4
Laboratory moisture ratio	%	117
Laboratory density ratio	%	95
Test details		
Moisture content top 30mm	%	35.7
Surcharge mass	kg	4.5
Swell	%	3.0
C.B.R. VALUE	**%**	**2**
Penetration	mm	2.5
Sample description		CLAY, high plasticity, brown, orange-brown, red and grey

Approved Signatory : Peter Fry

STANDARD COMPACTION

AS 1289.5.1.1

Job No	15048
Report No	15048/R097
Date of Issue	21/10/15

CIVIL GEOTECHNICAL SERVICES

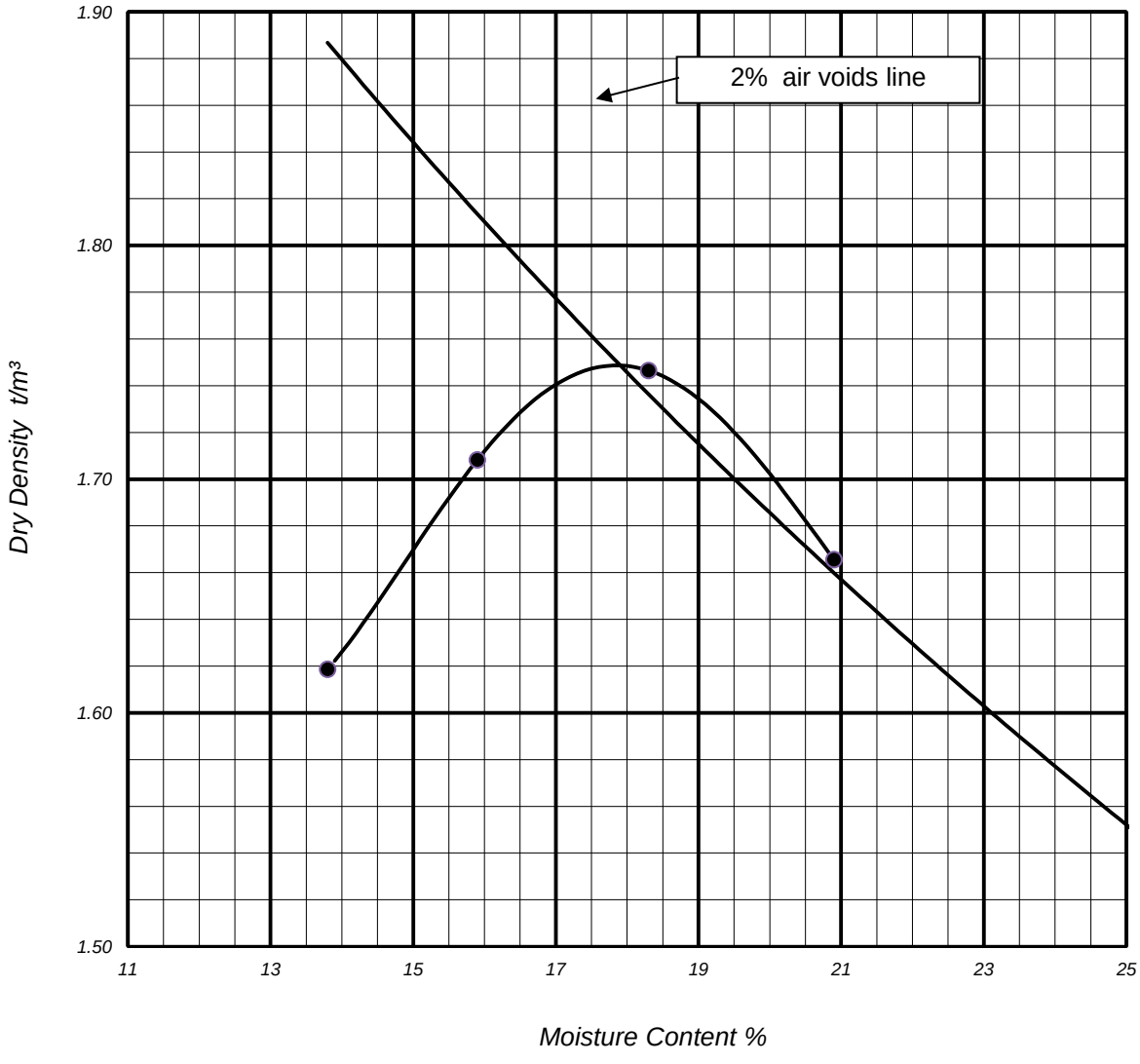
6 - 8 Rose Avenue, Croydon 3136

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E3 1.0 - 1.5m	*Sample No*	15048098
Sample Description		*Sampled by*	Client
CLAY, medium plasticity, grey and brown		*Sampling date*	2015

Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.75 *t/m³*	*Optimum Moisture Content*	18.0 %

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.62 *t/m³*



AS512-R8-MAR 13

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Accreditation No 9909

Approved Signatory : Peter Fry

SOAKED C.B.R. TEST

AS 1289.6.1.1

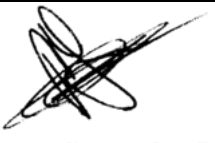
CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No	15048
Report No	15048/R098
Date of Issue	21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048098
Sample identification		BH-E3 1.0 - 1.5m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	18.9
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R097
Maximum Dry Density	t/m³	1.75
Optimum Moisture Content	%	18.0
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.71
Moisture content	%	17.9
Laboratory moisture ratio	%	100
Laboratory density ratio	%	98
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.66
Moisture content	%	20.7
Laboratory moisture ratio	%	116
Laboratory density ratio	%	95
Test details		
Moisture content top 30mm	%	24.2
Surcharge mass	kg	4.5
Swell	%	3.0
C.B.R. VALUE	**%**	**1**
Penetration	mm	2.5
Sample description		CLAY, medium plasticity, grey and brown



Approved Signatory : Peter Fry

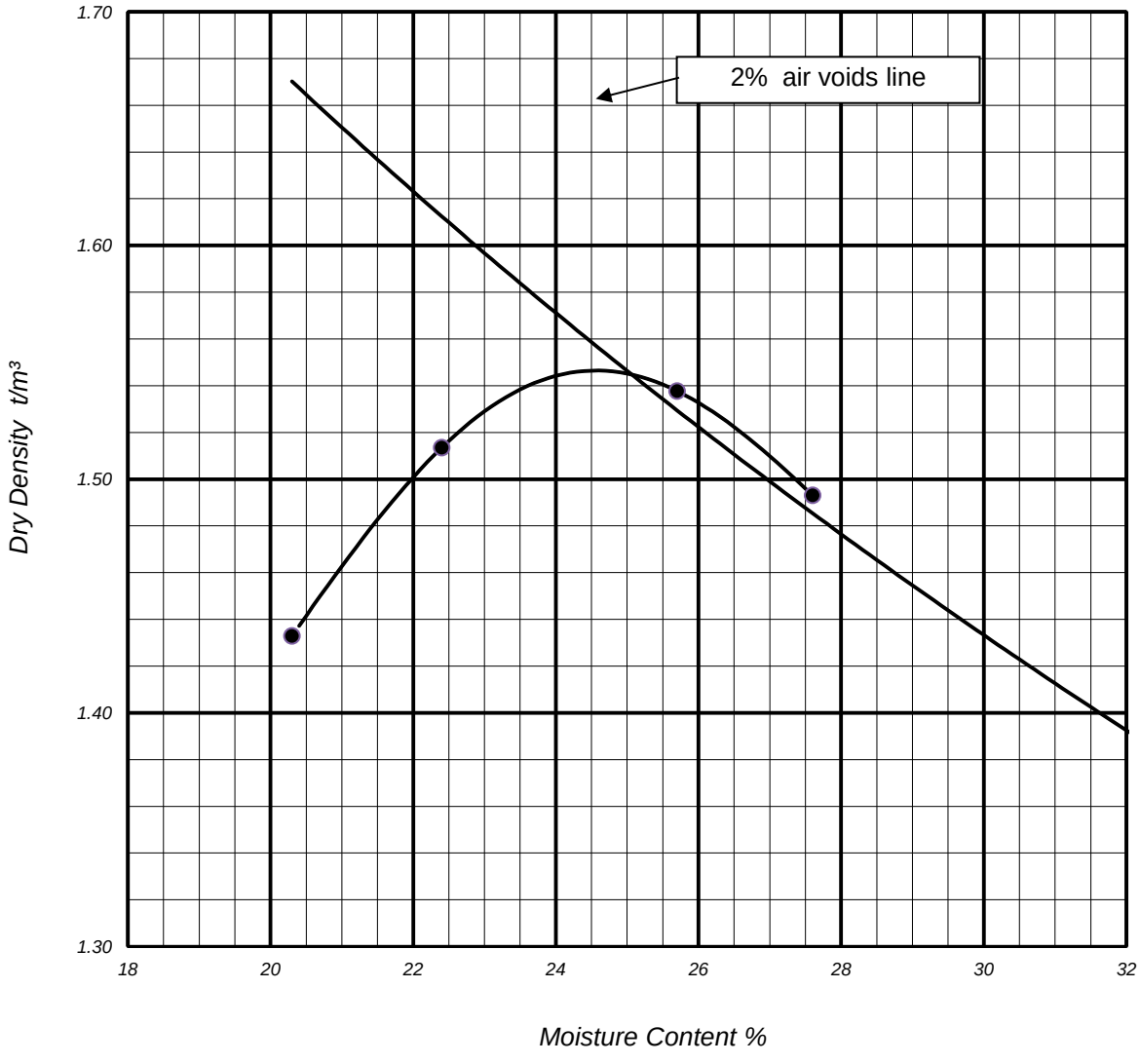
STANDARD COMPACTION

AS 1289.5.1.1

		Job No	15048
CIVIL GEOTECHNICAL SERVICES		*Report No*	15048/R099
6 - 8 Rose Avenue, Croydon 3136		*Date of Issue*	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E4 0.7 - 0.9m	*Sample No*	15048099
Sample Description		*Sampled by*	Client
CLAY, high plasticity, brown, grey and orange-brown, with fine to coarse sand		*Sampling date*	2015
Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.55 *t/m³*	*Optimum Moisture Content*	24.5 %

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.61 *t/m³*



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SOAKED C.B.R. TEST

AS 1289.6.1.1

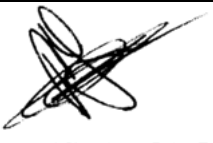
CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No 15048
Report No 15048/R100
Date of Issue 21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048099
Sample identification		BH-E4 0.7 - 0.9m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	26.2
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R099
Maximum Dry Density	t/m³	1.55
Optimum Moisture Content	%	24.5
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.51
Moisture content	%	25.4
Laboratory moisture ratio	%	103
Laboratory density ratio	%	97
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.49
Moisture content	%	27.7
Laboratory moisture ratio	%	113
Laboratory density ratio	%	96
Test details		
Moisture content top 30mm	%	29.1
Surcharge mass	kg	4.5
Swell	%	1.0
C.B.R. VALUE	**%**	**3.5**
Penetration	mm	2.5
Sample description		CLAY, high plasticity, brown, grey and orange-brown, with fine to coarse sand



Approved Signatory : Peter Fry

STANDARD COMPACTION

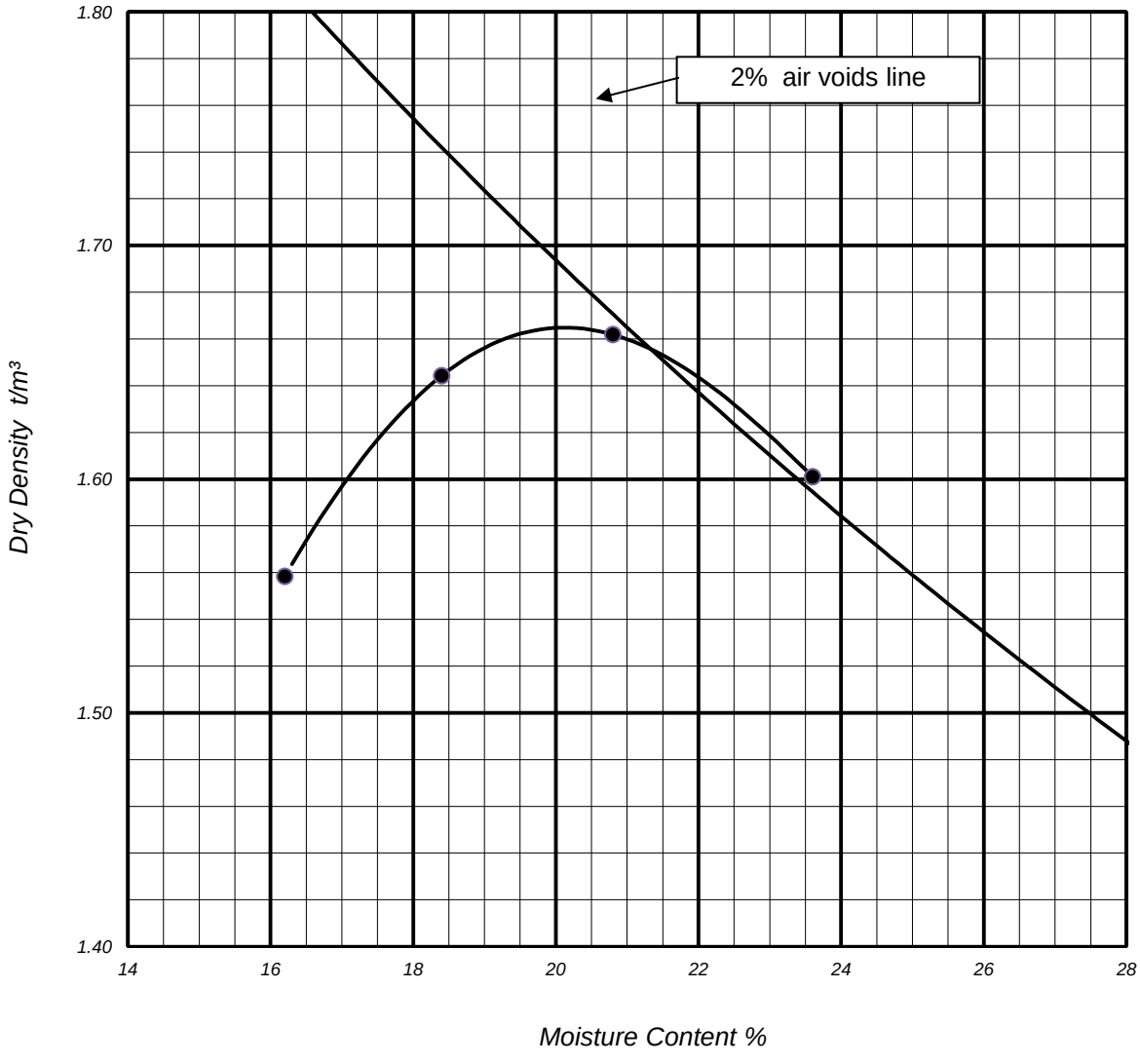
AS 1289.5.1.1

		Job No	15048
CIVIL GEOTECHNICAL SERVICES		*Report No*	15048/R101
6 - 8 Rose Avenue, Croydon 3136		*Date of Issue*	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E5 0.5 - 0.9m	*Sample No*	15048100
Sample Description		*Sampled by*	Client
CLAY, medium plasticity, brown and grey, trace of fine to coarse sand		*Sampling date*	2015

Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.66 *t/m³*	*Optimum Moisture Content*	20.0 %

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.64 *t/m³*



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AS 1289.6.1.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No 15048
Report No 15048/R102
Date of Issue 21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048100
Sample identification		BH-E5 0.5 - 0.9m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	23.9
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R101
Maximum Dry Density	t/m³	1.66
Optimum Moisture Content	%	20.0
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.63
Moisture content	%	20.1
Laboratory moisture ratio	%	100
Laboratory density ratio	%	98
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.61
Moisture content	%	22.9
Laboratory moisture ratio	%	114
Laboratory density ratio	%	97
Test details		
Moisture content top 30mm	%	24.1
Surcharge mass	kg	4.5
Swell	%	1.5
C.B.R. VALUE	**%**	**3**
Penetration	mm	2.5
Sample description		CLAY, medium plasticity, brown and grey, trace of fine to coarse sand

Approved Signatory : Peter Fry

STANDARD COMPACTION

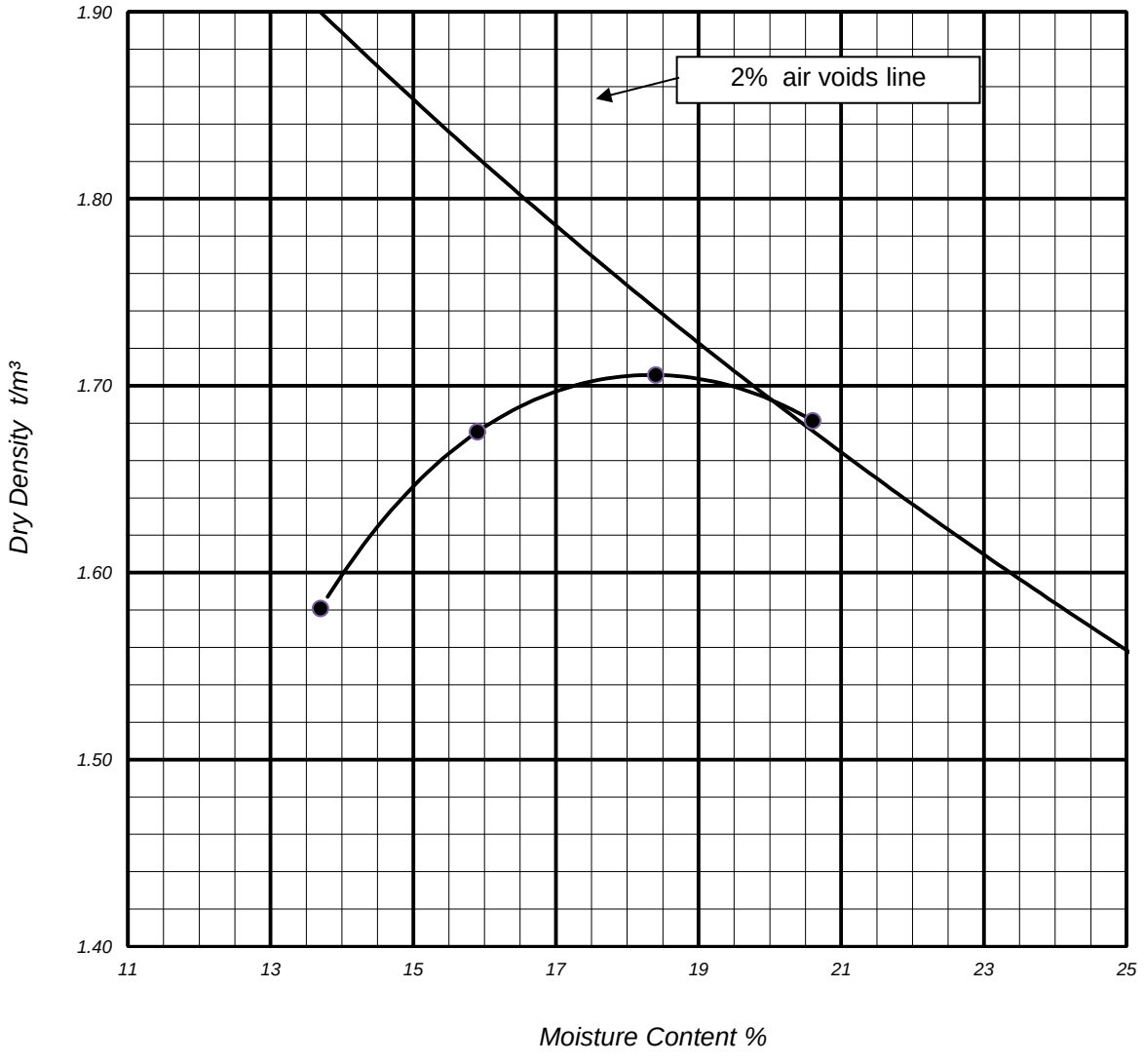
AS 1289.5.1.1

		Job No	15048
CIVIL GEOTECHNICAL SERVICES		*Report No*	15048/R103
6 - 8 Rose Avenue, Croydon 3136		*Date of Issue*	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-E6 0.9 - 1.3m	*Sample No*	15048101
Sample Description		*Sampled by*	Client
CLAY, medium plasticity, brown and grey		*Sampling date*	2015

Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.71 *t/m³*	*Optimum Moisture Content*	18.5 *%*

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.64 *t/m³*



AS512-R8-MAR 13

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The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/National standards. Accredited for compliance to ISO/IEC 17025. **Accreditation No 9909**

Approved Signatory : Peter Fry

SOAKED C.B.R. TEST

AS 1289.6.1.1

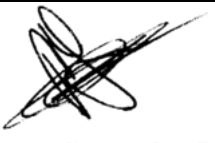
CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No 15048
Report No 15048/R104
Date of Issue 21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048101
Sample identification		BH-E6 0.9 - 1.3m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	21.7
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R103
Maximum Dry Density	t/m³	1.71
Optimum Moisture Content	%	18.5
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.67
Moisture content	%	18.6
Laboratory moisture ratio	%	102
Laboratory density ratio	%	98
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.66
Moisture content	%	21.2
Laboratory moisture ratio	%	116
Laboratory density ratio	%	97
Test details		
Moisture content top 30mm	%	21.0
Surcharge mass	kg	4.5
Swell	%	0.5
C.B.R. VALUE	**%**	**4.5**
Penetration	mm	2.5
Sample description		CLAY, medium plasticity, brown and grey



Approved Signatory : Peter Fry

STANDARD COMPACTION

AS 1289.5.1.1

CIVIL GEOTECHNICAL SERVICES

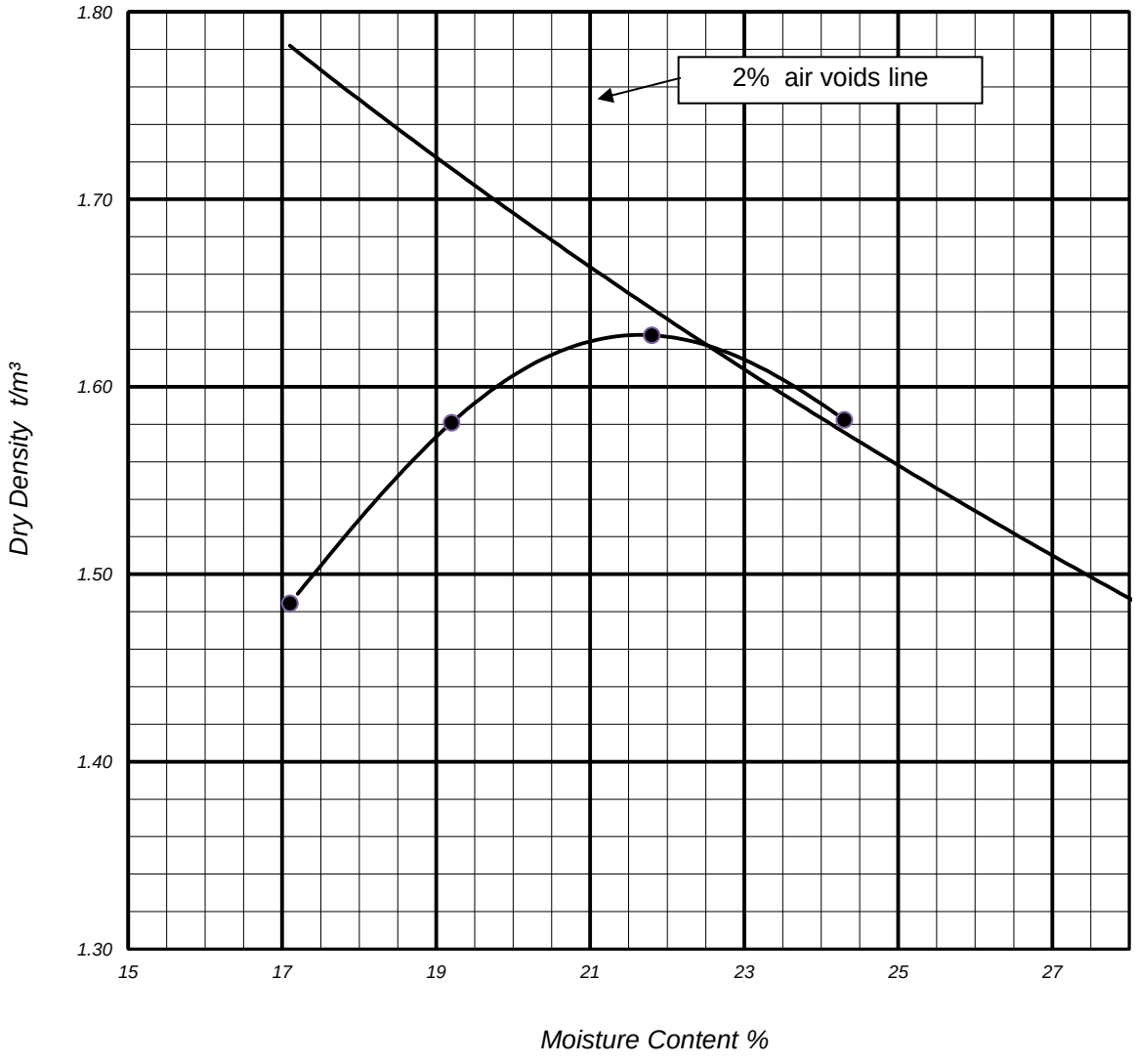
6 - 8 Rose Avenue, Croydon 3136

		Job No	15048
		Report No	15048/R105
		Date of Issue	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-S1 0.5 - 1.0m	*Sample No*	15048102
Sample Description		*Sampled by*	Client
CLAY, high plasticity, brown and grey		*Sampling date*	2015

Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.63 *t/m³*	*Optimum Moisture Content*	21.5 *%*

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.64 *t/m³*



AS512-R8-MAR 13

Approved Signatory : Peter Fry

SOAKED C.B.R. TEST

AS 1289.6.1.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

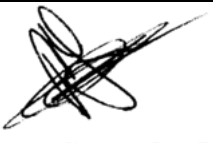
Job No 15048

Report No 15048/R106

Date of Issue 21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048102
Sample identification		BH-S1 0.5 - 1.0m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	25.5
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R105
Maximum Dry Density	t/m³	1.63
Optimum Moisture Content	%	21.5
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.59
Moisture content	%	21.5
Laboratory moisture ratio	%	99
Laboratory density ratio	%	98
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.56
Moisture content	%	24.6
Laboratory moisture ratio	%	114
Laboratory density ratio	%	96
Test details		
Moisture content top 30mm	%	27.0
Surcharge mass	kg	4.5
Swell	%	2.5
C.B.R. VALUE	**%**	**2**
Penetration	mm	2.5
Sample description		CLAY, high plasticity, brown and grey



Approved Signatory : Peter Fry

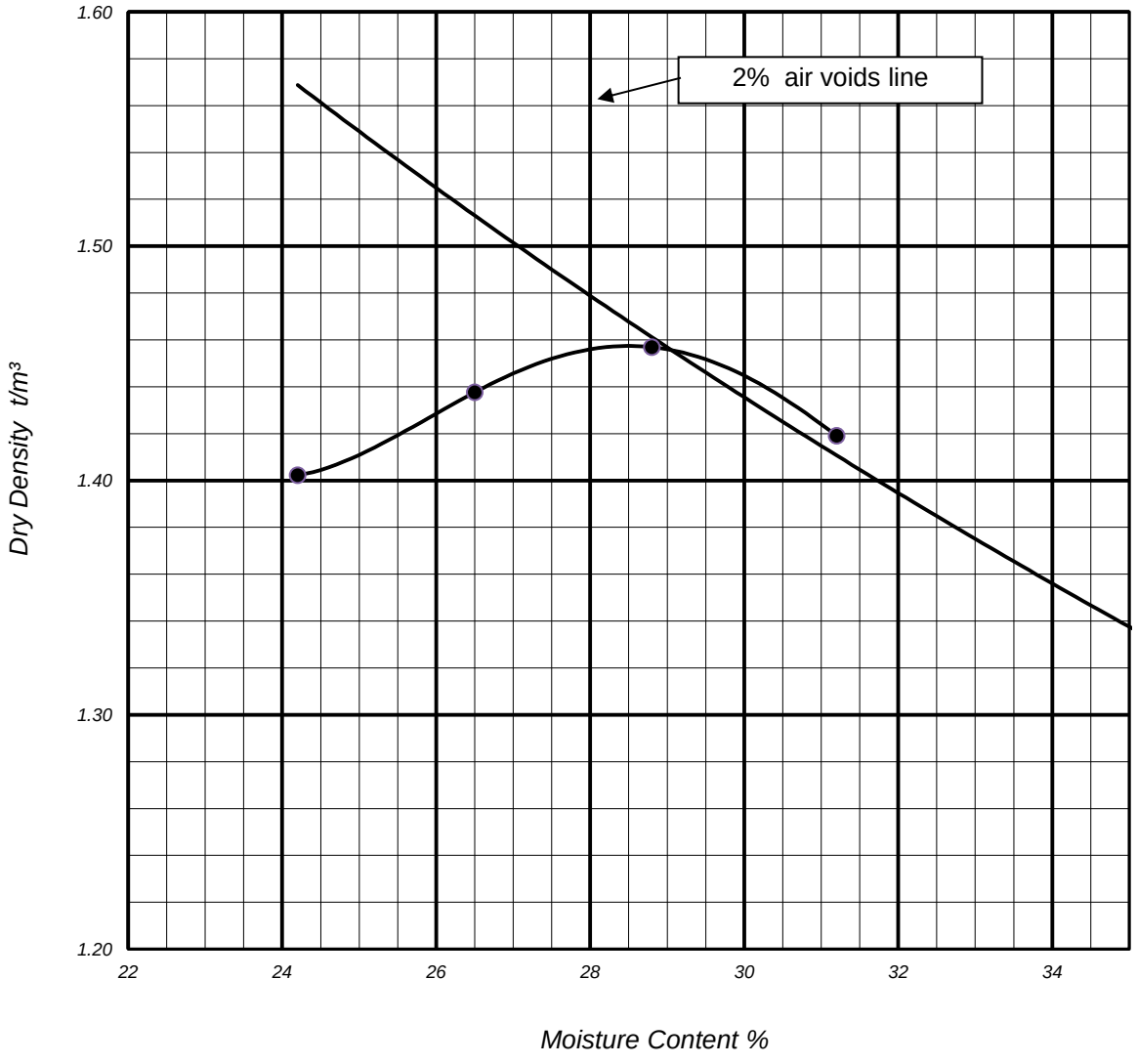
STANDARD COMPACTION

AS 1289.5.1.1

		Job No	15048
CIVIL GEOTECHNICAL SERVICES		*Report No*	15048/R107
6 - 8 Rose Avenue, Croydon 3136		*Date of Issue*	21/10/15
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-S2 0.4 - 0.9m	*Sample No*	15048103
Sample Description	silty CLAY, high plasticity, brown, red-brown and white, with fine to coarse sand	*Sampled by*	Client
		Sampling date	2015
Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.46 *t/m³*	*Optimum Moisture Content*	28.5 *%*

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.61 *t/m³*



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Approved Signatory : Peter Fry

SOAKED C.B.R. TEST

AS 1289.6.1.1

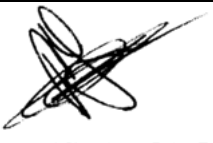
CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No 15048
Report No 15048/R108
Date of Issue 21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048103
Sample identification		BH-S2 0.4 - 0.9m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	26.7
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R107
Maximum Dry Density	t/m³	1.46
Optimum Moisture Content	%	28.5
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.42
Moisture content	%	28.6
Laboratory moisture ratio	%	101
Laboratory density ratio	%	98
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.37
Moisture content	%	33.7
Laboratory moisture ratio	%	118
Laboratory density ratio	%	94
Test details		
Moisture content top 30mm	%	36.7
Surcharge mass	kg	4.5
Swell	%	3.5
C.B.R. VALUE	**%**	**2.5**
Penetration	mm	2.5
Sample description		silty CLAY, high plasticity, brown, red-brown and white, with fine to coarse sand



Approved Signatory : Peter Fry

STANDARD COMPACTION

AS 1289.5.1.1

Job No	15048
Report No	15048/R109
Date of Issue	21/10/15

CIVIL GEOTECHNICAL SERVICES

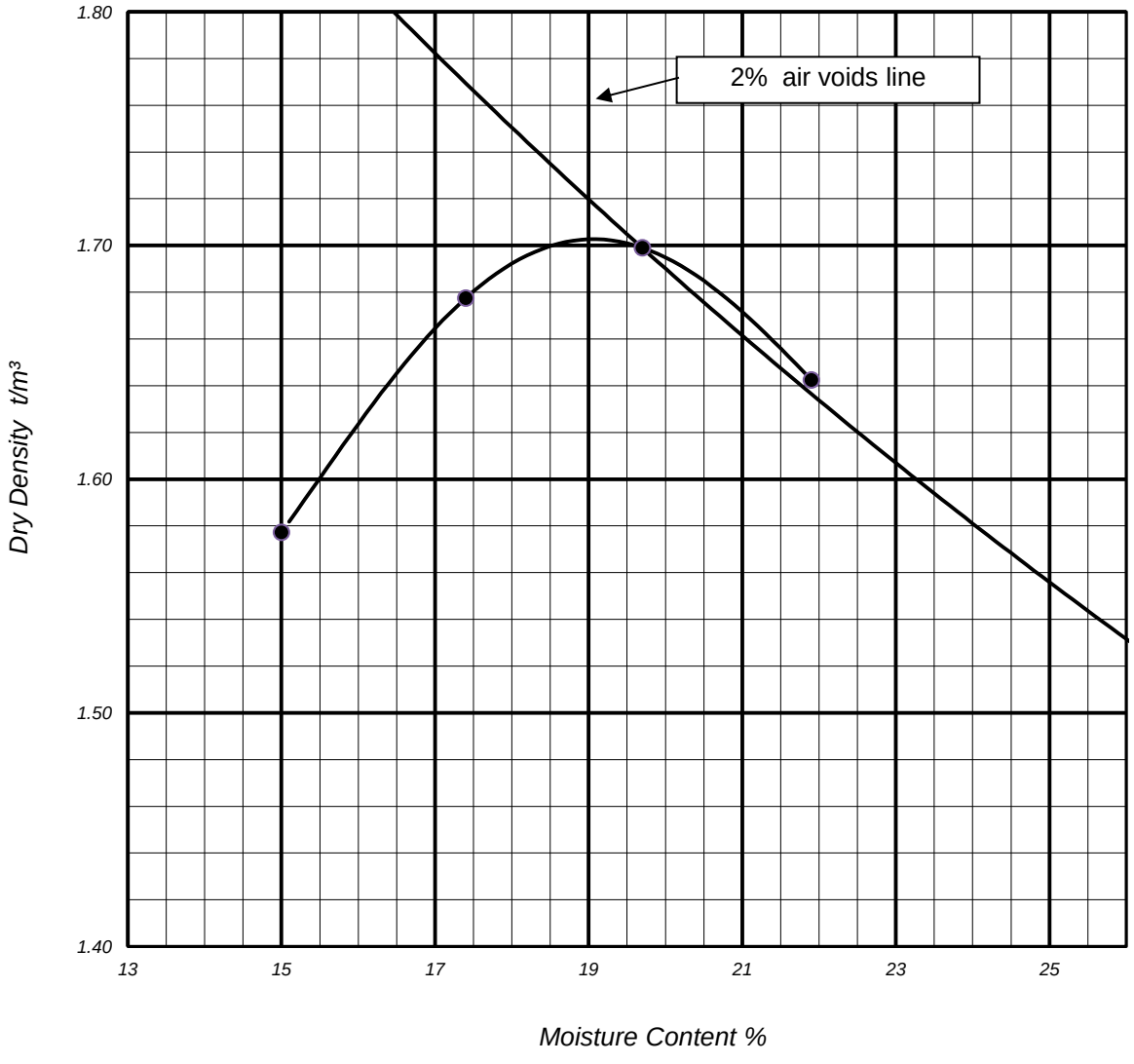
6 - 8 Rose Avenue, Croydon 3136

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	14/10/15
Location	VIA PAKENHAM	*Checked by*	PJF
Sample Identification	BH-S3 0.6 - 1.1m	*Sample No*	15048104
Sample Description		*Sampled by*	Client
sandy CLAY, high plasticity, brown and grey, fine to coarse sand		*Sampling date*	2015

Oversize material retained on 19.0mm sieve = 0 %		*Mould Type*	A
Maximum Dry Density	1.70 *t/m³*	*Optimum Moisture Content*	19.0 *%*

DRY DENSITY - MOISTURE CONTENT PLOT

Calculated apparent particle density = 2.63 *t/m³*



AS512-R8-MAR 13

Approved Signatory : Peter Fry

SOAKED C.B.R. TEST

AS 1289.6.1.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No 15048

Report No 15048/R110

Date of Issue 21/10/15

Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	BG
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	20/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample No		15048104
Sample identification		BH-S3 0.6 - 1.1m
Date sampled		2015
Sampled by		Client
Sampling method		By Client
Field moisture content		
Moisture content	%	22.2
Compaction details 1		
AS 1289.5.1.1 Standard Compaction - see Report No		15048/R109
Maximum Dry Density	t/m³	1.70
Optimum Moisture Content	%	19.0
Material retained on 19.0mm sieve and discarded	%	0
Compaction details 2		
Target laboratory density ratio	%	98
Target laboratory moisture ratio	%	100
No of layers		3
Specimen details before soaking		
Dry density	t/m³	1.67
Moisture content	%	19.0
Laboratory moisture ratio	%	100
Laboratory density ratio	%	98
Period of soaking	days	4
Specimen details after soaking		
Dry density	t/m³	1.64
Moisture content	%	21.3
Laboratory moisture ratio	%	112
Laboratory density ratio	%	96
Test details		
Moisture content top 30mm	%	23.0
Surcharge mass	kg	4.5
Swell	%	1.5
C.B.R. VALUE	**%**	**2**
Penetration	mm	2.5
Sample description		sandy CLAY, high plasticity, brown and grey, fine to coarse sand

Approved Signatory : Peter Fry

TEST RESULTS

AS 1289.2.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1

CIVIL GEOTECHNICAL SERVICES

6 - 8 Rose Avenue, Croydon 3136

Job No	15048		
Report No	15048/R111		
Date of Issue	21/10/15		
Client	SMEC AUSTRALIA LIMITED (MELBOURNE)	*Tested by*	SK
Project	30041261 PAKENHAM INVESTIGATION	*Date tested*	19/10/15
Location	VIA PAKENHAM	*Checked by*	PJF

Sample Identification	*Soil Description*	*Field Moisture Content* %	*Liquid Limit* %	*Plastic Limit* %	*Plasticity Index* %	*Linear Shrinkage* %	*% Passing 75µm sieve*
15048096 BH-E1 0.3 - 0.9m	CLAY, high plasticity, brown and grey	33.1	66	24	42	19.0	95
15048097 BH-E2 0.4 - 0.8m	CLAY, high plasticity, brown, orange-brown, red and grey	30.1	-	-	-	-	-
15048098 BH-E3 1.0 - 1.5m	CLAY, medium plasticity, grey and brown	18.9	-	-	-	-	-
15048099 BH-E4 0.7 - 0.9m	CLAY, high plasticity, brown, grey and orange-brown, with fine to coarse sand	26.2	77	27	50	19.0	76
15048100 BH-E5 0.5 - 0.9m	CLAY, medium plasticity, brown and grey, trace of fine to coarse sand	23.9	49	17	32	13.5	92
15048101 BH-E6 0.9 - 1.3m	CLAY, medium plasticity, brown and grey	21.7	-	-	-	-	-
15048102 BH-S1 0.5 - 1.0m	CLAY, high plasticity, brown and grey	25.5	-	-	-	-	-
15048103 BH-S2 0.4 - 0.9m	silty CLAY, high plasticity, brown, red-brown and white, with fine to coarse sand	26.7	79	35	44	16.0	78
15048104 BH-S3 0.6 - 1.1m	sandy CLAY, high plasticity, brown and grey, fine to coarse sand	22.2	59	19	40	16.5	68

Notes

AS 1289.3.1.2, 3.2.1 & 3.4.1

Method of drying: Oven dried
Dry/Wet sieve: Dry
Curing time: >24hrs

Approved Signatory : Peter Fry

APPENDIX F:
VICROADS RC500.20 SCALE A, B & C ASSESSMENT SUMMARY

The table below presents a summary of VicRoads requirements for assigning CBR and percent swell values, as described in VicRoads RC500.20 'Assignment of CBR and Percent Swell to Earthworks and Pavement Materials' June 2013

	Scale A Assessment	Scale B Assessment	Scale C Assessment
CBR	The assigned CBR is the lower of either; • The second lowest CBR value, or • The mean of the lowest three values	• The mean value of the two lowest values from 3 soaked CBR tests	• Based on default CBR values.
% Swell	The assigned swell is the higher of either; • The second highest value, or • The mean of the highest three values	• The mean value of the two highest values from 3 swell tests	• Based on estimated % swell values.
Comments/ Applicability	• Freeways, arterial, highways, national road network roads and all other roads with an average annual daily traffic (AADT) of more than 10000 vehicles per day or where there are more than 15000m2 of new pavement represented by the testing. • Requires soaked CBR and % swell testing on 6 separate representative samples	• All other roads where either AADT is less than 10000 vehicles per day, or where the area of new pavement is >5000m^2 but <15000m^2. Unclassified roads where the area of new pavement represented by the testing is more than 15000m^2 • Requires soaked CBR and % swell testing on 3 separate representative samples.	• Where the Scale A or Scale B assessment is not warranted.