Limited Geotechnical Investigation

At

Various Lots, Sections A to V DP 1596 off Saddlers Way, Wyee Point

For

RPS HSO

17 November 2009
BH Ref: 90343

barker harle
consulting engineers

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17 November 2009
BH Ref: 90343

RPS HSO
PO Box 428
HAMILTON NSW 2303

Attention: Mr Darren Holloway

Dear Sir,

Limited Geotechnical Investigation

Re: Proposed Rezoning Application: Various Lots, Sections A to V DP 1596 off Saddlers Way, Wyee Point

1. Introduction

Barker Harle have completed a Limited Geotechnical Investigation including a Preliminary Contaminated Site Investigation, Preliminary Acid Sulfate Soil Investigation and a General Geotechnical Assessment of the above site.

This Limited Geotechnical Investigation was undertaken on various lots within Sections A to V DP 1596 Saddlers Way, Wyee Point. For the extent of this report, all indicated lots will be known as "the site".

The objective of this investigation was to determine whether the site would be suitable from a geotechnical aspect for rezoning and subsequently development for residential purposes.

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2. Site Description and Proposed Development

The site is located on the northern side of Saddlers Way, Wyee Point. The site was bordered by Saddlers Way to the south, by Short, Bay, Lake, Railway and High Streets as well as residential dwellings to the east, by Lake Macquarie to the north and northwest and by undeveloped bushland to the west.

At the time of the investigation, the majority of the site was undeveloped and contained a moderate to thick understorey and a moderate to thick cover of intermediate to mature trees. The southwestern portion of the site currently contained 5 residential dwellings and associated buildings. Vegetation within the southwestern portion of the site contained numerous scattered mature trees with a moderate grass ground cover.

Topographically, the majority of the site sloped down in a general south to north direction towards Lake Macquarie at an average of approximately 2-4°. A broad drainage line that sloped down in a general south to north direction in the central to eastern portion of the site had modified localised slope direction towards the drainage line. Modified slopes varied between 2-5°. A portion of the site located adjacent to the northern and northwestern boundaries of the site sloped down in a general south to north direction at a slope less than 1°. It is understood that this area is located within the 1 in 100 year flood level.

No visible sign of site contamination was identified across the entire site.

It is understood that the site is to be rezoned from the current land zoning to a new zoning that would allow the construction of residential dwellings on the site. At the time of writing this report, the proposed land zoning was not known. The existing site layout can be seen in Barker Harle drawing 90343/1. Photographs 1 and 2 show the existing site.

3. Review of Available Data

3.1 Geological Setting

Reference to the 1:100 000 Newcastle Coalfield Regional Geology Map published by Department of Mineral Resources indicates that the site lies within the Munmorah Conglomerate Formation of the Clifton Subgroup of the Narrabeen Group. The Munmorah Conglomerate Formation overlies the Wallarah Seam.

The Munmorah Conglomerate Formation consists of conglomerate, sandstone and thin, lenticular coal bands. Some tuffaceous claystones are also associated with the lenticular coal

bands. The Munmorah Conglomerate has been regarded as the basal unit of the Narrabeen Group but no sharp break in sedimentation can be recognised in the Vales Point area between the underlying coal measures and this formation. The transitional members are the Wallarah Tuff Member, the Karignan Conglomerate Member and the Vales point Seam.

3.2 Soil Landscape

The site contains two different soil landscapes as identified on the "Soil landscapes of the Lake Macquarie-Gosford 1:100 000 Sheet" published by the Department of Land and Water Conservation. The higher elevated sloping portion of the site (majority of site) contains the Doyalson Landscape and the lower-lying, flat portion of the site (in the northern and western portions of the site adjacent to boundaries) contains the Wyong Landscape.

The Doyalson Landscape is an erosional landscape characterised by gently undulating rises on Munmorah Conglomerate north of Tuggerah Lake on the Central Coast Lowlands. Soils consist of moderately deep (50-150cm) Yellow Earths, Yellow Podzolic Soils and Soloths on sandstones and conglomerates, moderately deep (50-150cm) Yellow Podzolic Soils, Soloths and some Red Podzolic Soils on fine-grained siltstones and claystones, moderately deep to deep (100->150cm) Yellow leached Earths, Grey Earths, Soloths and Gleyed Podzolic Soils along drainage lines. The open-forest of the Doyalson Landscape has been extensively cleared although some small areas of disturbed bushland remain. The Doyalson Landscape consist generally of undulating rises with local reliefs to 30m and slope gradients <10%. Broad crests, ridges and long gently inclined slopes are major landform elements along with broad drainage lines.

The Wyong Landscape is an alluvial landscape characterised by broad poorly drained deltaic floodplains and alluvial flat of Quaternary sediments on the central Coast Lowlands. Soils consist of deep (>2m) Yellow Podzolic Soils, Brown Podzolic Soils and some Soloths with some Humus Podzols around lake edges. The original closed-forest of the Landscape has been extensively cleared and replaced with pasture. Levees, meander scrolls, oxbows and swamps are common within the Landscape with low lying, slightly elevated terraces occasionally present. Slope gradients are <3% on local reliefs <10m.

3.3 Desktop Acid Sulfate Soil Study

A desktop study was undertaken using the Department of Land and Water Conservation's "Acid Sulfate Soil Risk Map" for Catherine Hill Bay. The Department of Land and Water Conservation's "Acid Sulfate Soil Risk Map" for Catherine Hill Bay indicated that small

sections in the northern and western portions of the site are located within an Estuarine Sandplain which has a High Probability of having actual or potential acid sulfate soil within 1 metre of the existing surface.

Figure 1 below shows a portion of the Department of Land and Water Conservation's "Acid Sulfate Soil Risk Map" for Catherine Hill Bay and the approximate location of the site (shown hatched).

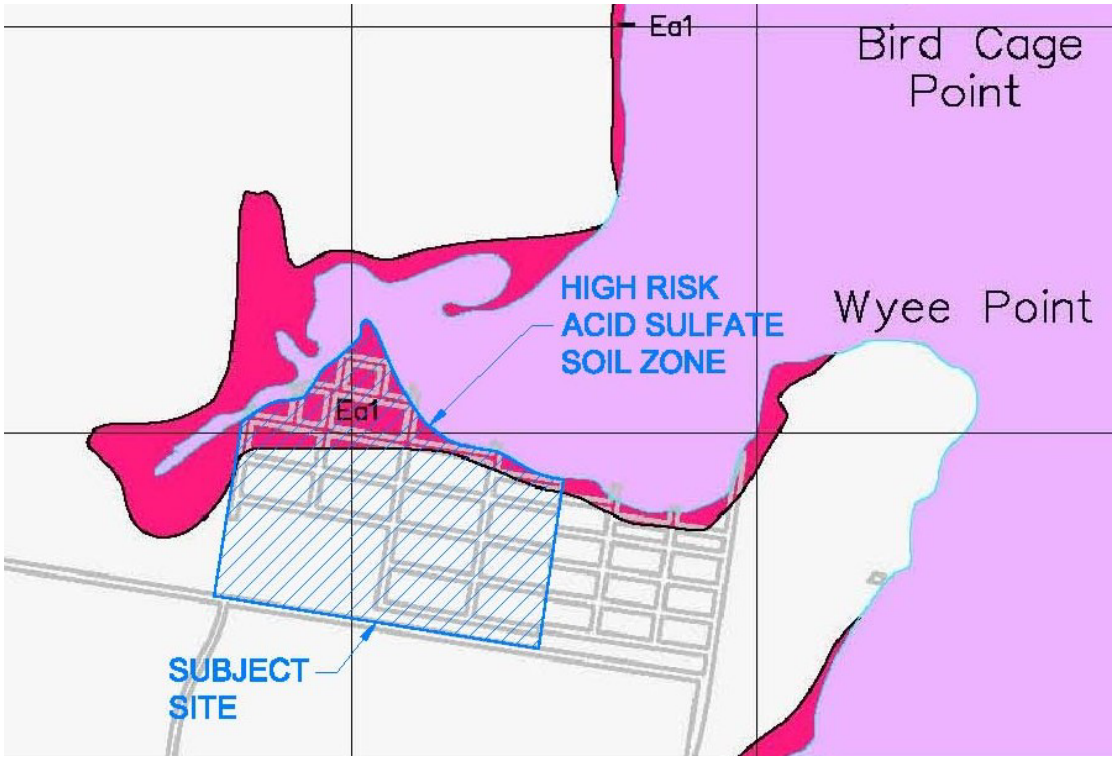


Figure 1 – Extract from Department of Land and Water Conservation's "Acid Sulfate Soil Risk Map" for Catherine Hill Bay and the approximate location of the site

It is believed that extent of acid sulfate soil shown in Figure 1 does not exactly correlate with the existing site topography and consequently the extent of acid sulfate soil in the northern and western portions of the site. It is believed that the extent of the estuarine sandplain and consequently the extent of acid sulfate soil on the site is less than shown in Figure 1.

3.4 Groundwater Bore Search

A groundwater bore search was undertaken using the Department of Environment and Climate Change's (DECC) "New South Wales Natural Resources Atlas". Information obtained during the search indicated that 22 known bores are located either on or within a

1km radius of the site. Of the 22 bores known to DECC, information was only available for 3 of the bores, namely bores GW078094, GW078060 and GW078214.

Information supplied on GW078094, GW078060 and GW078214 indicated that all bores encountered water bearing zones. Table 1 below shows the bore and depth of the encountered water bearing zones. Full bore information can be seen in the attachment section of this report.

Table 1 - Groundwater bore and bore details

Groundwater Bore	Authorised Use	Water Bearing Zone	
		Depth (m)	Thickness (m)
GW078094	Domestic and Stock	21.30 – 22.00 25.00 – 25.50	0.70 0.50
GW078060	Domestic	21.50 – 23.50	2.00
GW078214	Domestic and Stock	9.80 – 20.70 28.80 – 29.90	10.90 1.10

Figures 2 and 3 below show details of the search and the location of bores GW078094, GW078060 and GW078214 as well as other bores where no information was available.

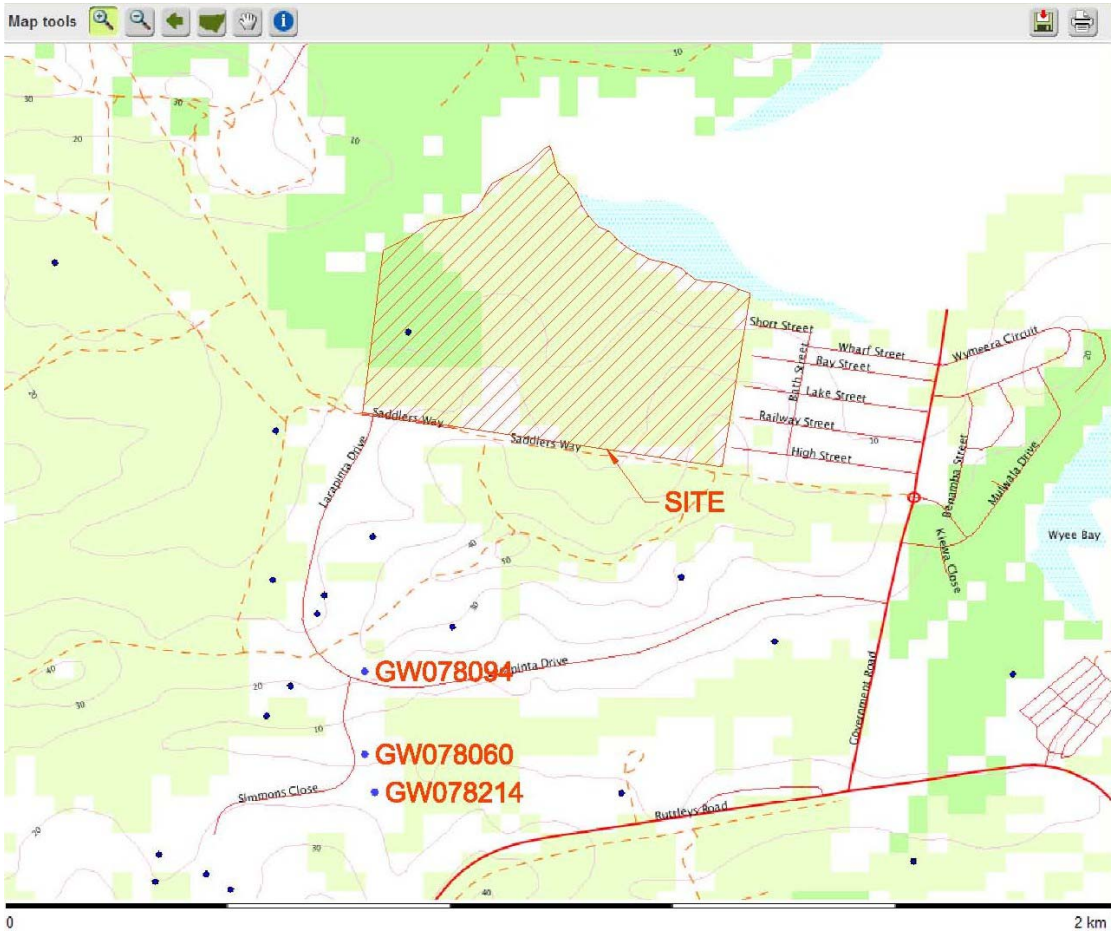


Figure 2 – Extract from Department of Environment and Climate Change's (DEC) "New South Wales Natural Resources Atlas", the approximate location of the site and the location of known bores.

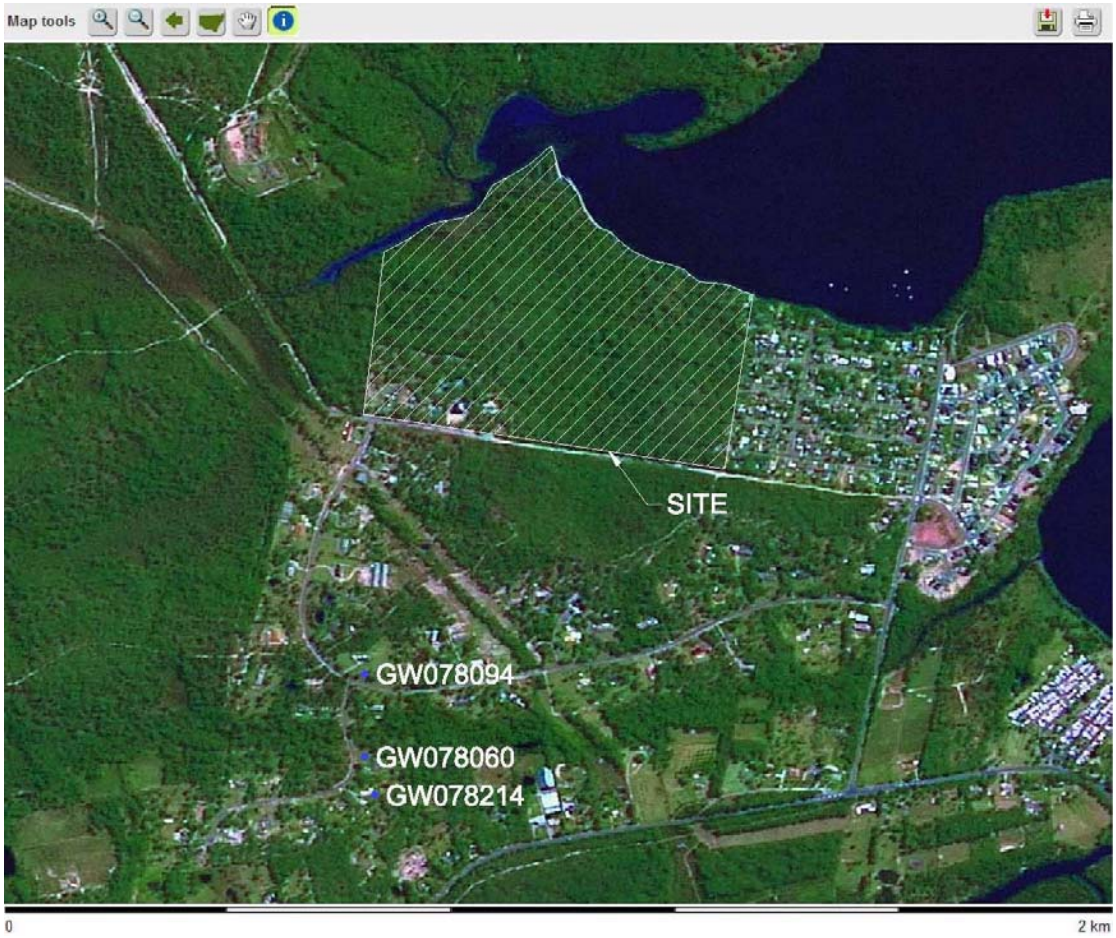


Figure 3 – Extract from Department of Environment and Climate Change's (DEC) "New South Wales Natural Resources Atlas", the approximate location of the site and the location of known bores.

3.5 Previous Geotechnical Investigations

It is understood that no previous geotechnical investigations have been undertaken on the site.

4. Fieldwork

The fieldwork undertaken on the 1 June 2009, consisted of a visual assessment of the site and surrounding area, the excavation of fifteen boreholes and the driving of eleven falling weight penetrometer probes in order to assess the typical subsurface conditions of the site.

Drawing 90343/Geo1 shows the location of the excavated boreholes and falling weight penetrometer probes.

4.1 Sampling Rationale

4.1.1 Preliminary Contaminated Site Investigation

Based on information obtained from the completion of the site history investigation, a random soil sampling procedure was used within the Preliminary Contaminated Site Investigation to determine contaminant concentrations across the site. The recovered soil samples were tested for hydrocarbons (C6 – C36 and BTEX), OC Pesticides, PCB and metals including Arsenic, Cadmium, Chromium, Copper, Lead, Mercury and Zinc.

The sampling procedures were undertaken in accordance with the New South Wales Environment Protection Agency's "Contaminated Sites – Sampling Design Guidelines".

4.1.2 Preliminary Acid Sulfate Soil Investigation

Based on information obtained from the Desktop Acid Sulfate Soil Investigation (Section 3.3), a random soil sampling procedure was used within the Preliminary Acid Sulfate Soil Investigation across the northern and western portions of the site to determine the likelihood of encountering acid sulfate soils within this area.

Based on the "Acid Sulfate Soil Risk Map" for Catherine Hill Bay, the Preliminary Acid Sulfate Soil Investigation was limited to Estuarine Sandplains located in the northern and western portions of the site.

The recovered samples were preserved in air tight containers and placed on ice as recommended by soil test method SPOCAS method 23, in accordance with the "Acid Sulfate Soil Manual 1998".

4.1.3 General Geotechnical Investigation

Random sampling procedures were used to recover samples used within the General Geotechnical Investigation. Samples were recovered from both the Doyalson and Wyong Soil Landscapes (as detailed in Section 3.2). Recovered samples were used to determine soil reactivity, CBR, compaction, Plastic Limit, Plasticity Index, Linear Shrinkage and Dispersivity (Emerson Aggregate Test).

The sampling procedures were undertaken in accordance with the Australian Standard AS 4482.1-1997.

4.2 Sampling Method

Table 2 below shows details and a description of the location of the soil sample recovery.

Table 2 - Details and a description of the location of the soil sample recovery

Location	Depth (mm)	Zone and Location in Zone	Investigation
BH1	100, 400, 100, 400	Excavated in the southeastern portion of the site	PCSI, React, Disp, CBR
BH2	100, 500, 100, 500	Excavated in the southeastern portion of the site	PCSI, React, Disp, CBR
BH3	100, 100	Excavated in the eastern portion of the site	PCSI, Disp
BH4	100, 100	Excavated in the eastern portion of the site	PCSI, Disp
BH5	100, 100	Excavated in the central to eastern portion of the site	PCSI, Disp
BH6	100, 500, 100, 500	Excavated in the northeastern portion of the site	PCSI, React, Disp, CBR
BH7	100, 100	Excavated in the northeastern portion of the site	PCSI, Disp
BH8	500, 1000	Excavated in the northeastern portion of the site adjacent to the northern boundary	PASSI
BH9	100, 100	Excavated in the northern portion of the site	PCSI, Disp
BH10	-	Excavated in the northeastern portion of the site adjacent to the northern boundary	-
BH11	500, 1000	Excavated in the northwestern portion of the site	PASSI
BH12	100, 600, 100	Excavated in the central to northern portion of the site	PCSI, React, Disp
BH13	100, 500, 100, 500	Excavated centrally in the site	PCSI, React, Disp, CBR
BH14	500, 1000	Excavated in the western portion of the site	PASSI
BH15	500, 1000	Excavated in the northern portion of the site adjacent to the northern boundary	PASSI

PCSI – Used in Preliminary Contaminated Site Investigation
React – Used in General Geotechnical Investigation in shrink/swell testing
Disp – Used in General Geotechnical Investigation in dispersivity testing (EAT)
CBR – Used in General Geotechnical Investigation in CBR and compaction testing
PASSI – Used in Preliminary Acid Sulfate Soil Investigation

Drawing 80310/Geo1 shows the location of the excavated testpits.

4.3 Field Observations

During fieldwork, a visual assessment of the site was undertaken. During the visual assessment, dominant soil landscapes, site slopes site features and potential sources of contamination were noted.

No visual signs of contamination were identified across the site.

4.4 Subsurface Conditions

Two separate dominant subsurface soil profiles were identified on the site. These typical dominant subsurface profiles consisted of soils in the Wyong and Doyalson Soil Landscapes. A different dominant subsurface profile was located in each of the two separate topographical zones of the site.

4.4.1 Typical Soil Profile 1

The following general soil profile was identified across the majority of the site:

0 – 200/350mm	Grey/Orange Sandy Clay with Some Medium Gravel
200/350 – 500/700mm	Orange Sand Gravelly Clay
500/700 – 800/1500mm	Orange/Red Weathered Sandstone
800/1500mm	Terminated in Orange/Red Weathered Sandstone

The above soil profile is consistent with the soils described in the Doyalson Soil Landscape described in Section 3.2 of this report.

Neither groundwater nor surfacewater were encountered within the Typical Soil Profile 1.

4.4.2 Typical Soil Profile 2

The following general soil profile was identified within the northern and western portions of the site adjacent to the sites boundary:

0 – 200/500mm	Black Silty Clay overlying
200/500 – 700/800mm	Brown/Grey Clayey Gravelly Sand
700/800 – 1000mm	Dark Grey Sandy Clay

The above soil profile is consistent with the soils described in the Wyong Soil Landscape described in Section 3.2 of this report.

Groundwater was encountered a depths varying between 600 and >1000mm below the existing surface level. Surfacewater was not encountered during the investigation.

5. Preliminary Contaminated Site Investigation

5.1 Introduction

A Preliminary Contaminated Site Investigation is a collection and examination of information derived from records of the site, site inspections, limited sampling and chemical testing.

The collection and examination of information, pertaining to the prior use of the site, is to determine whether the site had previously or currently has potentially contaminating land uses, identify the probable contaminants and the possible location of the contaminants.

The purpose of the investigation was to identify whether previous site activities have caused contamination.

This Preliminary Contaminated Site Investigation was conducted in accordance with:

- Australian Standard AS 4482.1-1997 " Guide to the sampling of potentially contaminated soil – Part 1: Non-volatile and semi-volatile compounds"
- New South Wales Environment Protection Agency's "Contaminated Sites – Sampling Design Guidelines"
- Department of Urban Affairs and Planning/ New South Wales Environment Protection Agency "State Environmental Planning Policy 55 - Managing Land Contamination"
- New South Wales Environment Protection Agency's "Contaminated Sites, Guidelines for Consultants Reporting on Contaminated Sites"
- National Environment Protection Councils "Assessment of Site Contamination"
- Department of Urban Affairs and Planning/ New South Wales Environment Protection Agency "State Environmental Planning Policy 55 - Managing Land Contamination"
- Lake Macquarie City Councils "Development Control Plan 2004".

5.2 Lake Macquarie City Council Records Search

A review of development applications that had been lodged with Lake Macquarie City Council indicated that numerous development applications had been submitted on lots located within the southwestern portion of the site with no development applications lodged for the remainder of the site. The development applications made on lots in the southwestern portion of the site related to the construction of residential dwellings and associated buildings.

5.3 New South Wales Department of Environment and Conservation Search

A review of the New South Wales Department of Environment and Climate Change's public register indicated that no statuary notices had been issued for the site under the Contaminated Land and Management Act.

5.4 Potential Contaminants

Based on the site history and a visual assessment of the site, no specific contaminants were targeted across the entire site.

5.5 Laboratory Testing

A summary of the laboratory test results are set out in Tables 3 and 4 below. Detailed laboratory test results can be seen in the attachment section of this report.

Table 3 - Laboratory Test Results for boreholes BH1 – BH5

Laboratory Test	Limit of Results	BH1 100mm	BH2 100mm	BH3 100mm	BH4 100mm	BH5 100mm
Benzene	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ethylebenzene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
C6 – C9	10	<10	<10	<10	<10	<10
C10 – C14	50	<50	<50	<50	<50	<50
C15 – C28	100	<100	<100	<100	<100	120
C29 – C36	100	<100	<100	<100	<100	250
OC Pesticides	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
PCB	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Mercury	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Arsenic	1	1	<1	1	<1	1
Cadmium	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	1	6	6	2	4	2
Copper	2	2	<2	<2	<2	<2
Nickel	1	2	<1	<1	<1	<1
Lead	2	5	3	4	4	5
Zinc	5	15	<5	<5	<5	<5

Table 4 - Laboratory Test Results for boreholes BH6, BH7, BH9, BH12, BH13

Laboratory Test	Limit of Results	BH6 100mm	BH7 100mm	BH9 100mm	BH12 100mm	BH13 100mm
Benzene	0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ethylebenzene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
C6 – C9	10	<10	<10	<10	<10	<10
C10 – C14	50	<50	120	<50	<50	<50
C15 – C28	100	<100	<100	<100	<100	<100
C29 – C36	100	<100	130	130	<100	<100
OC Pesticides	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
PCB	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Mercury	0.05	0.05	0.05	<0.05	<0.05	<0.05
Arsenic	1	3	1	<1	<1	<1
Cadmium	0.1	0.3	<0.1	0.2	<0.1	0.1
Chromium	1	8	8	2	4	3
Copper	2	<2	2	<2	2	<2
Nickel	1	<1	<1	<1	2	<1
Lead	2	5	8	4	5	3
Zinc	5	<5	<5	<5	10	<5

5.6 Guideline Levels

Table 5 below shows the residential threshold limits as defined by the:

- NSW EPA Guideline's "Guidelines for Assessing Service Station Sites";
- National Environment Protection Council's "Schedule B(1) – Guideline on the Investigation Levels for Soil san Groundwater";
- NSW DECC "Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (2nd edition)".

Threshold limit is the contaminate concentration that determines whether further action is required. Should contaminate levels exceed threshold levels, either further investigation to determine the extent of contaminate levels that exceed threshold levels should be undertaken or remedial action is required.

Table 5 – Threshold Levels for Residential Land

Contaminant	Guideline 1	Guideline 2	Guideline 3
TPH (C6-C9)	65	-	-
TPH (C10-C36)	1000	-	-
Benzene	1[a]	-	-
Toluene	1.4[b]/130[e]	-	-
Ethylbenzene	3.1[c]/50[f]	-	-
Total Xylene	14[d]/25[f]	-	-
OCP – Aldrin + Dieldrin	-	10	10
– Chlordane	-	50	50
– DDT + DDD + DDE	-	200	200
– Heptachlor	-	10	10
Total PCB	-	10	10
Arsenic	-	100	100
Cadmium	-	20	20
Chromium	-	100	100
Copper	-	1000	1000
Nickel	-	600	600
Lead	300	300	300
Zinc	-	7000	7000
Mercury	-	15	15

Guideline 1 – "Guidelines for Assessing Service Station Sites"
Guideline 2 – "Schedule B(1) – Guideline on the Investigation Levels for Soil san Groundwater"
Guideline 3 – "Contaminated Sites: Guidelines for the NSW Site Auditor Scheme (2nd edition)"

[a] – A lower benzene threshold concentration may be needed to protect groundwater.
[b] – The toluene threshold concentration is the Netherlands MPC to protect terrestrial organisms in soil. This value was obtained by applying a US EPA assessment factor to terrestrial chronic No Observed Effect Concentration (NOEC) data. The MPC is an 'indicative' value (Van de Plassche et al. 1993; Van de Plassche & Bockting 1993).
[c] – The ethyl benzene threshold concentration is the Netherlands MPC for the protection of terrestrial organisms in soil. No terrestrial ecotoxicological data could be found for use in the Netherlands criteria derivation. Therefore, equilibrium partitioning has been applied to the MPC for water to obtain estimates of the MPC for soil. The MPC for water has been derived from aquatic ecotoxicological data (Van de Plassche et al. 1993; Van de Plassche & Bockting 1993).
[d] – The xylene threshold concentration is the Netherlands MPC for the protection of terrestrial organisms in soil. No terrestrial ecotoxicological data could be found for use in the Netherlands criteria derivation. Therefore, equilibrium partitioning has been applied to the MPC for water to obtain an estimate of the MPC for soil. The MPC for water has been derived from aquatic ecotoxicological data. The concentration shown applies to total xylenes and is based on the arithmetic average of the individual xylene MPCs (Van de Plassche et al. 1993; Van de Plassche & Bockting 1993).
[e] – Human health and ecologically based protection level for toluene. The threshold concentration presented here is the Netherlands intervention value for the protection of terrestrial organisms. Other considerations such as odours and the protection of groundwater may require a lower remediation criterion.

5.7 Discussion

As can be seen from the laboratory test results in Tables 3 and 4, none of the recovered soil samples exceeded threshold limits.

Low levels of hydrocarbons (C15-C36) were identified in three boreholes (BH5, BH7 and BH9). The maximum hydrocarbon level was approximately 37% of the guideline level. The presence of hydrocarbons within the recovered samples could not be explained.

Very low levels of metal were identified within all recovered samples. The maximum recorded level for all tested metals was less than 8% of the guideline level.

The remainder of the recovered soil samples recorded either undetectable or just over undetectable results.

5.8 Further Investigation

It is advised that a Detailed Contaminated Site Investigation will not be required on the site.

6. Preliminary Acid Sulfate Soil Investigation

6.1 Introduction

A Preliminary Acid Sulfate Soil Investigation was undertaken on the subject site in accordance with the "Acid Sulfate Soil Manual 1998" (Stone Y. Ahern, C.R. Blunden. B., Acid Sulfate Soil Management Advisory Committee, 1998).

Acid sulfate soils are naturally occurring sediments containing iron sulfides. The exposure of the sulfide in these sediments to oxygen by drainage or excavation leads to the generation of sulfuric acid. Acid sulfate soils include potential and actual acid sulfate soils. Potential acid sulfate soils are soils containing iron sulfides which have not been exposed to air or oxygen. Actual acid sulfate soils are highly acidic soil horizons resulting from aeration of iron sulfides.

6.2 Laboratory Testing

A summary of the laboratory test results are set out in Table 6 below. Detailed laboratory test results can be seen in the attachment section of this report.

Table 6 – Laboratory Results

Test	Limit of Results	BH8 0.5m	BH8 1.0m	BH11 0.5m	BH11 1.0m	BH15 0.5m	BH15 1.0m
Texture	-	Medium	Medium	Medium	Medium	Medium	Medium
POCAS TAA (mol H+/t)	1	0	17	22	31	**70**	17
POCAS TPA (mol H+/t)	1	3	**589**	28	**38**	**1001**	**197**
POCAS TSA (mol H+/t)	1	3	**572**	6	7	**931**	**180**
POCAS S_{OX} (%)	0.01	**0.13**	**0.48**	0.03	0.04	**0.75**	**0.35**
POCAS S_{KCL} (%)	0.01	0.04	0.04	0.01	0.01	**0.19**	0.03
POCAS S_{POS} (%)	0.01	**0.09**	**0.44**	0.02	0.03	**0.56**	**0.32**
pH KCL	0.01	7.03	5.39	4.45	4.42	5.15	5.11
pH ox	0.01	5.77	2.05	3.26	3.45	2.04	2.45

6.3 Guideline Levels

The interpretation of the above results is dependent on the soil texture category. Based on the "Acid Sulfate Soil Manual 1998", all recovered soil samples fell into the medium soil classification.

The soil texture classification sets out the Action Criteria required for acid sulfate soils. The Action Criteria sets out a level of risk, which if exceeded, triggers the need for an Acid Sulfate Soil Management Plan. Table 7 below shows the action criteria for a medium textured soil.

Table 7 – Action Criteria based on ASS analysis for medium textured soil

Soil Type	Action Criteria (1-1000 tonnes disturbed)	
	POCAS Spos (%) (Sulfur Trail)	POCAS TPA/TSA (Acid Trail)
Medium	0.06	36

6.4 Discussion

From the acid sulfate soil tests conducted, POCAS Spos and POCAS TSA and TPA, are the two most important test results in determining the potential risk of acid sulfate soils. POCAS Spos is an indication of the sulfur trail or oxidisable sulfur and POCAS TSA and TPA are an indication of the acid trail or total sulfuric acidity.

The Action Criteria for soil with a medium texture, based on the sulfur trail, or percentage of sulfur oxidisable is 0.06%. The POCAS Spos results for four of the six samples recovered exceeded the action criteria for a medium textured soil. The maximum laboratory test result was 12.5 times the action criteria.

The Action Criteria for soil with a medium texture, based on the POCAS TSA or TPA is 36mol H+/tonne. The POCAS TSA and TPA results for four of the six samples recovered exceeded the action criteria for a medium textured soil. The maximum laboratory test result was 27.8 times the action criteria.

pH KCL and pH ox are indications of the pH of the soil sample before and after oxidation. The pH KCL for the recovered soil samples varied between 4.42 to 7.03, indicating that the undisturbed soil is moderately acidic to neutral. The pH ox of the recovered soil samples fell between 0.97 and 3.34 to vary between 2.04 and 5.77.

6.5 Further Investigation

Laboratory results obtained from the recovered soil samples showed that:

- five of the six recovered soil samples exceeded guideline action criteria
- three of recovered soil samples could be classified as Actual Acid Sulfate Soils
- two of the recovered soil samples could be classified as Potential Acid Sulfate Soils
- one of the recovered soil samples could not be classified as either an Actual or Potential Acid Sulfate Soil.

It was determined that acid sulfate soils would be present within low-lying estuarine sandplains located in the northern and western portions of the site. It is anticipated that the areas of acid sulfate soils will not be developed as a result of the acid sulfate soils being located below the 1 in 100 year flood level.

Should development not be undertaken within the estuarine sandplain/acid sulfate soil zone, an Acid Sulfate Soil Management Plan will not be required. If development is however to be undertaken within the estuarine sandplain/acid sulfate soil zone, an Acid Sulfate Soil Management Plan will be required to support any future development application.

7. General Geotechnical Investigation

7.1 Introduction

This General Geotechnical Investigation was undertaken across the site in conjunction with the Preliminary Contaminated Site and Preliminary Acid Sulfate Soil Investigations. This General Geotechnical Investigation incorporated the following:

- The excavation and identification of subsurface soils
- Laboratory testing of recovered soils samples for soil erosion and dispersion potential
- Comment on site excavatability and implications to development of the site
- Comment on site slope stability and implications that slope stability may have on development
- Comment on footing recommendations across the site
- Comment on flexible and rigid road pavements that may be used on the site
- Comment of the presence of former mining activities and implications that mining activities may have on development

7.2 Erosion/Soil Dispersion

Nine soil samples were recovered across the site and were tested for dispersivity using the Emerson Crumb Test. Laboratory test results indicated that the soils were Emerson Class 5 and 6, that is, slightly to non-dispersive. Table 8 below shows laboratory test results.

Table 8 – Laboratory test results

Sample Location	Emerson Class
BH1	6
BH2	5
BH3	6
BH4	5
BH5	6
BH6	5
BH7	5
BH12	5
BH13	5

The Department of Land and Water Conservation's "Soil Landscapes of the Lake Macquarie-Gosford 1:100 000 Sheet" report notes that the Wyong Soil Landscape contains "no appreciable erosion occurs over most of this landscape except for severe stream bank erosion along major drainage channels".

The soils encountered in higher elevations of the site, that consist of soils from the Doyalson Soil Landscape as indicated by the Department of Land and Water Conservation's "Soil

Landscapes of the Lake Macquarie-Gosford 1:100 000 Sheet", are considered to be moderately dispersive. Table 9 below shows the erosion hazard indicated by the Department of Land and Water Conservation for the Doyalson Landscape.

Table 9 – Erosion hazard for the Doyalson Soil Landscape

Land Use	Non-Concentrated Flows	Concentrated Flows	Wind
Grazing	Moderate	Slight	Slight
Cultivation	High	High	Slight
Urban	Moderate	High	Slight

Moderate soil dispersion within the Doyalson Soil Landscape is not considered to be detrimental to any future development of the site provided that conventional construction methods and erosion and sediment control measures are employed.

7.3 Excavatability

Based on the subsurface profile encountered during the fieldwork, it is anticipated that conventional excavation equipment and techniques would be efficiently employed on the site.

It is noted that weathered sandstone/conglomerate rock was encountered at depths varying between 0.65 and 1.50m across the majority of the site. It is believed that greater depth of soil may be encountered within drainage lines. If required, further geotechnical investigation to determine the excavation conditions of the sandstone rock may be undertaken.

7.4 Slope Stability

7.4.1 Introduction

The purpose of this investigation was to determine the slope stability risk category for the site in accordance with the methodology set out in the "Australian Geomechanics Society Sub-committee on Landslide Risk Management" guidelines, AG Vol 37 No 2 (see attachment). Details of the investigation, stability assessment and development recommendations have been detailed below.

7.4.2 Stability Assessment

The site was assessed as being underlain by sandstone rock with no tuff or coal seams present on or within the area immediately surrounding the site. No movement of the sandstone/conglomerate rock nor surficial soils was identified on the site. Table 10 below shows a summary of site conditions.

Table 10 – Summary of Geotechnical Report Data for slope stability assessment

Assessed By:	Mark Smith	**Assessment Date**	1 June 2009
Lot No: Various	**Street No:** Various	**Street:** Off Saddlers Way	
DP: 1596	**Section:** A to V	**Suburb:** Wyee Point	
Site Data		**Proposed Building Envelope**	
Site Classification (AS 2870)		N/A	
Land Slope (degrees)		<1 – 5°	
Geological abbreviation of underlying bedrock type		Conglomerate/Sandstone	
Description of surficial soil		See Section 4.4	
Type of Stability Risk		Soil Slide/Soil Flow	
Risk Assessment		Very Low	
Geotechnical Inspections required during construction		Nil	
Risks from adjoining land		Nil	

The subject site was assessed as having a "**rare**" potential for a soil slide/soil flow landslide within the alluvial soil with a "**minor**" measure of consequences to property and therefore, a "**very low**" risk level of instability as defined in the attachment "Landslide Risk Assessment – Example of Qualitative Terminology For Use in Assessing Risk to Property".

7.4.3 Development Guidelines

7.4.3.1 Excavations

Excavations in soil in excess of 1.0m depth should be supported by an engineered designed retaining wall.

Unretained cuts in soil should be battered in accordance with the requirements of the Building Code of Australia, but in no case should be steeper than 2H:1V and should be protected from erosion.

7.4.3.2 Filling

Fill in excess of 1.0m should be retained by an engineer designed retaining wall.

Unretained fill less than 1.0m in depth should be battered in accordance with the requirements of the Building Code of Australia, but in no case should be steeper than 2H:1V and should be protected from erosion.

Fill should be placed in maximum 200mm deep layers and be compacted to 95% maximum dry relative density for cohesive material or 70% relative density for non-cohesive (sand) material.

7.4.3.3 Retaining Walls

Engineer designed retaining walls should be designed in accordance with the requirements of AS4678 “Earth-retaining Structures” to support, where appropriate, surcharge loading due to the upslope battered surface level above the retaining walls and the depth of cut or fill material. Retaining walls should be constructed with adequate surface and subsurface drainage to the Engineer’s and Council’s requirements.

7.4.3.4 Site Drainage

The effective drainage from the site of surface and subsurface water is important to ensure the stability of the surface soil and the long term performance of any footing system and retaining walls.

Any development on the site should be in accordance with the guidelines set out in Section 3 of the BCA and Appendix B of AS 2870.

In particular the following measures are recommended:

- Catch/dish drains formed at the top of all batters.
- Dish and rubble drains installed at the toe of all batters.
- Subsoil drains installed behind new retaining walls.
- Cut areas sloped to fall away from buildings and water not allowed to pond around buildings.
- The site graded to prevent water from ponding on any compacted fills.
- Surface stormwater and subsoil water collected and disposed of to Council’s requirements.
- Erosion control measures to be undertaken during construction to Council’s requirements.
- It is recommended that a subsoil drain be constructed immediately upslope of any proposed residence to intercept and dispose of any groundwater seepage.

7.4.3.5 Proposed Development

It is believed that the construction of residential dwellings on the site will not create land stability issues on either the site or land immediately surrounding the site, provided development is undertaken in accordance with the preceding development guidelines as well as good engineering design and construction.

7.5 Preliminary Site Classification and Footing Recommendations

7.5.1 General

Site classification is a method adopted in residential development for quantifying the anticipated surface movements that may occur on a site, generally due to soil reactivity. Soil reactivity is an appreciable change in soil volume due to a change in the moisture content of the soil. The extent of ground movement due to a reactive clay soil depends on the degree of reactivity of the clay, depth of clay in the soil profile, the depth of potential moisture variation in the soil and the change in soil suction that occurs from dry to wet soil conditions.

AS2870 – 1996 "Residential Slabs and Footings" classifies soil profiles in terms of their potential for shrink/swell movement due to changes in moisture content, to be slight (Class S), moderate (Class M), high (Class H) or extreme (Class E). Sites with little or no reactivity are classified rock or sand (Class A).

Sites which include soft soils such as soft clay, silt or loose sands, landslip, mine subsidence, collapsing soils, soils subject to erosion or fill sites greater than 0.8m for sand and 0.4m for material other than sand are classified as problem sites (Class P).

7.5.2 Laboratory Test Results

Laboratory shrink/swell testing was carried out on samples recovered from boreholes BH1, BH2, BH6 and BH12. Table 11 below shows the laboratory test results.

Table 11 – Laboratory shrink/swell test results

Borehole	Sample Depth	Iss Value
BH1	400-700	1.0
BH2	500-800	0.1
BH6	500-800	1.1
BH12	600-900	1.0

The laboratory test result obtained from borehole BH2 showed inconsistent values compared to the other three laboratory Iss values and has therefore has been excluded from any calculations within this report.

7.5.3 Preliminary Site Classification

The subject site was classified as **Class P** (Problem) as defined in AS2870 - 1996 "Residential Slabs and Footings". This site classification was based upon a visual assessment of the site and surrounding areas, the excavated testpits, and the anticipation that soil disturbance greater than 0.4m depth will occur during site clearing.

This site classification has not included the effects of trees, poor site drainage, leaking plumbing and exceptional moisture. Induced movements such as those that could follow removal of trees prior to construction have also not been included. These should be taken into consideration in the design of footing systems.

7.5.4 Preliminary Footing Recommendations

Based on Barker Harle's understanding that any future development of the site would involve the construction of residential dwellings, it was anticipated that the residences could typically comprise single and double storey masonry or masonry veneer residences with either a sheet metal or tile roof.

Based on this assumption, it is believed that the site would be suitable for development with a building supported on a slab on grade or strip footing system designed by a structural engineer in accordance with engineering principles and AS 2870 - 1996 "Residential Slabs and Footings" for no less than the minimum requirements for a **Class M** site.

7.5.4.1 Reassessment of Footing Recommendations

Footing recommendations indicated above should be reassessed following site clearing and development of any future building lots. Based on the nature of any future development proposal, additional geotechnical testing may be required.

7.6 Preliminary Road Pavement Thickness Design

7.6.1 General

Based on the soil profiles encountered during the investigation (see Section 4.4), the site is considered suitable for the construction of both flexible and rigid pavements.

7.6.2 Laboratory Results

Table 12 below shows laboratory test results that were used within typical road pavement thickness designs.

Table 12 – Laboratory test results

Borehole	CBR (%)	Compaction (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity index (%)	Linear Shrinkage (%)
BH1	3.0	99.0	44	21	23	9.5
BH2	5.0	99.5	23	12	11	4
BH6	5.0	99.5	35	15	20	8
BH13	4.0	99.5	31	15	16	6.5

7.6.3 Traffic Loading Rates

Based on the limited information currently available in relation to the possible future development of the site, design traffic loading rates for any future development have been estimated based on the potential number of residential lots.

The ESA for both flexible and rigid pavements have been estimated using design specifications detailed in Lake Macquarie City Councils "Development Control Plans 1 and 2" and "Engineering Guidelines". Councils guideline details that flexible pavements must be designed for a life of 30 years and that rigid pavements must be designed for a life of 40 years. The estimated traffic loadings can be seen in Table 13 below.

Table 13 – ESA Loading Rates for urban residential development

Street Type	**ESA Loading Rate**	
	Flexible Pavement 30 Year Design Life	**Rigid Pavement 40 Year Design Life**
Local Road – Access place or cul-de-sac	7×10^4	9.3×10^4
Local Road – Primary or secondary	4×10^5	5.3×10^5
Collector Road	1×10^6	1.3×10^6

7.6.4 Typical Rigid Pavement Thickness Design

The typical rigid pavement thickness design was calculated using procedures set out in Cement and Concrete Association of Australia's "Concrete Street and Parking Area Pavement Design" for non-fixed level construction with an 32MPa reinforced concrete pavement. The pavement has been designed for a life of 40 years.

Based on a laboratory test results shown in Section 7.6.2 above, a worst case CBR of 3% was used within calculations.

The typical rigid pavement thickness design, based on the above design process, can be seen in Table 14 below.

Table 14 – Typical rigid pavement thickness design

Street Type	Rigid Pavement Design	
Local Road – Access place or cul-de-sac	Wearing/Base Course	200mm
	Sub-Base Course	125mm LMC
	Total	325mm
Local Road – Primary or secondary	Wearing/Base Course	220mm
	Sub-Base Course	125mmLMC
	Total	345mm
Collector Road	Wearing/Base Course	230mm
	Sub-Base Course	150mm LMC
	Total	380mm

The recommended material, construction specification and pavement thickness is summarised in Table 15 below:

Table 15 – Summary of Pavement Formation Material Quality & Compaction

Layer	Material Quality		Compaction
Base Course	<175mm thick	32 MPa concrete with SL72 reinforcement	N/A
	>175mm thick	32 MPa concrete with SL82 reinforcement	N/A
Subbase Course	Conform to RTA Spec. 3051 Minimum Soaked CBR 30% Maximum PI = 12%		98% Modified (AS 3798/ AS 1289.5.1.1)
Subgrade	Conform to RTA Spec. 3051 Minimum Soaked CBR 10% Maximum PI = 20%		98% Standard (AS 3798/ AS 1289.5.1.1)

7.6.5 Typical Flexible Pavement Thickness Design

The typical flexible pavement thickness design was calculated using procedures set out in Specification D2 of Lake Macquarie City Councils "Engineering Guildeines" as well as AUSTROADS "Pavement Design (2004)" for non-fixed level construction with an AC sealed wearing course.

Based on a laboratory test results shown in Section 7.6.2 above, a worst case CBR of 3% was used within calculations.

The typical flexible pavement thickness design, based on the above design process, can be seen in Table 16 below.

Table 16 – Typical flexible pavement thickness design

Street Type	Flexible Pavement Design	
Local Road – Access place or cul-de-sac	Wearing Course	30mm AC Seal
	Primer Seal	7mm
	Base Course	150mm
	Sub-Base Course	310mm
	Total	470mm
Local Road – Primary or secondary	Wearing Course	30mm AC Seal
	Primer Seal	7mm
	Base Course	150mm
	Sub-Base Course	380mm
	Total	540mm
Collector Road	Wearing Course	30mm AC Seal
	Primer Seal	7mm
	Base Course	150mm
	Sub-Base Course	410mm
	Total	570mm

The recommended material, construction specification and pavement thickness is summarised in Table 17 below:

Table 17 – Summary of Pavement Formation Material Quality & Compaction

Layer	Material Quality	Compaction
Wearing Course	30mm Asphaltic Concrete + Primer Seal to Lake Macquarie City Council Design Specifications (including primer seal)	
Base Course	Minimum Soaked CBR 80% Maximum PI = 6%	98% Modified (AS 3798/ AS 1289.5.1.1)
Subbase Course	Minimum Soaked CBR 30% Maximum PI = 12%	95% Modified (AS 3798/ AS 1289.5.1.1)
Subgrade	Minimum Soaked CBR 10% Maximum PI = 20%	98% Standard (AS 3798/ AS 1289.5.1.1)

7.6.6 Subsurface Drainage

Subsurface drainage will be required to ensure the long-term structural adequacy of the proposed pavement. Subsurface drainage should be installed with Specification Number D4 of Lake Macquarie City Councils “Engineering Guidelines”.

Subsoil drainage should be installed in conjunction with the construction of the subbase and base course layers.

7.7 Mine Subsidence Issues

An internet search was undertaken using the Mine Subsidence Board's "District Maps". Figure 4 below shows an extract from the Mines Subsidence Board's West Lake Mine Subsidence District map "Plan No MSD16b".

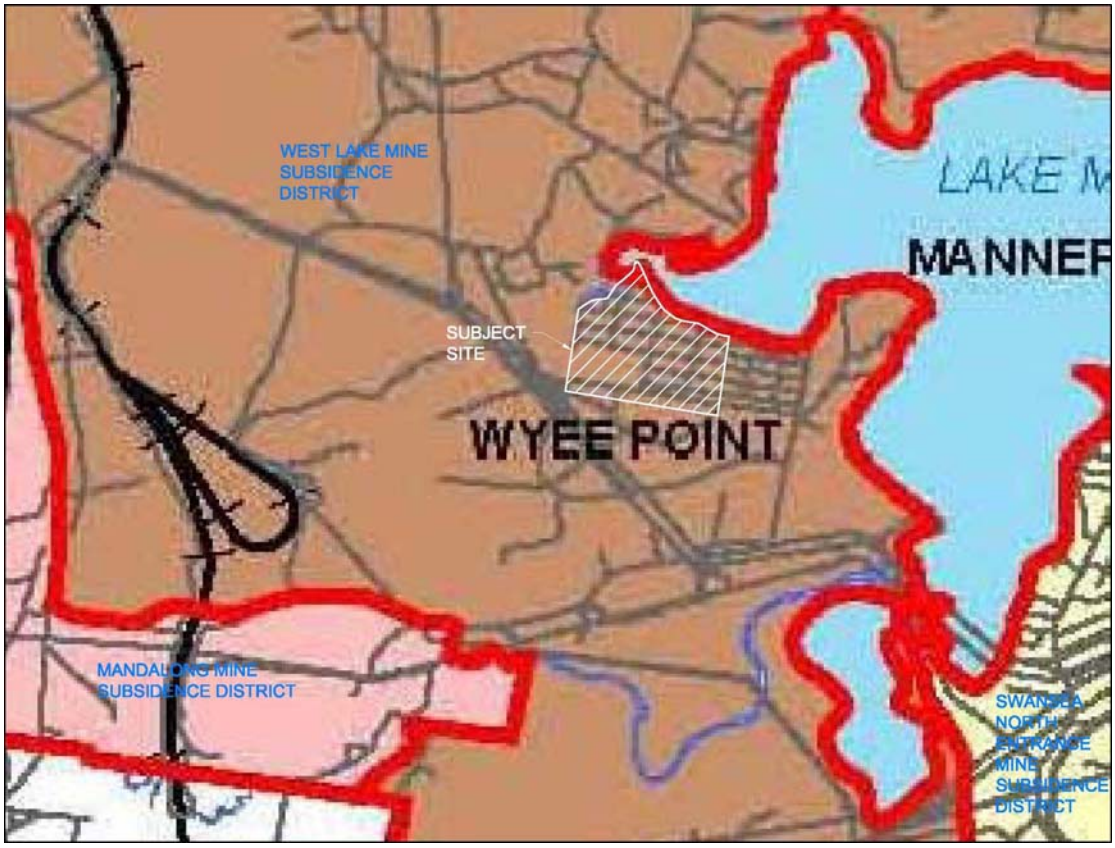


Figure 4 – An extract from the Mines Subsidence Boards West Lake Mine Subsidence District map "Plan No MSD16b" and the location of the site.

As can be seen in Figure 4 above, the site is located within the West Lake Mine Subsidence District. As a result, a telephone conversation was undertaken with a representative of the Mine Subsidence Board and confirmed that the site is "adjacent to future mining areas identified in the 2007 Mining and Landuse report for parts of Munmorah and Mannering Collieries". Mannering Collieries requests "limited development till mining is completed" with any residential and commercial development to be designed using a "±3mm/m strain and 4mm/m tilt."

8. Possible Construction and Site Difficulties

Preliminary subdivision layout shown on McElwee Stratasurv drawing A17405 sheet P12 Edition F indicated that the proposed subdivision would consist of residential lots on the eastern and western sides of the existing broad drainage line that runs centrally through the site. Access to the both portions of the subdivision would be provided from the existing bitumen sealed road to the east of the site with access to the western section of the site provided using a access road, approximately 140m in length, across the broad drainage line.

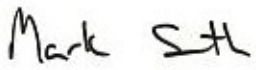
It is believed that construction of the 140m road across the broad drainage line could be problematic and expensive to construct. It is recommended that further investigation into suitable construction techniques and their associated costs be completed prior to finalisation of the subdivision layout.

9. Investigation Limitations

Barker Harle's professional opinions presented in this report are based on observations of the site and information provided to Barker Harle and are subject to modification if additional information is obtained, through further investigation, observation, verification testing or analysis during further investigations or subsequent building works.

Yours faithfully

Barker Harle



Mark Smith

B.E. (Environmental)
Environmental Engineer

Attachments:
i) Drawing 90343/Geo1
ii) Photographs 1 and 2
iii) Engineering Logs
iv) Falling Weight Penetrometer Logs
v) Laboratory Test Results

Attachments

LOCALITY PLAN

N.T.S.

LEGEND

- BH1/P1 - APPROXIMATE BOREHOLE/FALLING WEIGHT PENETROMETER PROBE LOCATION
- (1) - PHOTOGRAPH LOCATION AND DIRECTION

ISSUE	DATE	DESCRIPTION	DESIGN	DRAWN
A	26.05.09	REPORT ISSUE	MS	MS

barker harle consulting engineers

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LIMITED GEOTECHNICAL INVESTIGATION
VARIOUS LOTS OFF SADDLERS WAY,
WYEE POINT
RPS HSO

Drawing: 90309

Sheet: GEO1

Issue: A

Original Sheet Size: A3

Photograph 1 – Taken in the southeastern portion of the site looking west through north to the east

Photograph 2 - Taken on the southern side of the site in looking west through north to the east

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH1
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description															Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture				Plasticity		
							VS	Fb	VL	L	M	D	VSt	H	VD	D	SM	M	W		
0.25						GREY/ORANGE SANDY CLAY WITH SOME MEDIUM GRAVEL		S		F		St									
0.50						ORANGE SANDY GRAVELLY CLAY															
0.75																					
1.00						REFUSED ON WEATHERED SANDSTONE															
1.25																					
1.50																					
1.75																					
2.00																					
2.25																					
2.50																					
3.00																					

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

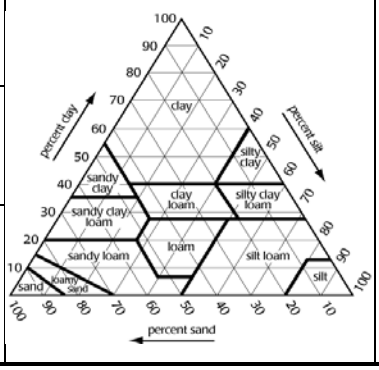
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH2
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description															Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture					Plasticity	
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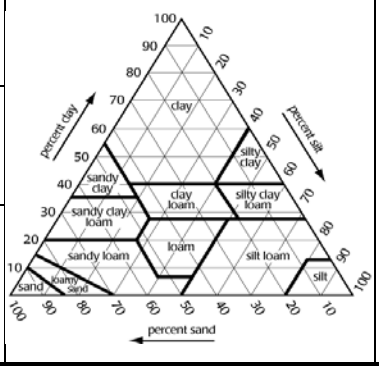

Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH3
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description															Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture				Plasticity		
							VS	Fb	S	VL	F	L	St	M	VSt	D	H	VD	D	SM	M	W		
0.25						GREY/ORANGE SANDY CLAY WITH SOME MEDIUM GRAVEL																		
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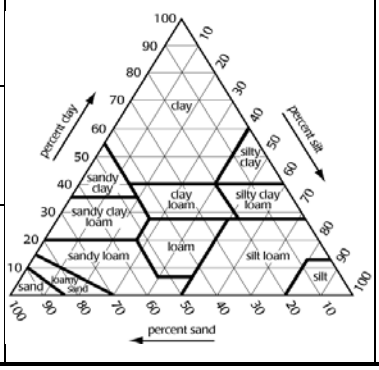

Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH4
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description																		Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture				Plasticity					
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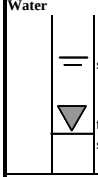
0.50						GREY SANDY CLAY			F		St													
0.75						ORANGE SANDY GRAVELLY CLAY						VSt												
1.00						GREY SILTY CLAY WITH FEW FINE GRAVEL AND AN ORANGE/RED MOTTLE								H										
1.25						YELLOW SANDY CLAY WITH FEW MEDIUM GRAVEL																		
1.50						WEATHERED SANDSTONE																		
1.75						TERMINATED IN WEATHERED SANDSTONE																		
2.00																								
2.25																								
2.50																								
3.00																								

Key

Water



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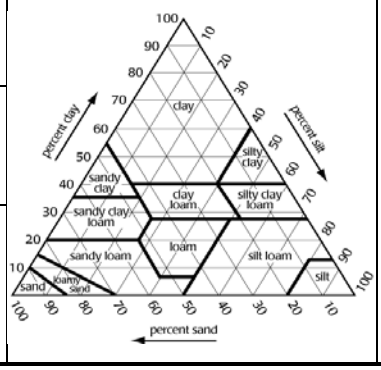


Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH5
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description															Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture					Plasticity	
							VS	Fb	VL	L	M	D	VD	H	D	SM	M	W		
0.25						GREY SANDY CLAY		S		F	St	VSt									
0.50						GREY SILTY CLAY WITH FEW FINE GRAVEL AND AN ORANGE/RED MOTTLE															
0.75																					
						WEATHERED SANDSTONE															
1.00						TERMINATED IN WEATHERED SANDSTONE															
1.25																					
1.50																					
1.75																					
2.00																					
2.25																					
2.50																					
3.00																					

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

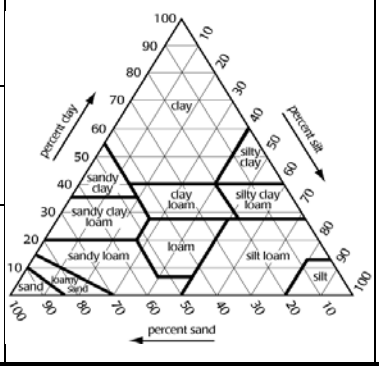
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH6
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description															Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture					Plasticity	
							VS	Fb	VL	L	M	D	VD	H	D	SM	M	W		
0.25						DARK BROWN SANDY CLAY WITH SOME SILT	S		F	St	VSt										
0.50						GREY SILTY CLAY WITH FEW FINE GRAVEL AND AN ORANGE/RED MOTTLE			L	M	D										
0.75						YELLOW TOTALLY WEATHERED SANDSTONE															
1.00						TERMINATED IN YELLOW TOTALLY WEATHERED SANDSTONE															
1.25																					
1.50																					
1.75																					
2.00																					
2.25																					
2.50																					
3.00																					

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

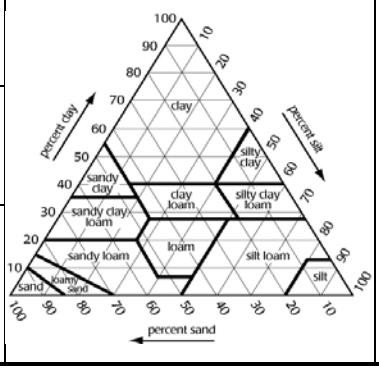
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH7
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description																	Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture					Plasticity			
							VS	Fb	VL	L	M	D	VD	H	D	SM	M	W				
0.25						DARK BROWN SANDY CLAY WITH SOME SILT		S		F	St	VSt											
0.50						GREY SANDY GRAVELLY CLAY																	
0.75						GREY SILTY CLAY WITH FEW FINE GRAVEL AND AN ORANGE/RED MOTTLE																	
1.00						TERMINATED IN GREY SILTY CLAY WITH FEW FINE GRAVEL AND AN ORANGE/RED MOTTLE																	
1.25																							
1.50																							
1.75																							
2.00																							
2.25																							
2.50																							
3.00																							

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

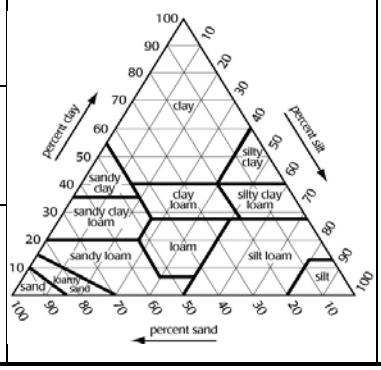
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH8
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description																Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture				Plasticity			
							VS	Fb	VL	L	M	D	VD	H	D	SM	M	W				
0.25						BLACK SILTY CLAY																
0.50						BROWN CLAYEY GRAVELLY SAND																	
0.75						AQUA CLAYEY GRAVELLY SAND																
1.00						TERMINATED IN AQUA CLAYEY GRAVELLY SAND																
1.25																						
1.50																						
1.75																						
2.00																						
2.25																						
2.50																						
3.00																						

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

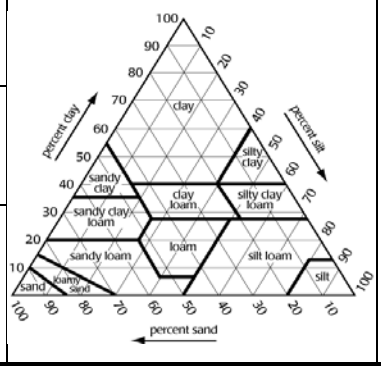
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH9
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description																	Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture					Plasticity			
							VS	Fb	VL	L	M	D	VD	H	D	SM	M	W				
0.25						GREY SANDY SILTY CLAY		S		F		St		VSt			SM					
0.50						GREY SILTY SANDY CLAY																	
0.75						ORANGE SANDY CLAY																	
1.00						TERMINATED IN ORANGE SANDY CLAY																	
1.25																							
1.50																							
1.75																							
2.00																							
2.25																							
2.50																							
3.00																							

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

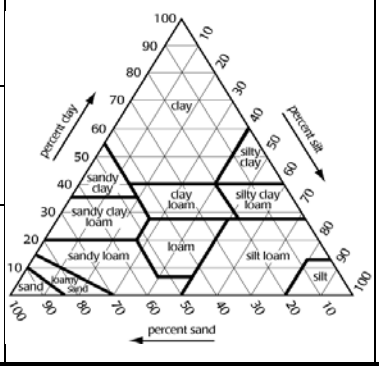
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH10
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description																	Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture					Plasticity	
							VS	Fb	S	VL	L	F	M	St	D	VSt	VD	H	D	SM	M	W	
0.25						GREY SANDY SILTY CLAY																	
0.50						ORANGE SANDY CLAY																	
0.75						GREY/ORANGE CLAY WITH SOME SAND																	
1.00						TERMINATED IN GREY/ORANGE CLAY WITH SOME SAND																	
1.25																							
1.50																							
1.75																							
2.00																							
2.25																							
2.50																							
3.00																							

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

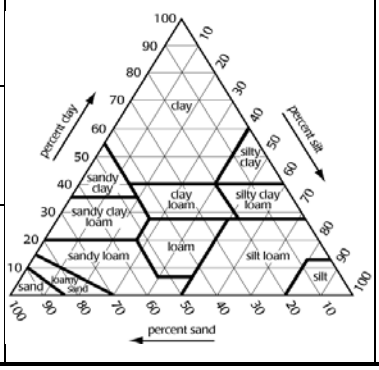
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH11
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description																Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture				Plasticity			
							VS	Fb	S	VL	F	L	St	M	VSt	D	H	VD	D	SM	M	W	
0.25						BLACK/BROWN LOAM																
0.50						GREY CLAYEY SAND WITH AN ORANGE MOTTLE																
0.75						DARK GREY SANDY CLAY																
1.00		▽				TERMIANTED IN DARK GREY SANDY CLAY																
1.25																						
1.50																						
1.75																						
2.00																						
2.25																						
2.50																						
3.00																						

Key

Water

- seeping
- free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

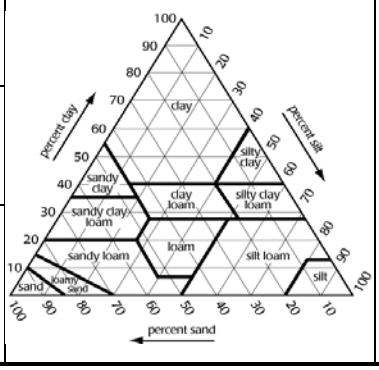
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH12
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description														Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture					Plasticity	
							VS	Fb	S	VL	F	L	St	M	VSt	D	H	VD	D	SM	M	W		
0.25						GREY SANDY GRAVELLY CLAY					■									■				
0.50											■									■				
0.75						ORANGE SANDY CLAY					■									■				
1.00											■									■				
1.25						TERMINATED IN ORANGE SANDY CLAY					■									■				
1.50											■									■				
1.75											■									■				
2.00											■									■				
2.25											■									■				
2.50											■									■				
3.00											■									■				

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

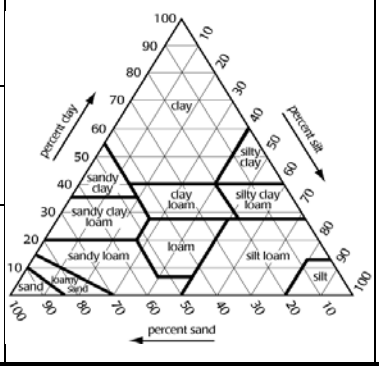
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH13
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description																	Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density								Moisture							Plasticity	
							VS	Fb	S	VL	F	L	St	M	VSt	D	H	VD	D	SM	M	W	
0.25						GREY SANDY GRAVELLY CLAY																	
0.50						ORANGE SANDY CLAY																	
0.75																							
1.00						TERMINATED IN ORANGE SANDY CLAY																	
1.25																							
1.50																							
1.75																							
2.00																							
2.25																							
2.50																							
3.00																							

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

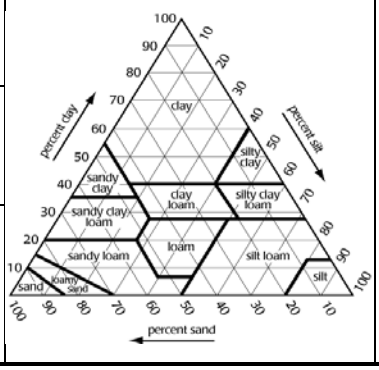
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH14
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description				Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency / Rel. Density (VS Fb S VL F L St M VSt D H VD)	Moisture (D SM M W)	Plasticity	
0.25						GREY SANDY GRAVELLY CLAY				
0.50						ORANGE SANDY CLAY				
0.75										
1.00						TERMINATED IN ORANGE SANDY CLAY				
1.25										
1.50										
1.75										
2.00										
2.25										
2.50										
3.00										

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

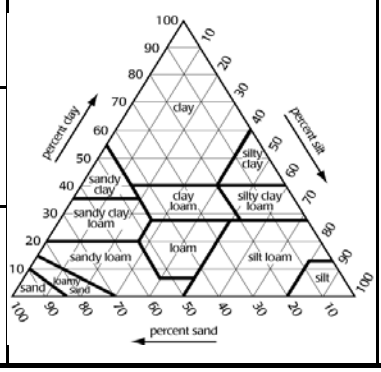
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

Textural Classification Diagram



Site Plan N.T.S / Comments

ENGINEERING LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT	**Borehole No:**	BH15
Client:	RPS HSO	**Equipment:**	AUGER
Position:	SEE SITE PLAN	**Job No:**	90343
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	1/06/2009

Drilling Information			Sampling Data			Profile Description																	Structure and Additional Comments
Depth in metres	Progress	Water	Sample type	Graphic Log	USC	Material/Strata	Consistency Rel. Density								Moisture				Plasticity				
							VS	Fb	VL	L	M	D	VD	H	D	SM	M	W				
0.25						BLACK SILTY CLAY																	
0.50																							
0.75						GREY CLAYEY SAND																	
1.00																							
1.25						TERMINATED IN GREY CLAYEY SAND																	
1.50																							
1.75																							
2.00																							
2.25																							
2.50																							
3.00																							

Key

Water

seeping

free standing

Plasticity

NP	Non Plastic
T	Trace
VL	Very Low
L	Low
M	Medium
H	High
VH	Very High
EH	Extra High

Moisture

D	dry
SM	slightly moist
M	moist
W	wet

Sampling Data

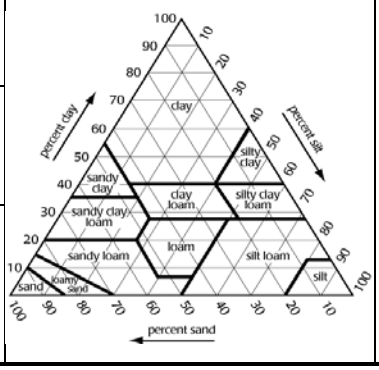
U50	undisturbed sample 50mm diameter
D	disturbed sample
NC	cone penetrometer
B	bulk sample

Consistency

Relative Density

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

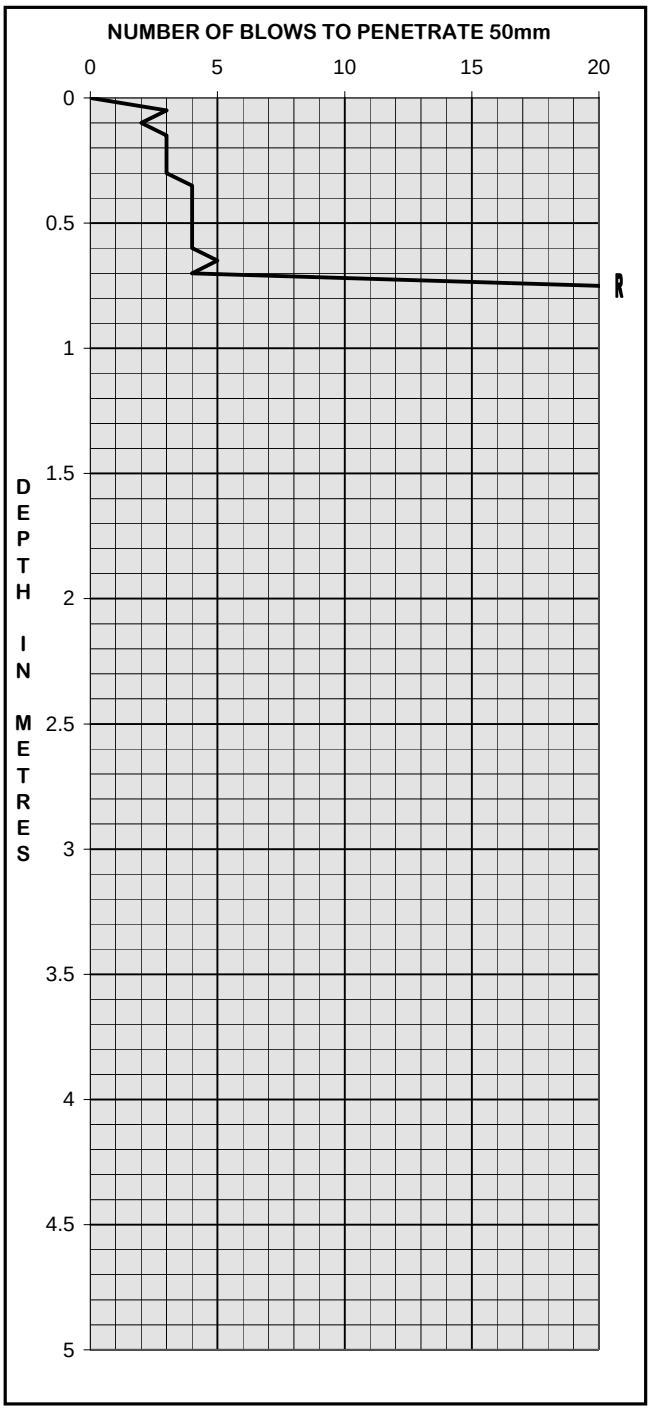
Textural Classification Diagram



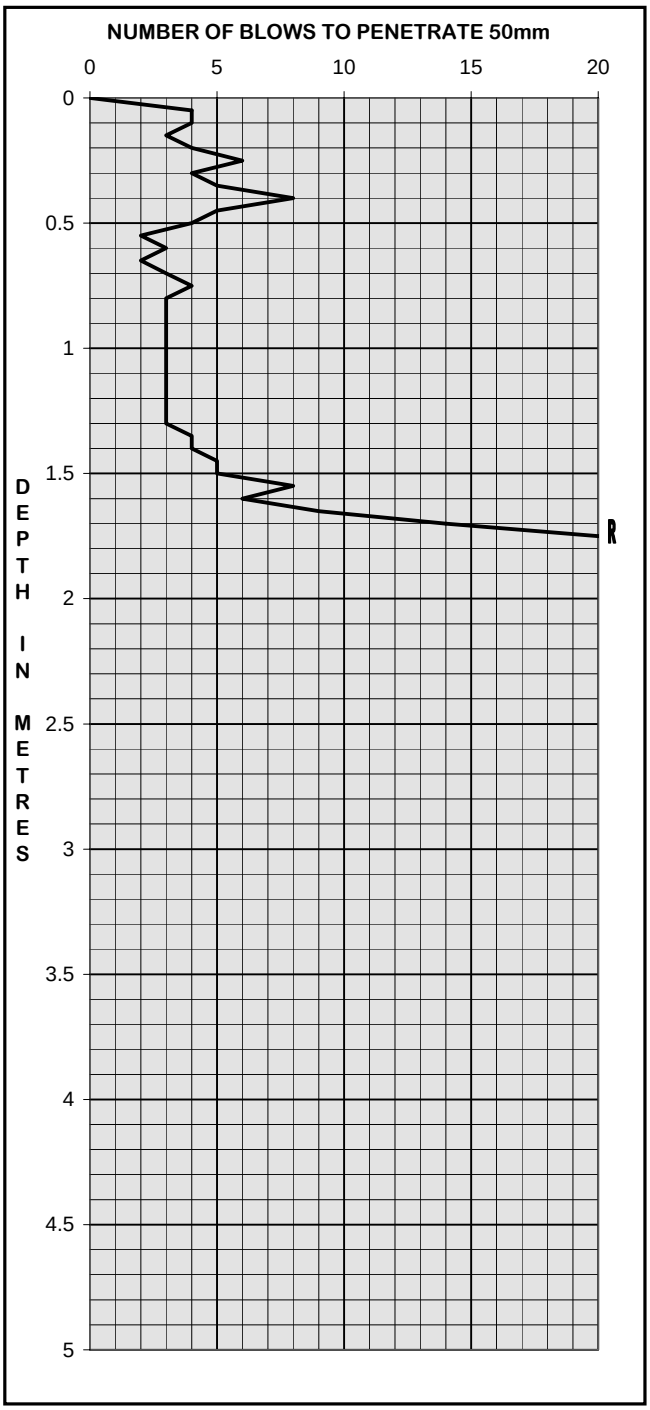
Site Plan N.T.S / Comments

DYNAMIC CONE PENETROMETER LOG

Location:	SADDLERS WAY, WYEE POINT		
Client:	RPS HSO		
Position:	SEE SITE PLAN	**Job No:**	90272
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	01/06/09



PENETROMETER : P1



PENETROMETER : P2

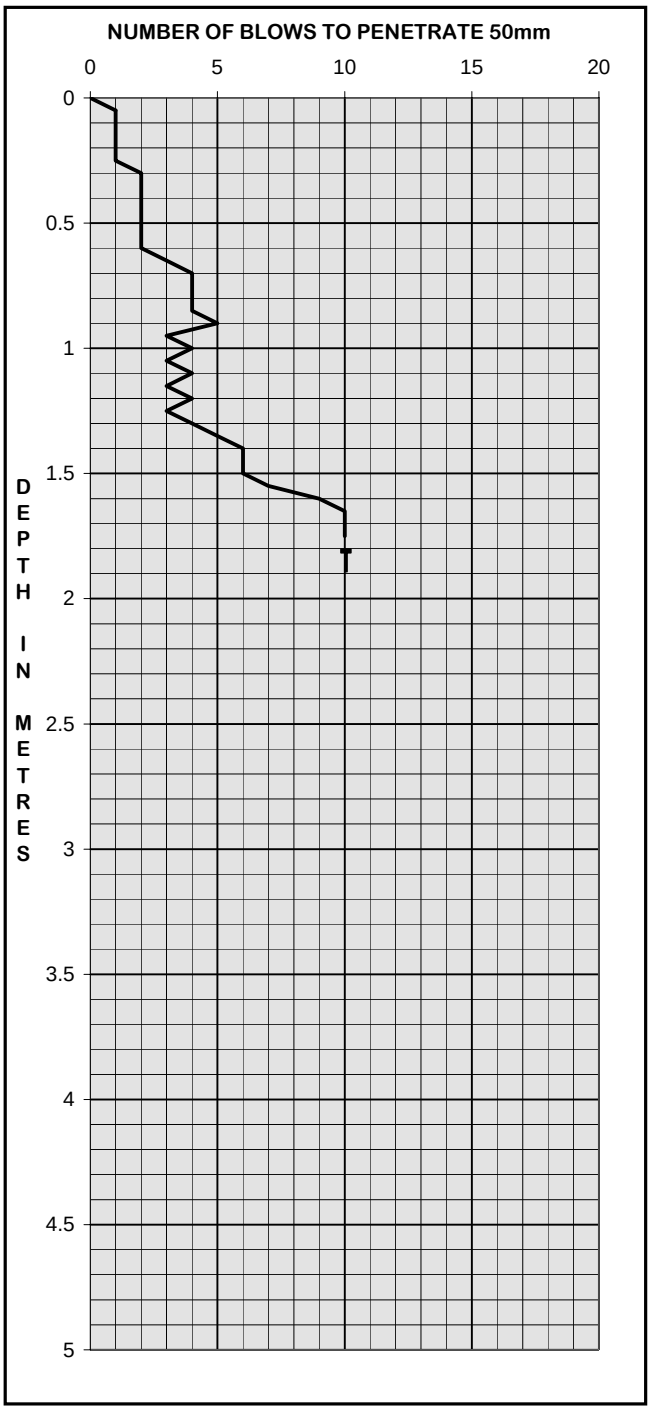
T - TERMINATED
R - REFUSED

T - TERMINATED
R - REFUSED

DYNAMIC CONE PENETROMETER LOG

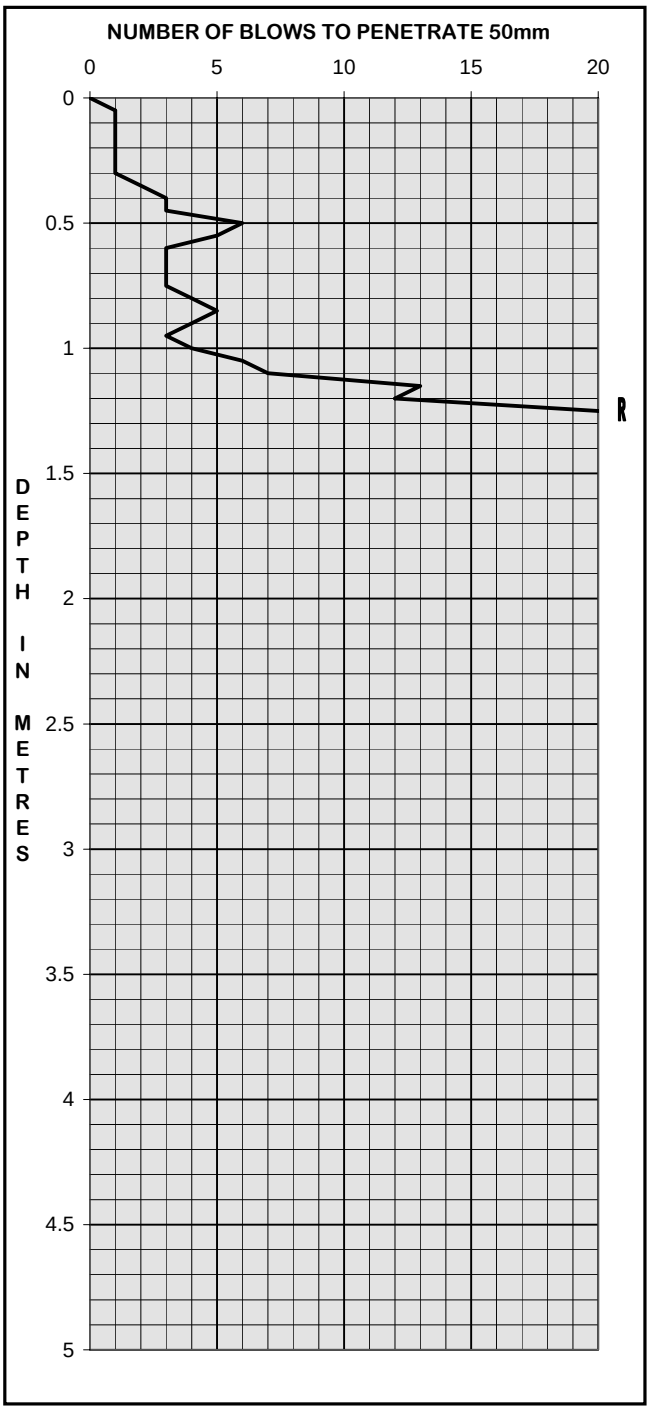
barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT		
Client:	RPS HSO		
Position:	SEE SITE PLAN	**Job No:**	90272
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	01/06/09



PENETROMETER : P3

T - TERMINATED
R - REFUSED



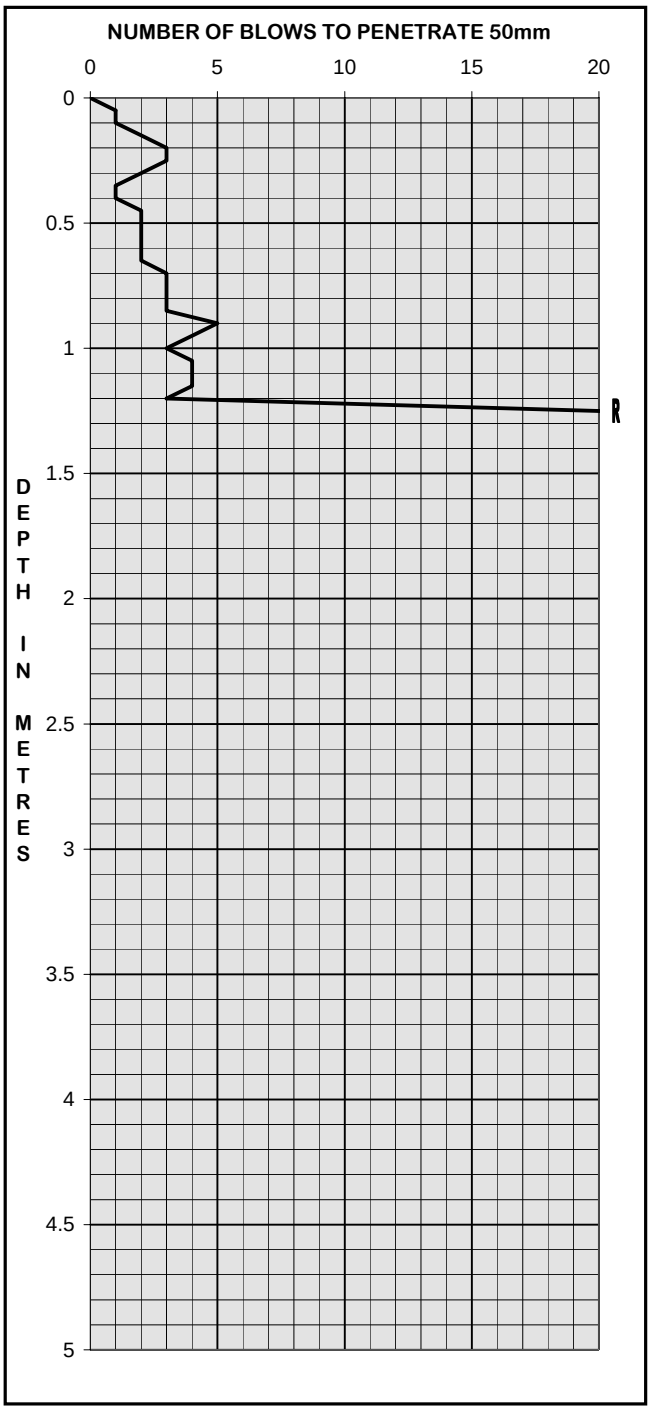
PENETROMETER : P4

T - TERMINATED
R - REFUSED

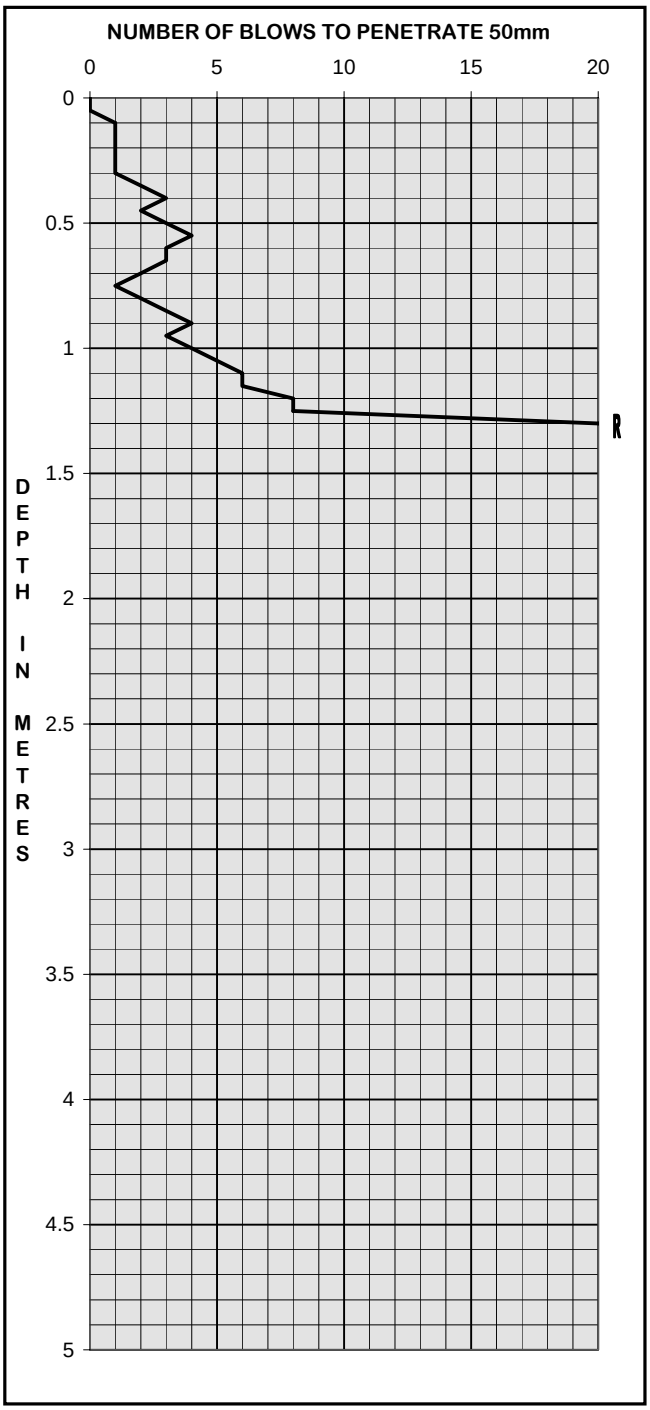
DYNAMIC CONE PENETROMETER LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT		
Client:	RPS HSO		
Position:	SEE SITE PLAN	**Job No:**	90272
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	01/06/09



PENETROMETER : P5



PENETROMETER : P6

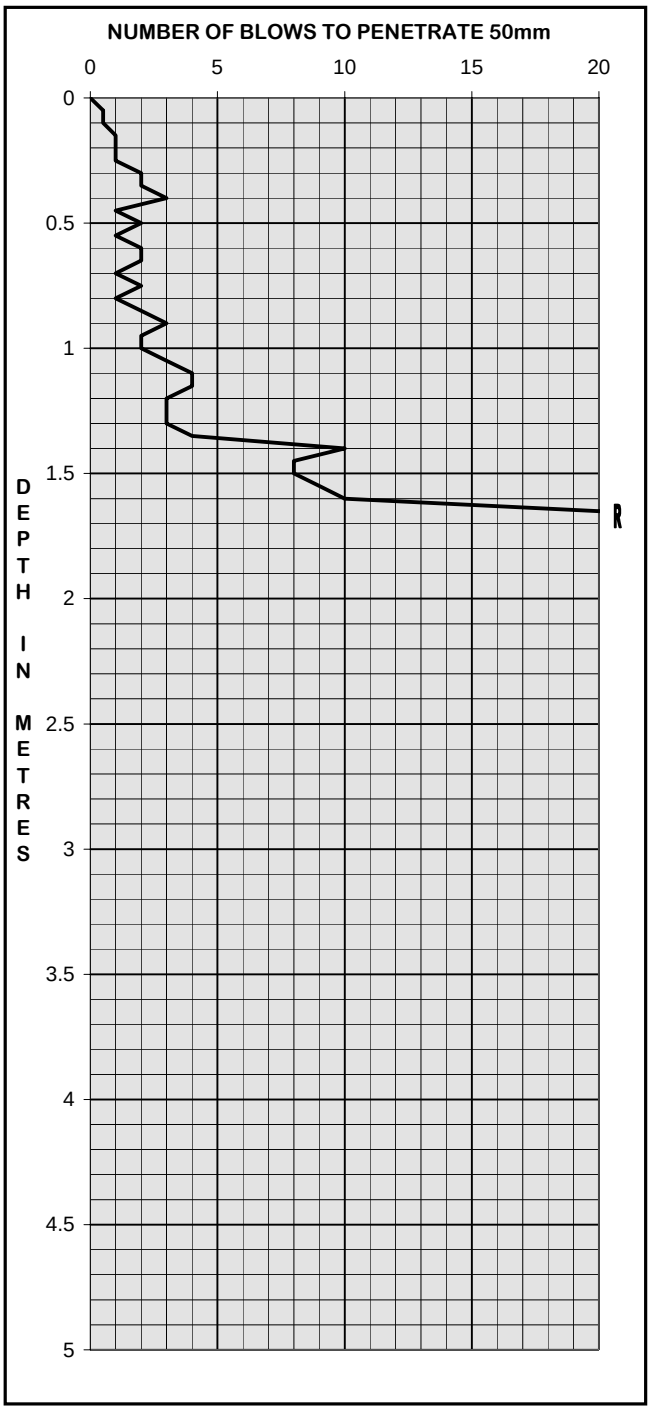
T - TERMINATED
R - REFUSED

T - TERMINATED
R - REFUSED

DYNAMIC CONE PENETROMETER LOG

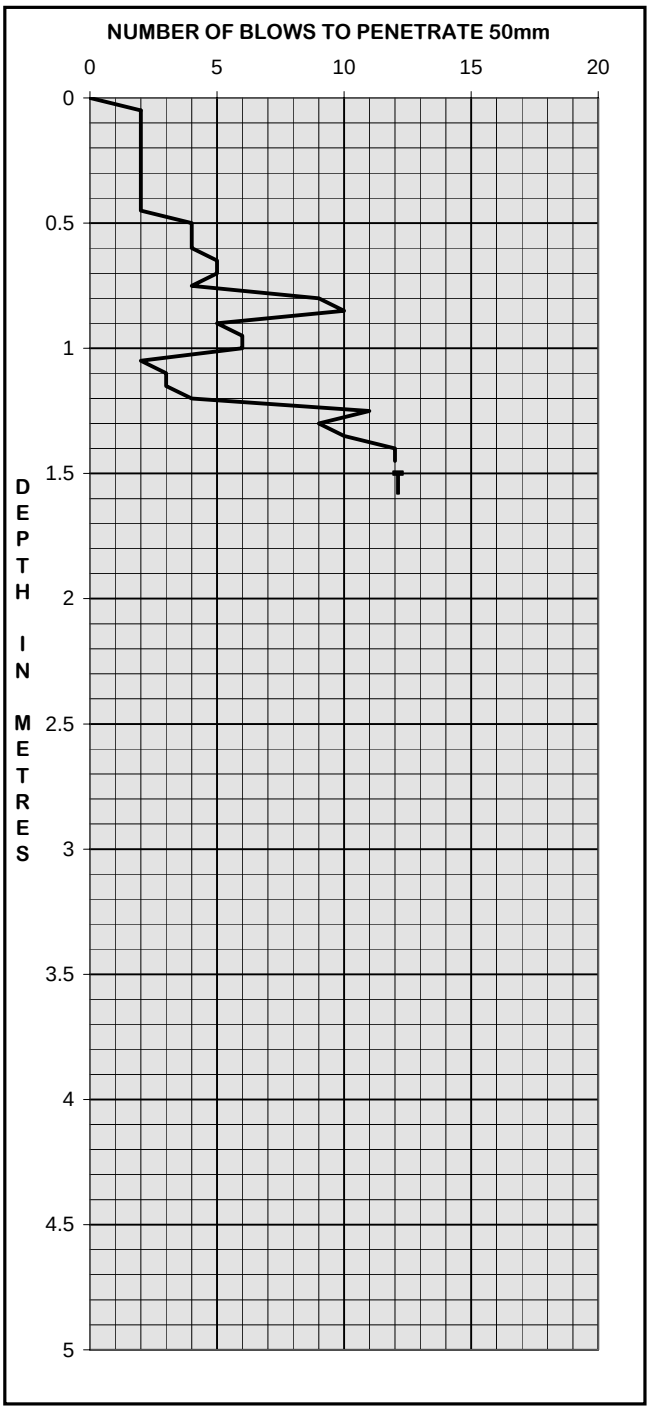
barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT		
Client:	RPS HSO		
Position:	SEE SITE PLAN	**Job No:**	90272
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	01/06/09



PENETROMETER : P7

T - TERMINATED
R - REFUSED



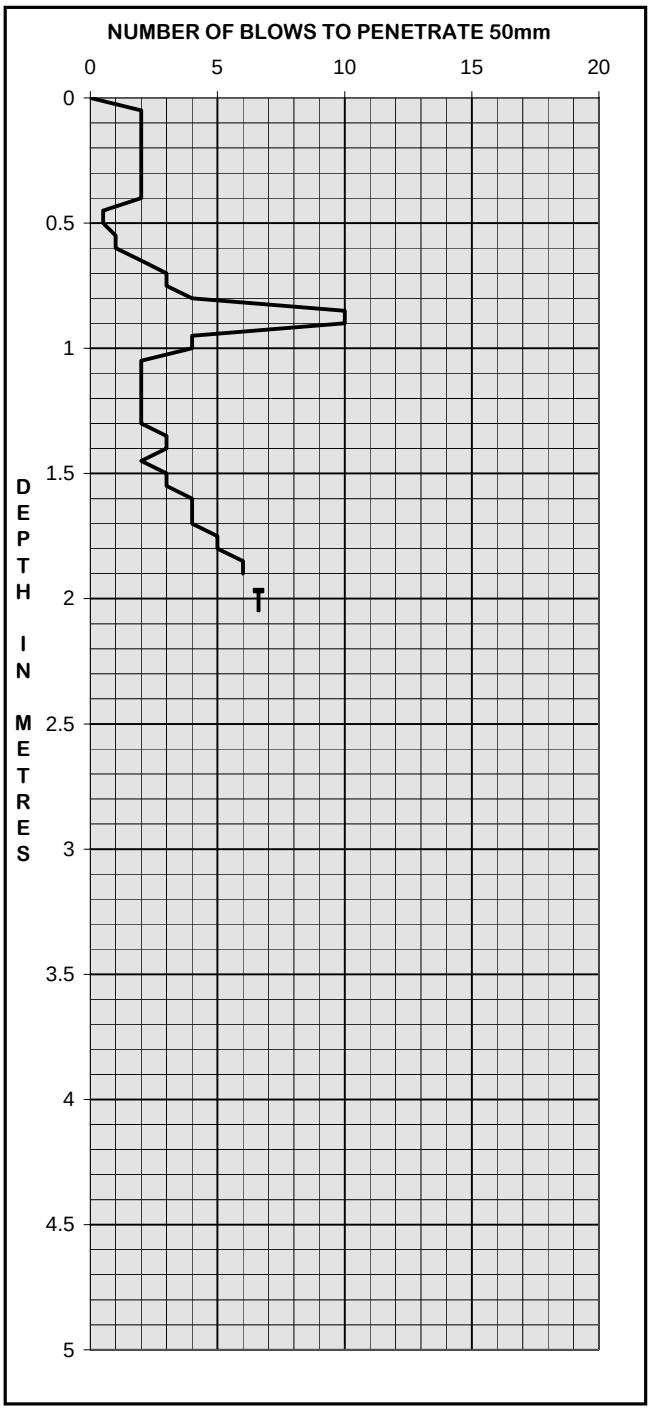
PENETROMETER : P9

T - TERMINATED
R - REFUSED

DYNAMIC CONE PENETROMETER LOG

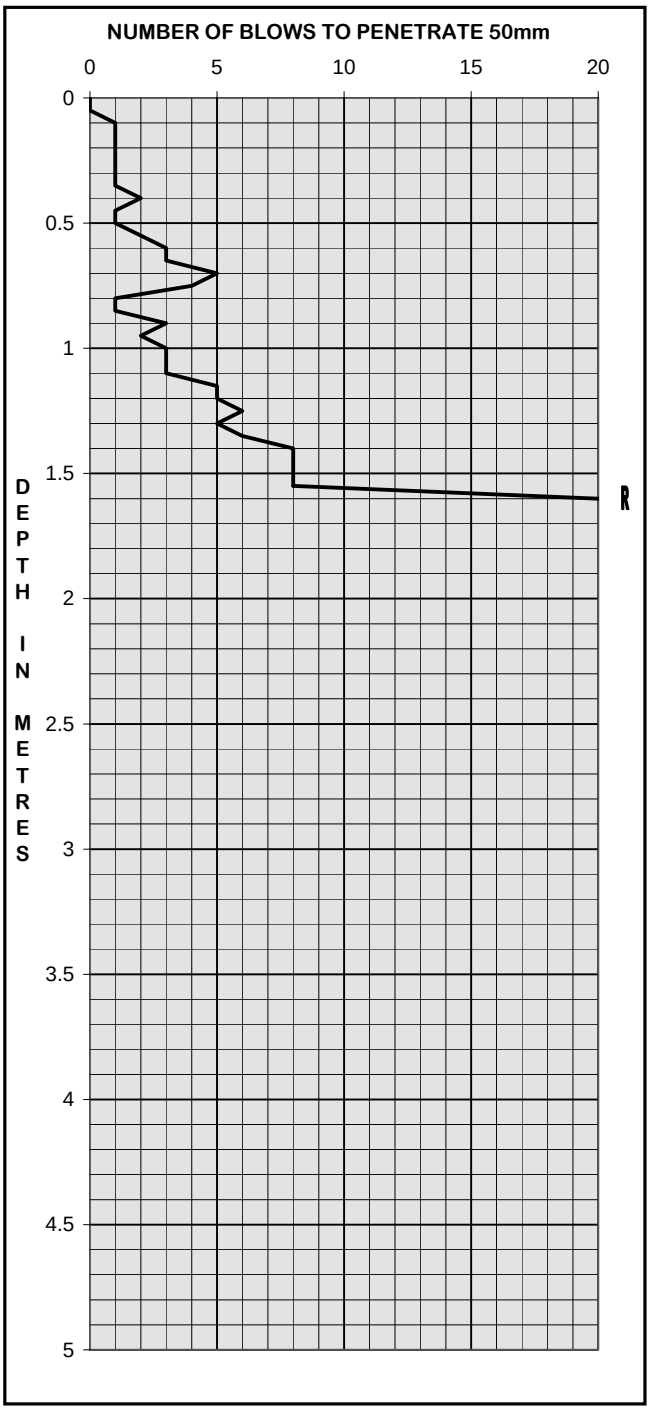
barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT		
Client:	RPS HSO		
Position:	SEE SITE PLAN	**Job No:**	90272
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	01/06/09



PENETROMETER : P10

T - TERMINATED
R - REFUSED



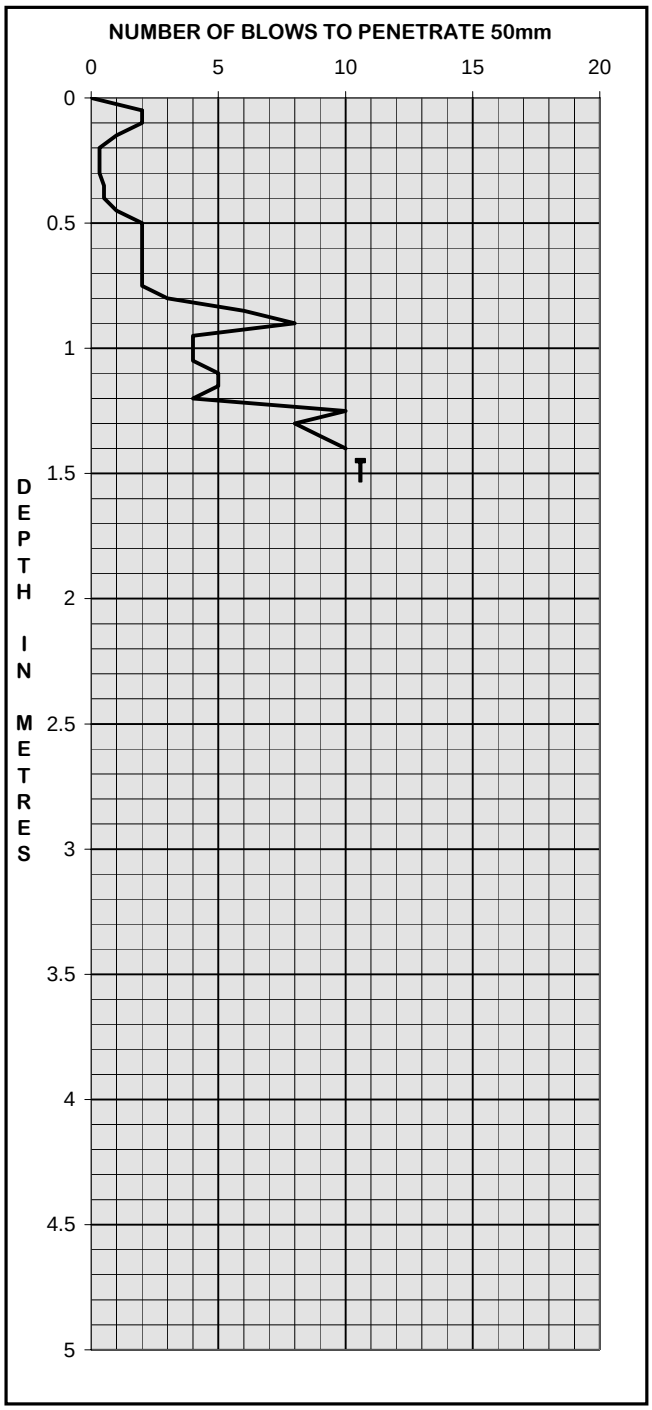
PENETROMETER : P12

T - TERMINATED
R - REFUSED

DYNAMIC CONE PENETROMETER LOG

barker harle consulting engineers

Location:	SADDLERS WAY, WYEE POINT		
Client:	RPS HSO		
Position:	SEE SITE PLAN	**Job No:**	90272
Surface RL:	EXISTING	**Logged By:**	MS
Groundwater:	NIL ENCOUNTERED	**Date:**	01/06/09



PENETROMETER :P13

T - TERMINATED
R - REFUSED

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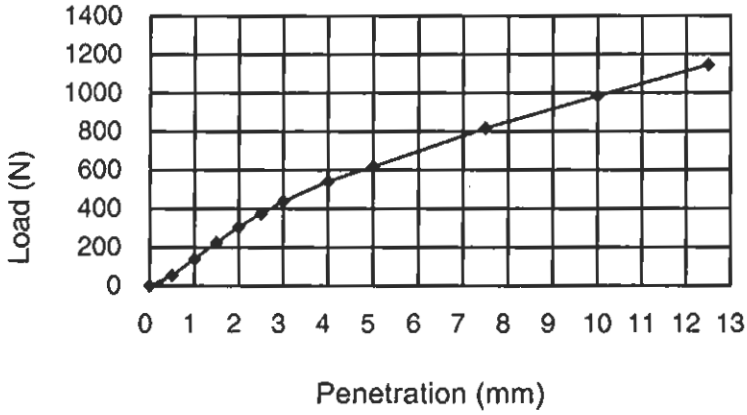
California Bearing Ratio Report (AS)

Client:	Barker Harle	**Job No.**	P09009-96
Project:	Material Assessment	**Report No.**	2
Location:	Saddlers Way, Wyee Point		



Sample Information

Date Sampled:	02/06/09	Date Tested:	09/06/09	Sample No.	1
Soil Description:	(CH) Sandy Silty CLAY, pale brown/grey				
Source Location:	BH1				

Compaction and Placement Data

Compaction Used		Standard	Dry Density			
Maximum Dry Density	t/m3	1.71	Before Soaking	1.69 t/m3	99.0	% Comp.
Optimum Moisture Content	%	15.8	After Soaking	1.63 t/m3	95.0	% Comp.
No. of Layers		3	Moisture Content			
Blows per Layer		53	At Compaction	%	16.0	
Drop of Rammer	mm	300	After Soaking	%	21.5	
Mass of Rammer	kg	2.7	After Penetration (Top 30mm)	%	26.0	
Surcharge Used	kg	4.5	After Penetration (Entire Depth)	%	20.5	
Substitution +19mm Sieve		No	Swell After 4 Days Soaking	%	2.2	

California Bearing Ratio

CBR (Soaked) = 3.0 % at 2.5 mm Penetration

Procedures Used A,C

AS 1289.6.1.1 DETERMINATION OF THE CALIFORNIA BEARING RATIO OF A SOIL - Standard Laboratory Method.

A. AS 1289 5.1.1 Determination of The Dry Density/Moisture Relation of a Soil Using Standard Compaction - Standard Method.

B. AS 1289 5 2.1 Determination of The Dry Density/Moisture Relation of a Soil Using Modified Compaction - Standard Method.

C. AS 1289 2.1.1 Determination of The Moisture Content of a Soil - Oven Drying Method (Standard Method).

D. AS 1289 2.1.4 Determination of The Moisture Content of a Soil - Microwave-oven drying method(Subsidiary Method).

E. AS 1289 1.2.1(Clause 6.2)sampling from Stockpiles

F. AS 1289 1.2.1(Clause 6.5.3)Power Auger Drilling

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NATA Accredited Laboratory Number:14975

Authorised Signatory: Karl Dawes

Date: 23/6/09

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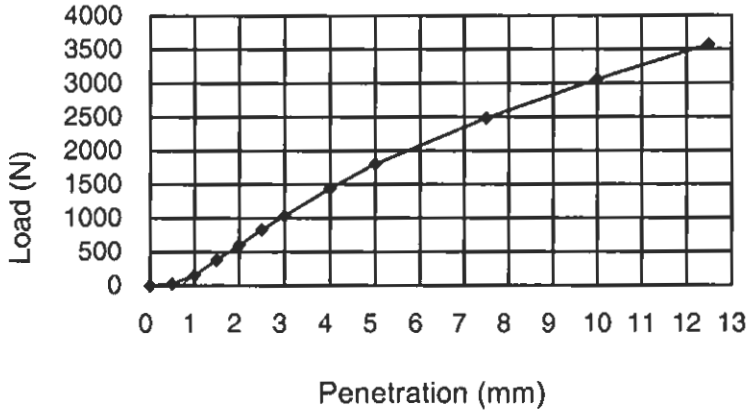
California Bearing Ratio Report (AS)

Client:	Barker Harle	**Job No.**	P09009-96
Project:	Material Assessment	**Report No.**	6
Location:	Saddlers Way, Wyee Point		



Sample Information

Date Sampled:	02/06/09	Date Tested:	09/06/09	Sample No.	2
Soil Description:	(CH) Sandy Silty CLAY, pale brown/grey				
Source Location:	BH2 -500mm				

Compaction and Placement Data

Compaction Used		Standard	Dry Density			
Maximum Dry Density	t/m3	1.97	Before Soaking	1.96 t/m3	99.5	% Comp.
Optimum Moisture Content	%	10.9	After Soaking	1.98 t/m3	100.5	% Comp.
No. of Layers		3	Moisture Content			
Blows per Layer		53	At Compaction	%	11.5	
Drop of Rammer	mm	300	After Soaking	%	12.0	
Mass of Rammer	kg	2.7	After Penetration (Top 30mm)	%	13.0	
Surcharge Used	kg	4.5	After Penetration (Entire Depth)	%	12.0	
Substitution +19mm Sieve		No	Swell After 4 Days Soaking	%	-0.5	

California Bearing Ratio

CBR (Soaked) = 10.0 % at 5.0 mm Penetration

Procedures Used A,C

AS 1289.6.1.1 DETERMINATION OF THE CALIFORNIA BEARING RATIO OF A SOIL - Standard Laboratory Method.

A. AS 1289 5.1.1 Determination of The Dry Density/Moisture Relation of a Soil Using Standard Compaction - Standard Method.

B. AS 1289 5 2.1 Determination of The Dry Density/Moisture Relation of a Soil Using Modified Compaction - Standard Method.

C. AS 1289 2.1.1 Determination of The Moisture Content of a Soil - Oven Drying Method (Standard Method).

D. AS 1289 2.1.4 Determination of The Moisture Content of a Soil - Microwave-oven drying method(Subsidiary Method).

E. AS 1289 1.2.1(Clause 6.2)sampling from Stockpiles

F. AS 1289 1.2.1(Clause 6.5.3)Power Auger Drilling

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Authorised Signatory: Kari Dawes

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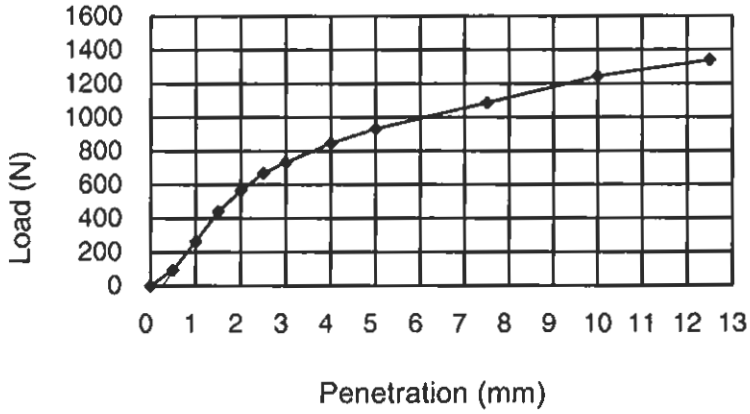
California Bearing Ratio Report (AS)

Client:	Barker Harle	**Job No.**	P09009-96
Project:	Material Assessment	**Report No.**	13
Location:	Saddlers Way, Wyee Point		



Sample Information

Date Sampled:	02/06/09	Date Tested:	09/06/09	Sample No.	6
Soil Description:	(CH) Sandy CLAY, dark brown, m-h plas, fico sand with a trace of fime gravel				
Source Location:	BH6 -500mm				

Compaction and Placement Data

Compaction Used		Standard	Dry Density			
Maximum Dry Density	t/m3	1.66	Before Soaking	1.65 t/m3	99.5	% Comp.
Optimum Moisture Content	%	20.4	After Soaking	1.65 t/m3	99.5	% Comp.
No. of Layers		3	Moisture Content			
Blows per Layer		53	At Compaction		%	20.5
Drop of Rammer	mm	300	After Soaking		%	21.5
Mass of Rammer	kg	2.7	After Penetration (Top 30mm)		%	24.5
Surcharge Used	kg	4.5	After Penetration (Entire Depth)		%	20.0
Substitution +19mm Sieve		No	Swell After 4 Days Soaking		%	0.5

California Bearing Ratio

CBR (Soaked) = 5.0 % at 2.5 mm Penetration

Procedures Used A,C

AS 1289.6.1.1 DETERMINATION OF THE CALIFORNIA BEARING RATIO OF A SOIL - Standard Laboratory Method.

A. AS 1289 5.1.1 Determination of The Dry Density/Moisture Relation of a Soil Using Standard Compaction - Standard Method.

B. AS 1289 5 2.1 Determination of The Dry Density/Moisture Relation of a Soil Using Modified Compaction - Standard Method.

C. AS 1289 2.1.1 Determination of The Moisture Content of a Soil - Oven Drying Method (Standard Method).

D. AS 1289 2.1.4 Determination of The Moisture Content of a Soil - Microwave-oven drying method(Subsidiary Method).

E. AS 1289 1.2.1(Clause 6.2)sampling from Stockpiles

F. AS 1289 1.2.1(Clause 6.5.3)Power Auger Drilling

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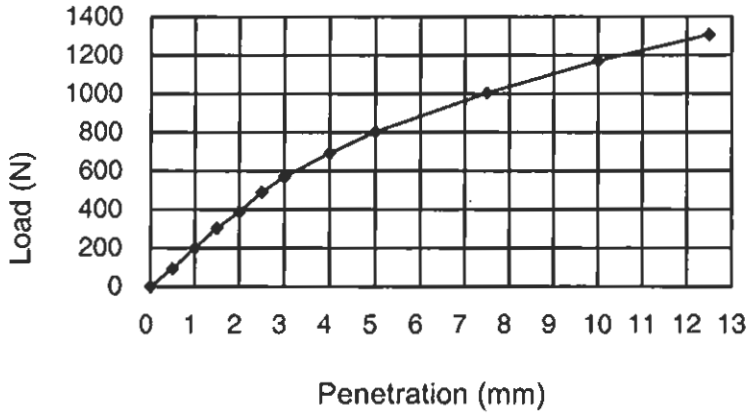
California Bearing Ratio Report (AS)

Client:	Barker Harle	**Job No.**	P09009-96
Project:	Material Assessment	**Report No.**	20
Location:	Saddlers Way, Wyee Point		



Sample Information

Date Sampled:	02/06/09	Date Tested:	09/06/09	Sample No.	9
Soil Description:	(CH) Sandy CLAY, pale brown, m-h plas, fico sand with a trace of fime gravel				
Source Location:	BH13 -500mm				

Compaction and Placement Data

Compaction Used		Standard	Dry Density			
Maximum Dry Density	t/m3	1.85	Before Soaking	1.84	t/m3	99.5 % Comp.
Optimum Moisture Content	%	14.7	After Soaking	1.84	t/m3	99.5 % Comp.
No. of Layers		3	Moisture Content			
Blows per Layer		53	At Compaction		%	15.0
Drop of Rammer	mm	300	After Soaking		%	15.5
Mass of Rammer	kg	2.7	After Penetration (Top 30mm)		%	16.0
Surcharge Used	kg	4.5	After Penetration (Entire Depth)		%	15.0
Substitution +19mm Sieve		No	Swell After 4 Days Soaking		%	0.2

California Bearing Ratio

CBR (Soaked) = 4.0 % at 2.5 mm Penetration

Procedures Used A,C

AS 1289.6.1.1 DETERMINATION OF THE CALIFORNIA BEARING RATIO OF A SOIL - Standard Laboratory Method.

A. AS 1289 5.1.1 Determination of The Dry Density/Moisture Relation of a Soil Using Standard Compaction - Standard Method.

B. AS 1289 5 2.1 Determination of The Dry Density/Moisture Relation of a Soil Using Modified Compaction - Standard Method.

C. AS 1289 2.1.1 Determination of The Moisture Content of a Soil - Oven Drying Method (Standard Method).

D. AS 1289 2.1.4 Determination of The Moisture Content of a Soil - Microwave-oven drying method(Subsidiary Method).

E. AS 1289 1.2.1(Clause 6.2)sampling from Stockpiles

F. AS 1289 1.2.1(Clause 6.5.3)Power Auger Drilling

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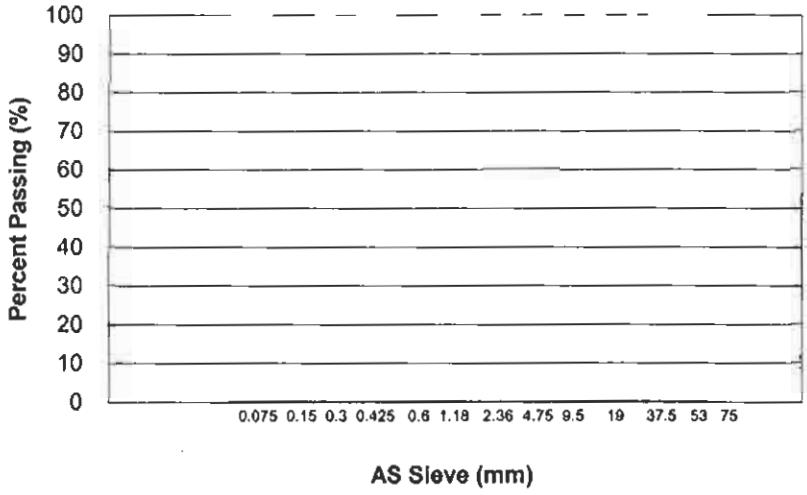
Aggregates for Engineering Purposes - A.S. Methods

Client: Barker Harle
Stockpile: BH 1
Stockpile Type:
Quarry:

Report No:P09009-96-1 **Page:** 1 of 1
Job No: P09009-96
Sample No: 1
Date Received: 2/6/09
Date Tested: 10/6/09

Sieve Size (mm)	% Passing	Specification
200	#DIV/0!	
75	#DIV/0!	
63	#DIV/0!	
53	#DIV/0!	
37.5	#DIV/0!	
26.5	#DIV/0!	
19	#DIV/0!	
13.2	#DIV/0!	
9.5	#DIV/0!	
6.7	#DIV/0!	
4.75	#DIV/0!	
2.36	#DIV/0!	
1.18	#DIV/0!	
0.600	#DIV/0!	
0.425	#DIV/0!	
0.300	#DIV/0!	
0.150	#DIV/0!	
0.075	#DIV/0!	

Particle Size Distribution



ATTERBERG LIMITS	Result	Spec.	Procedures
Liquid Limit	44%		
Plastic Limit	21%		
Plasticity Index	23%		
ear Shrinkage	9.5%		

Material Description:

Procedures Used: B, C, D, E, L

(A) AS 1289.3.1.1 L.L. - Standard Method
(B) AS 1289.3.1.2 L.L. - Subsidiary Method
(C) AS1289.3.2.1 Plastic Limit
(D) AS1289.3.3.1 Plasticity Index
(E) AS1289 3.4.1-Linear Shrinkage
(F) AS1289.3.6.1 (P.S.D)
(G) AS1141.11 (P.S.D)
(H) AS1141.12(Wash)
(I) AS1141.3.1(Clause 6.9.2)
(J) Sampled by Client
(K) Sampled by VCL to AS1289.1.2.1(clause 6.2)
(L) Sampled by VCL to AS1289.1.2.1(clause 6.5.1)

Comments

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Date: 23/6/09

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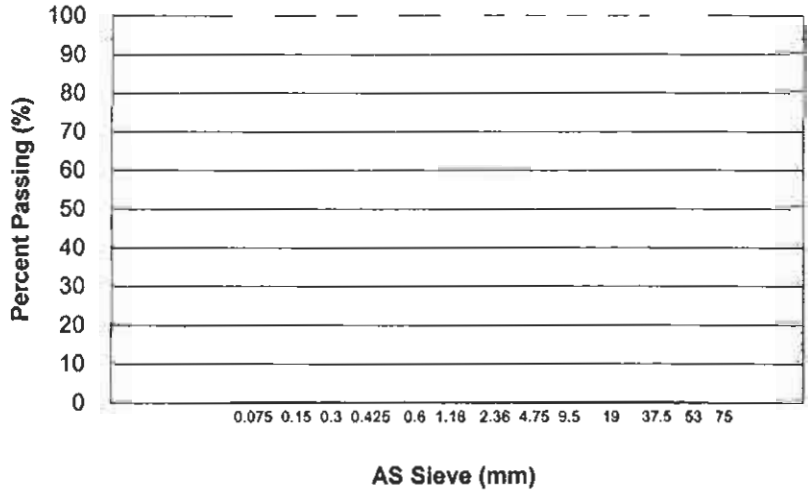
Aggregates for Engineering Purposes - A.S. Methods

Client: Barker Harle
Stockpile: BH 2
Stockpile Type:
Quarry:

Report No:P09009-96-5 **Page:** 1 of 1
Job No: P09009-96
Sample No: 2
Date Received: 2/6/09
Date Tested: 10/6/09

Sieve Size (mm)	% Passing	Specification
200	#DIV/0!	
75	#DIV/0!	
63	#DIV/0!	
53	#DIV/0!	
37.5	#DIV/0!	
26.5	#DIV/0!	
19	#DIV/0!	
13.2	#DIV/0!	
9.5	#DIV/0!	
6.7	#DIV/0!	
4.75	#DIV/0!	
2.36	#DIV/0!	
1.18	#DIV/0!	
0.600	#DIV/0!	
0.425	#DIV/0!	
0.300	#DIV/0!	
0.150	#DIV/0!	
0.075	#DIV/0!	

Particle Size Distribution



ATTERBERG LIMITS	Result	Spec.	Procedures
Liquid Limit	23%		
Plastic Limit	12%		
Plasticity Index	11%		
ear Shrinkage	4%		

Material Description:

Procedures Used: B, C, D, E, L

(A) AS 1289.3.1.1 L.L. - Standard Method
(B) AS 1289.3.1.2 L.L. - Subsidiary Method
(C) AS1289.3.2.1 Plastic Limit
(D) AS1289.3.3.1 Plasticity Index
(E) AS1289 3.4.1-Linear Shrinkage
(F) AS1289.3.6.1 (P.S.D)
(G) AS1141.11 (P.S.D)
(H) AS1141.12(Wash)
(I) AS1141.3.1(Clause 6.9.2)
(J) Sampled by Client
(K) Sampled by VCL to AS1289.1.2.1(clause 6.2)
(L) Sampled by VCL to AS1289.1.2.1(clause 6.5.1)

Comments

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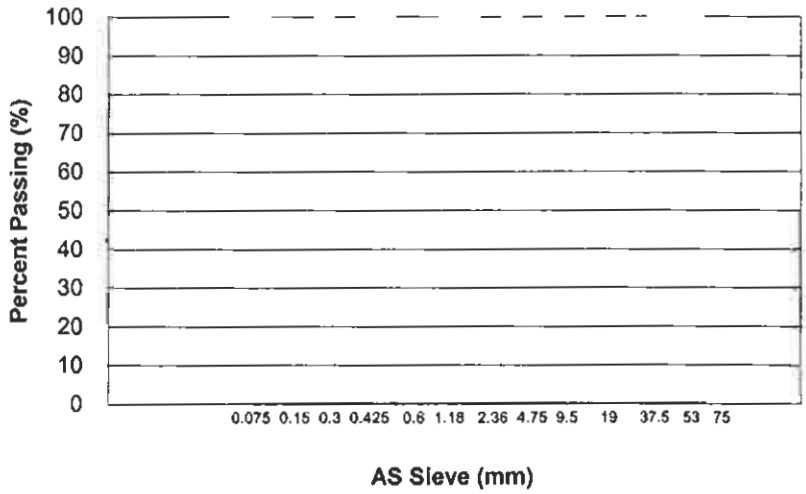
Aggregates for Engineering Purposes - A.S. Methods

Client: Barker Harle
Stockpile: BH 6
Stockpile Type:
Quarry:

Report No:P09009-96-12 **Page:** 1 of 1
Job No: P09009-96
Sample No: 6
Date Received: 2/6/09
Date Tested: 10/6/09

Sieve Size (mm)	% Passing	Specification
200	#DIV/0!	
75	#DIV/0!	
63	#DIV/0!	
53	#DIV/0!	
37.5	#DIV/0!	
26.5	#DIV/0!	
19	#DIV/0!	
13.2	#DIV/0!	
9.5	#DIV/0!	
6.7	#DIV/0!	
4.75	#DIV/0!	
2.36	#DIV/0!	
1.18	#DIV/0!	
0.600	#DIV/0!	
0.425	#DIV/0!	
0.300	#DIV/0!	
0.150	#DIV/0!	
0.075	#DIV/0!	

Particle Size Distribution



ATTERBERG LIMITS	Result	Spec.	Procedures
Liquid Limit	35%		
Plastic Limit	15%		
Plasticity Index	20%		
ear Shrinkage	8%		

Material Description:

Procedures Used: B, C, D, E, L

(A) AS 1289.3.1.1 L.L. - Standard Method
(B) AS 1289.3.1.2 L.L. - Subsidiary Method
(C) AS1289.3.2.1 Plastic Limit
(D) AS1289.3.3.1 Plasticity Index
(E) AS1289 3.4.1-Linear Shrinkage
(F) AS1289.3.6.1 (P.S.D)
(G) AS1141.11 (P.S.D)
(H) AS1141.12(Wash)
(I) AS1141.3.1(Clause 6.9.2)
(J) Sampled by Client
(K) Sampled by VCL to AS1289.1.2.1(clause 6.2)
(L) Sampled by VCL to AS1289.1.2.1(clause 6.5.1)

Comments

NATA
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NATA Accredited Laboratory Number: 14975

Authorised Signatory: Karl Dawes

Date: 23/6/09

VALLEY CIVILAB. PO BOX 284, THORNTON, NSW, 2322. PH. (02) 4966 1844 FAX (02) 4966 1855

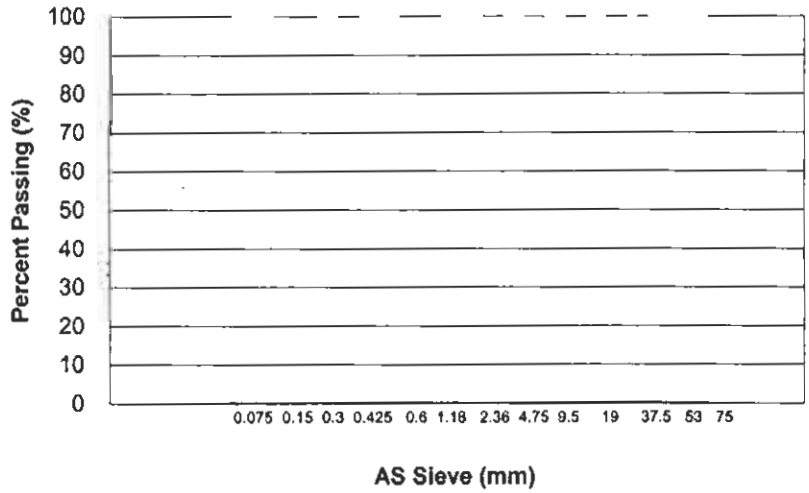
Aggregates for Engineering Purposes - A.S. Methods

Client: Barker Harle
Stockpile: BH 13
Stockpile Type:
Quarry:

Report No:P09009-96-19 **Page:** 1 of 1
Job No: P09009-96
Sample No: 9
Date Received: 2/6/09
Date Tested: 10/6/09

Sieve Size (mm)	% Passing	Specification
200	#DIV/0!	
75	#DIV/0!	
63	#DIV/0!	
53	#DIV/0!	
37.5	#DIV/0!	
26.5	#DIV/0!	
19	#DIV/0!	
13.2	#DIV/0!	
9.5	#DIV/0!	
6.7	#DIV/0!	
4.75	#DIV/0!	
2.36	#DIV/0!	
1.18	#DIV/0!	
0.600	#DIV/0!	
0.425	#DIV/0!	
0.300	#DIV/0!	
0.150	#DIV/0!	
0.075	#DIV/0!	

Particle Size Distribution



ATTERBERG LIMITS	Result	Spec.	Procedures
Liquid Limit	31%		
Plastic Limit	15%		
Plasticity Index	16%		
Linear Shrinkage	6.5%		

Material Description:

Procedures Used: B, C, D, E, L

(A) AS 1289.3.1.1 L.L. - Standard Method
(B) AS 1289.3.1.2 L.L. - Subsidiary Method
(C) AS1289.3.2.1 Plastic Limit
(D) AS1289.3.3.1 Plasticity Index
(E) AS1289 3.4.1-Linear Shrinkage
(F) AS1289.3.6.1 (P.S.D)
(G) AS1141.11 (P.S.D)
(H) AS1141.12(Wash)
(I) AS1141.3.1(Clause 6.9.2)
(J) Sampled by Client
(K) Sampled by VCL to AS1289.1.2.1(clause 6.2)
(L) Sampled by VCL to AS1289.1.2.1(clause 6.5.1)

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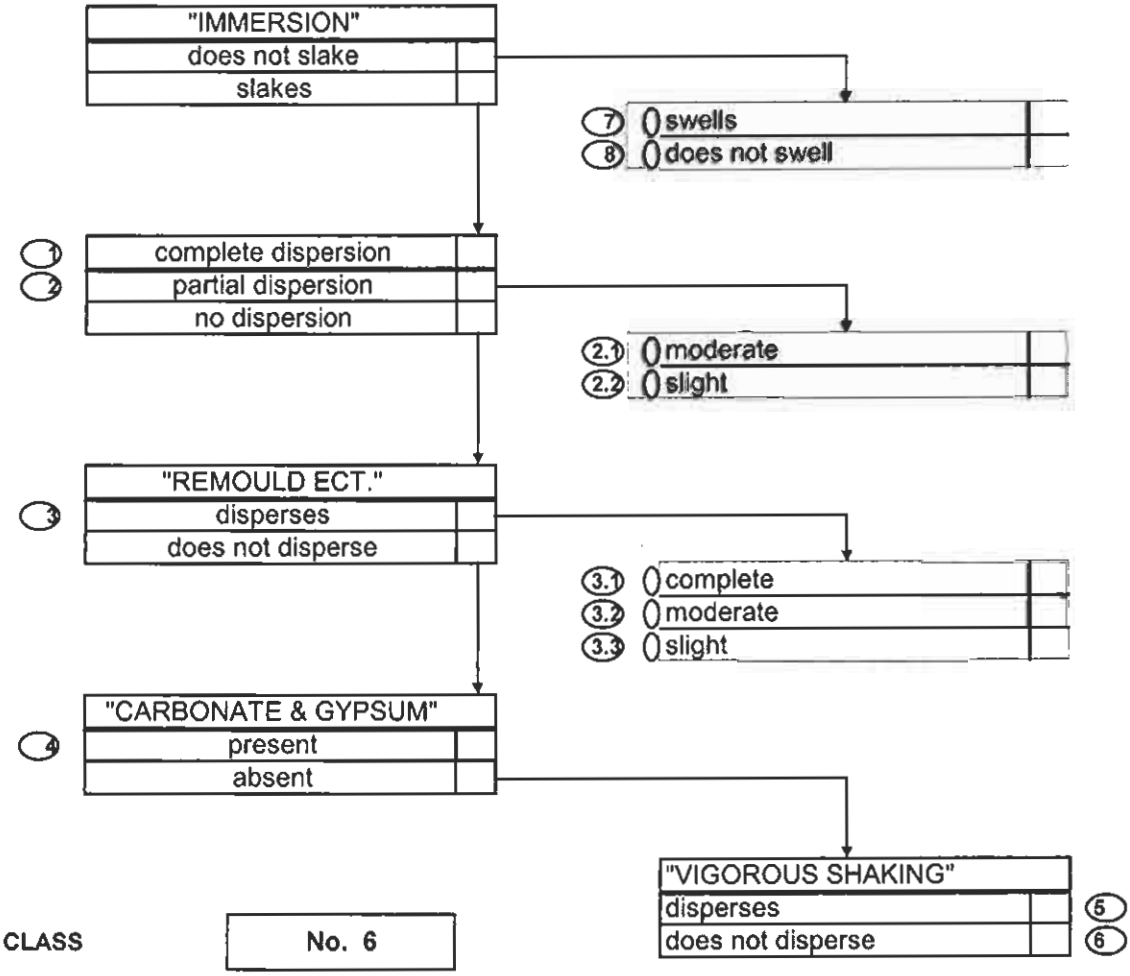
Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH1
Project:	Material Assessment	**Depth:**	0 - 100mm
Location:	Saddlers Way, Wyee Point	**Sample No:**	1
Date Tested:	4/06/2009	**Job No:**	P09009-96 **Report No:** 4

Test Method: AS1289 3.8.1



RESULT:
EMERSON CLASS **No. 6**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

Tested: **RB**	Date	**4/06/2009**	Comments
Checked:	**KD**		
Job No.	**P09009-96**		

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Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH2
Project:	Material Assessment	**Depth:**	-500mm
Location:	Saddlers Way, Wyee Point	**Sample No:**	2
Date Tested:	4/06/2009	**Job No:**	P09009-96 **Report No:** 8

Test Method: AS1289 3.8.1

"IMMERSION"
- does not slake
- slakes
  - (7) ( ) swells
  - (8) ( ) does not swell

(1) (2)
- complete dispersion
- partial dispersion
- no dispersion
  - (2.1) ( ) moderate
  - (2.2) ( ) slight

(3) "REMOULD ECT."
- disperses
- does not disperse
  - (3.1) ( ) complete
  - (3.2) ( ) moderate
  - (3.3) ( ) slight

(4) "CARBONATE & GYPSUM"
- present
- absent
  - "VIGOROUS SHAKING"
    - disperses (5)
    - does not disperse (6)

RESULT:
EMERSON CLASS **No. 5**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

Tested: **RB**		Date **4/06/2009**	Comments
Checked:	**KD**		
Job No.	**P09009-96**		

VALLEY CIVILAB. PO BOX 284, THORNTON, NSW, 2322. PH. (02) 4966 1844 FAX (02) 4966 1855

Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH3
Project:	Material Assessment	**Depth:**	
Location:	Saddlers Way, Wyee Point	**Sample No:**	3
Date Tested:	4/06/2009	**Job No:** P09009-96	**Report No:** 9

Test Method: AS1289 3.8.1

"IMMERSION"
- does not slake
- slakes
  - (7) swells
  - (8) does not swell

(1) complete dispersion
(2) partial dispersion
no dispersion
- (2.1) moderate
- (2.2) slight

"REMOULD ECT."
(3) disperses
does not disperse
- (3.1) complete
- (3.2) moderate
- (3.3) slight

"CARBONATE & GYPSUM"
(4) present
absent
- "VIGOROUS SHAKING"
  - disperses (5)
  - does not disperse (6)

RESULT:
EMERSON CLASS **No. 6**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

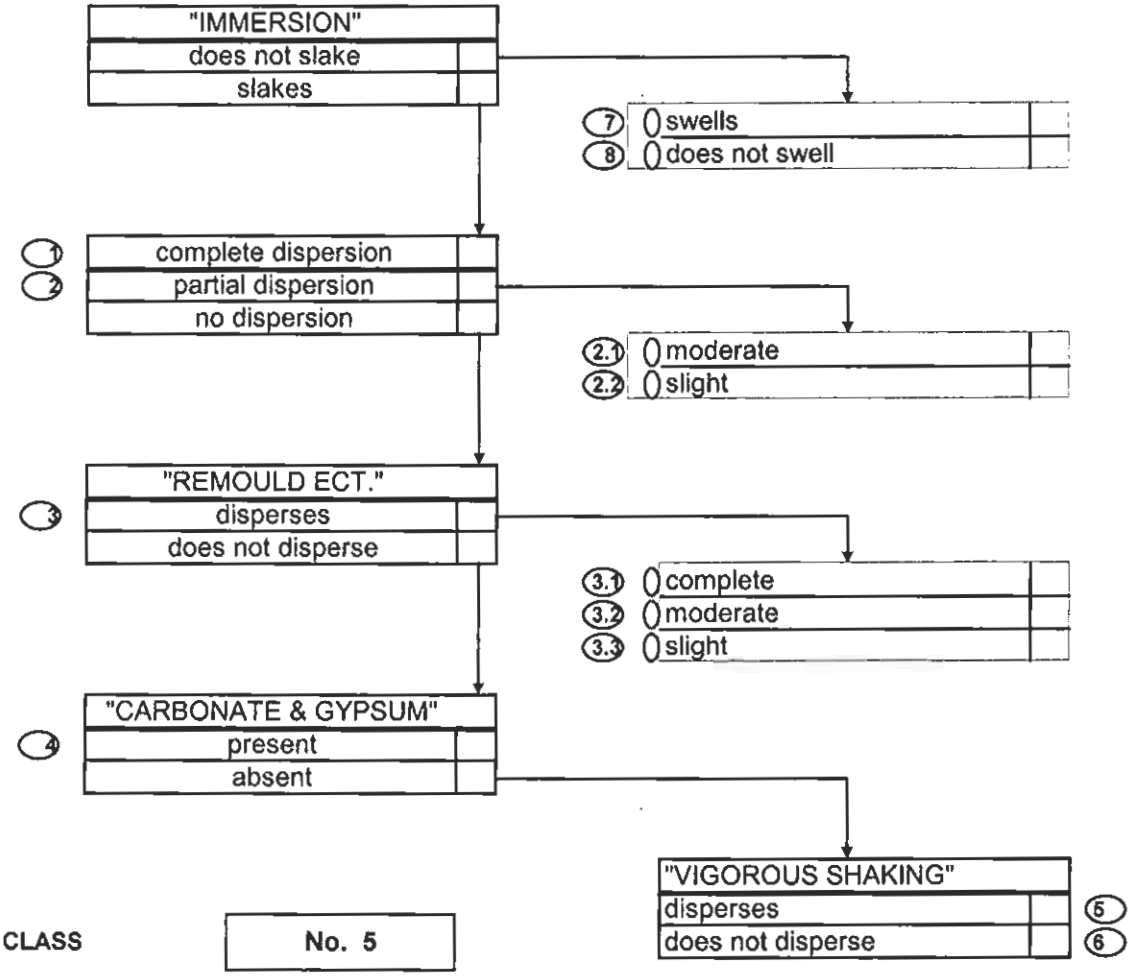
Tested: **RB**	Date	**4/06/2009**	Comments
Checked:	**KD**		
Job No.	**P09009-96**		

VALLEY CIVILAB. PO BOX 284, THORNTON, NSW, 2322. PH. (02) 4966 1844 FAX (02) 4966 1855

Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH4
Project:	Material Assessment	**Depth:**	
Location:	Saddlers Way, Wyee Point	**Sample No:**	4
Date Tested:	4/06/2009	**Job No:**	P09009-96 **Report No:** 10

Test Method: AS1289 3.8.1



RESULT:
EMERSON CLASS **No. 5**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

Tested: **RB**		Date	**4/06/2009**	Comments
Checked:	**KD**			
Job No.	**P09009-96**			

VALLEY CIVILAB. PO BOX 284, THORNTON, NSW, 2322. PH. (02) 4966 1844 FAX (02) 4966 1855

Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH5
Project:	Material Assessment	**Depth:**	0-100mm
Location:	Saddlers Way, Wyee Point	**Sample No:**	4
Date Tested:	4/06/2009	**Job No:**	P09009-96 **Report No:** 11

Test Method: AS1289 3.8.1

"IMMERSION"
- does not slake
- slakes
  - (7) ( ) swells
  - (8) ( ) does not swell

(1) (2)
- complete dispersion
- partial dispersion
- no dispersion
  - (2.1) ( ) moderate
  - (2.2) ( ) slight

(3) "REMOULD ECT."
- disperses
- does not disperse
  - (3.1) ( ) complete
  - (3.2) ( ) moderate
  - (3.3) ( ) slight

(4) "CARBONATE & GYPSUM"
- present
- absent
  - "VIGOROUS SHAKING"
    - disperses (5)
    - does not disperse (6)

RESULT:
EMERSON CLASS **No. 6**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

Tested: **RB**		Date	**4/06/2009**	Comments
Checked:	**KD**			
Job No.	**P09009-96**			

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Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH6
Project:	Material Assessment	**Depth:**	0-100mm
Location:	Saddlers Way, Wyee Point	**Sample No:**	6
Date Tested:	4/06/2009	**Job No:**	P09009-96 **Report No:** 15

Test Method: AS1289 3.8.1

"IMMERSION"
- does not slake
- slakes
  - (7) ( ) swells
  - (8) ( ) does not swell

(1) (2)
- complete dispersion
- partial dispersion
- no dispersion
  - (2.1) ( ) moderate
  - (2.2) ( ) slight

(3)
"REMOULD ECT."
- disperses
- does not disperse
  - (3.1) ( ) complete
  - (3.2) ( ) moderate
  - (3.3) ( ) slight

(4)
"CARBONATE & GYPSUM"
- present
- absent
  - "VIGOROUS SHAKING"
    - disperses (5)
    - does not disperse (6)

RESULT:
EMERSON CLASS **No. 5**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

Tested: **RB**		Date	**4/06/2009**	Comments
Checked:	**KD**			
Job No.	**P09009-96**			

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Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH7
Project:	Material Assessment	**Depth:**	0-100mm
Location:	Saddlers Way, Wyee Point	**Sample No:**	7
Date Tested:	4/06/2009	**Job No:**	P09009-96 **Report No:** 16

Test Method: AS1289 3.8.1

"IMMERSION"
- does not slake
- slakes
  - (7) ( ) swells
  - (8) ( ) does not swell

(1) (2) complete dispersion / partial dispersion / no dispersion
- (2.1) ( ) moderate
- (2.2) ( ) slight

(3) "REMOULD ECT."
- disperses
- does not disperse
  - (3.1) ( ) complete
  - (3.2) ( ) moderate
  - (3.3) ( ) slight

(4) "CARBONATE & GYPSUM"
- present
- absent

"VIGOROUS SHAKING"
- disperses (5)
- does not disperse (6)

RESULT:
EMERSON CLASS **No. 5**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

Tested: **RB**		Date	**4/06/2009**	Comments
Checked:	**KD**			
Job No.	**P09009-96**			

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Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH12
Project:	Material Assessment	**Depth:**	0-100mm
Location:	Saddlers Way, Wyee Point	**Sample No:**	8
Date Tested:	4/06/2009	**Job No:**	P09009-96 **Report No:** 18

Test Method: AS1289 3.8.1

"IMMERSION"
- does not slake
- slakes
  - (7) ( ) swells
  - (8) ( ) does not swell

(1) (2)
- complete dispersion
- partial dispersion
- no dispersion
  - (2.1) ( ) moderate
  - (2.2) ( ) slight

(3)
"REMOULD ECT."
- disperses
- does not disperse
  - (3.1) ( ) complete
  - (3.2) ( ) moderate
  - (3.3) ( ) slight

(4)
"CARBONATE & GYPSUM"
- present
- absent

"VIGOROUS SHAKING"
- disperses (5)
- does not disperse (6)

RESULT:
EMERSON CLASS **No. 5**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

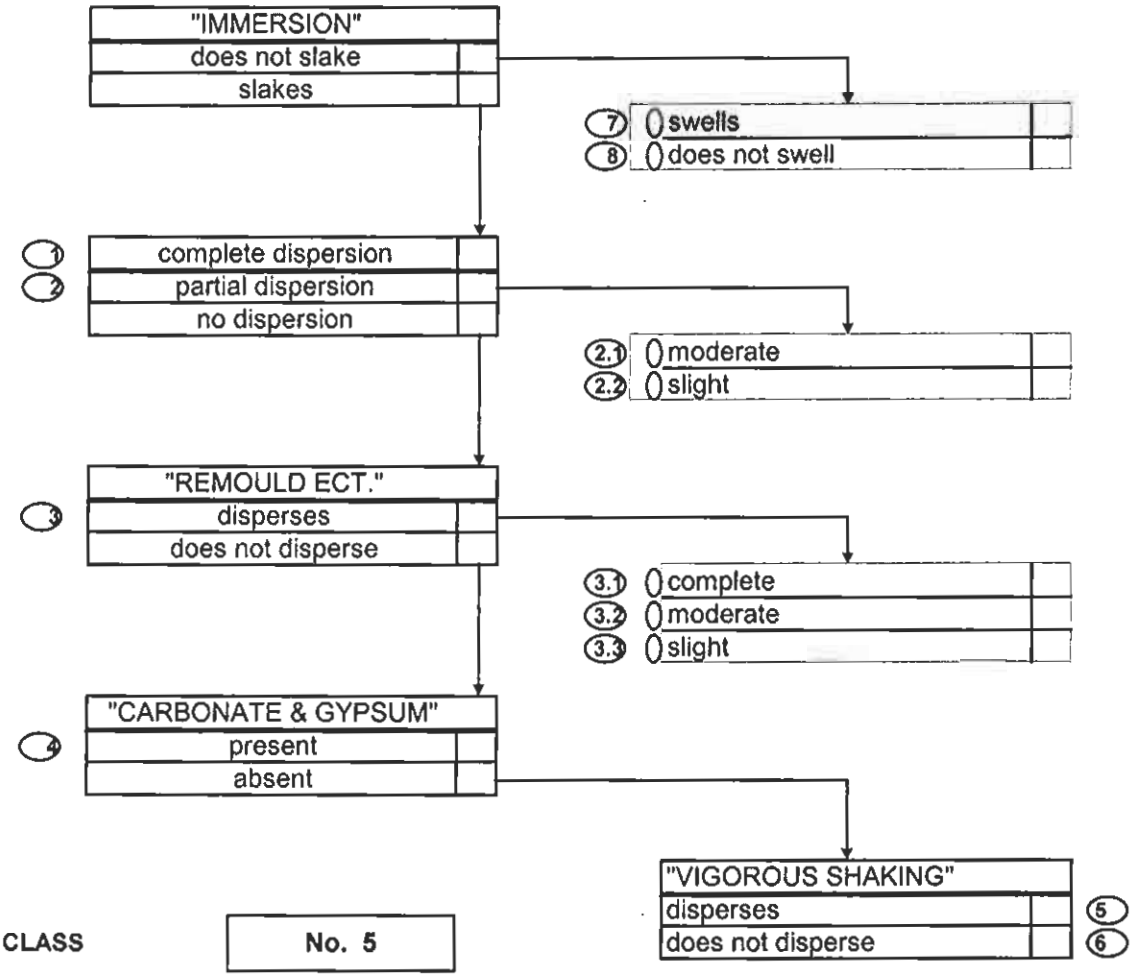
Tested: **RB**		Date	**4/06/2009**	Comments
Checked:	**KD**			
Job No.	**P09009-96**			

VALLEY CIVILAB. PO BOX 284, THORNTON, NSW, 2322. PH. (02) 4966 1844 FAX (02) 4966 1855

Emerson Crumb Test Worksheet / Report

Client:	Barker Harle	**Test Pit No:**	BH13
Project:	Material Assessment	**Depth:**	
Location:	Saddlers Way, Wyee Point	**Sample No:**	9
Date Tested:	4/06/2009	**Job No:**	P09009-96 **Report No:** 21

Test Method: AS1289 3.8.1



RESULT:
EMERSON CLASS **No. 5**

REMARKS:
Type & Temperature of Water Used for Testing
Distilled - 17°C

DESCRIPTION OF SAMPLE

Tested: **RB**		Date	**4/06/2009**	Comments
Checked:	**KD**			
Job No.	**P09009-96**			

VALLEYCIVILAB PTY LTD PO BOX 284 THORNTON NSW 2322 PH (02)49661844 FAX (02)49661855

SHRINK/SWELL INDEX REPORT

Client:	Barker Harle	**Job No.**	P09009-96
Project:	Material Assessment	**Report No.**	3
Location:	Saddlers Way, Wyee Point	**Date**	22/6/09

Sample Information

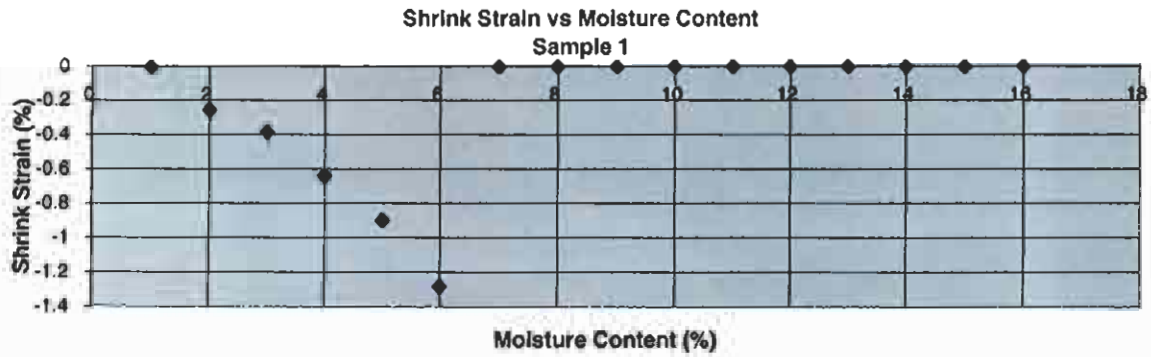
Sample No.	1
Date Sampled:	2/06/2009
Visual Description:	(CH) Sandy CLAY, m-h plas, fico sand with some fico gravel
Source location:	BH-1
Depth:	-0.4m

Sample Data

Extent of soil crumbling during shrinkage	Minor	
Extent of cracking of the shrinkage specimen	Minor	
Estimated Percentage of significant inert inclusion in the soil specimen %		10-15%
Sample Inundated with	Distilled Water	

Shrink- Swell Index Data

Swelling Strain	%	-1.7
Initial Moisture content	%	14.8
Initial Pocket Penetrometer reading	(kPa)	600
Final Moisture content	%	22.4
Final Pocket Penetrometer reading	(kPa)	500
Shrinkage Strain(oven Dry Condition)	%	1.3
Initial Moisture content	%	15.5
Shrink Swell Index. Iss	%	1.0



Procedures Used A C D

A. AS 1289. 1.3.1(Clause 3.1.3.2) Undisturbed Sampling using Thin walled sampler
B. AS 1289. 1.3.1(Clause 3.1.6.2) Auger core sampling
C. AS 1289. 7.1.1 Soil Reactivity Test - Determination of the Shrinkage index of a soil - Shrink swell index
D. AS 1289. 2.1.1 Determination of the Moisture Content of a Soil - Oven Drying Method (standard method)

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Authorised Signatory: Karl Dawes

Date: 23/6/09

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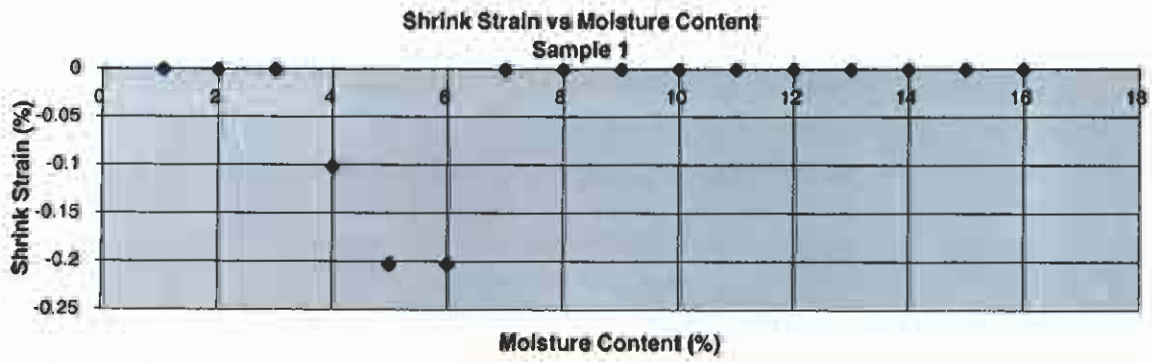
SHRINK/SWELL INDEX REPORT

Client:	Barker Harle	**Job No.**	P09009-96
Project:	Material Assessment	**Report No.**	7
Location:	Saddlers Way, Wyee Point	**Date**	22/6/09

Sample Information		
Sample No.	1	
Date Sampled:	2/06/2009	
Visual Description:	(CH) Sandy CLAY, grey/orange, m-h plas, fico sand with some fico gravel	
Source location:	BH-2	
Depth:	-0.5m	
Sample Data		
Extent of soil crumbling during shrinkage	Minor	
Extent of cracking of the shrinkage specimen	Minor	
Estimated Percentage of significant inert inclusion in the soil specimen %		10-15%
Sample Inundated with	Distilled Water	

Shrink- Swell Index Data		
Swelling Strain	%	-1.5
Initial Moisture content	%	12.3
Initial Pocket Penetrometer reading	(kPa)	400
Final Moisture content	%	13.4
Final Pocket Penetrometer reading	(kPa)	350
Shrinkage Strain(oven Dry Condition)	%	0.2
Initial Moisture content	%	10.9
Shrink Swell Index. Iss	%	0.1



Procedures Used A, C, D

A. AS 1289. 1.3.1(Clause 3.1.3.2) Undisturbed Sampling using Thin walled sampler
B. AS 1289. 1.3.1(Clause 3.1.6.2) Auger core sampling
C. AS 1289. 7.1.1 Soil Reactivity Test - Determination of the Shrinkage index of a soil - Shrink swell index
D. AS 1289. 2.1.1 Determination of the Moisture Content of a Soil - Oven Drying Method (standard method)

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Authorised Signatory: Karl Dawes

Date: 23/6/09

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SHRINK/SWELL INDEX REPORT

Client:	Barker Harle	**Job No.**	P09009-96
Project:	Material Assessment	**Report No.**	14
Location:	Saddlers Way, Wyee Point	**Date**	22/6/09

Sample Information

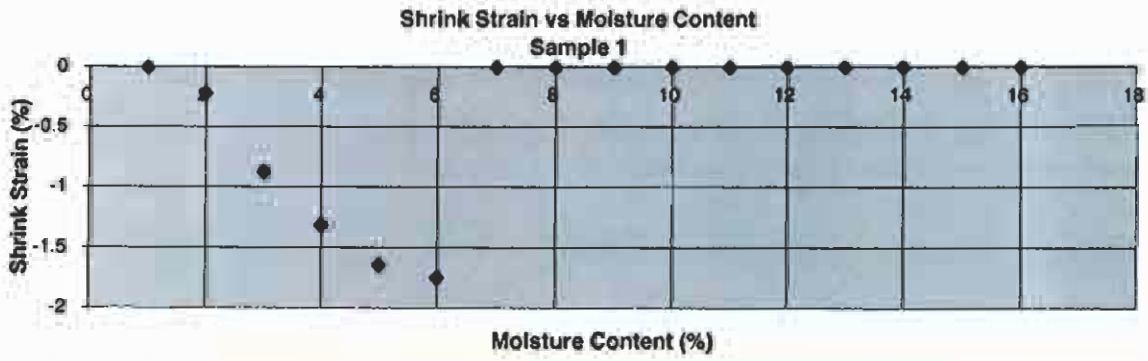
Sample No.	1
Date Sampled:	2/06/2009
Visual Description:	(CH) Sandy CLAY, grey/orange, m-h plas, fico sand with some fico gravel
Source location:	BH-6
Depth:	-0.5m

Sample Data

Extent of soil crumbling during shrinkage	Minor	
Extent of cracking of the shrinkage specimen	Minor	
Estimated Percentage of significant inert inclusion in the soil specimen %		10-15%
Sample Inundated with	Distilled Water	

Shrink- Swell Index Data

Swelling Strain	%	-0.9
Initial Moisture content	%	19.5
Initial Pocket Penetrometer reading	(kPa)	300
Final Moisture content	%	22
Final Pocket Penetrometer reading	(kPa)	300
Shrinkage Strain(oven Dry Condition)	%	1.7
Initial Moisture content	%	21
Shrink Swell Index. Iss	%	1.1



Procedures Used A, C, D

A. AS 1289. 1.3.1(Clause 3.1.3.2) Undisturbed Sampling using Thin walled sampler
B. AS 1289. 1.3.1(Clause 3.1.6.2) Auger core sampling
C. AS 1289. 7.1.1 Soil Reactivity Test - Determination of the Shrinkage index of a soil - Shrink swell index
D. AS 1289. 2.1.1 Determination of the Moisture Content of a Soil - Oven Drying Method (standard method)

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NATA Accredited Laboratory Number:14975

Authorised Signatory: Kari Dawes

Date: 23/6/09

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SHRINK/SWELL INDEX REPORT

Client:	Barker Harle	**Job No.**	P09009-96
Project:	Material Assessment	**Report No.**	17
Location:	Saddlers Way, Wyee Point	**Date**	22/6/09

Sample Information

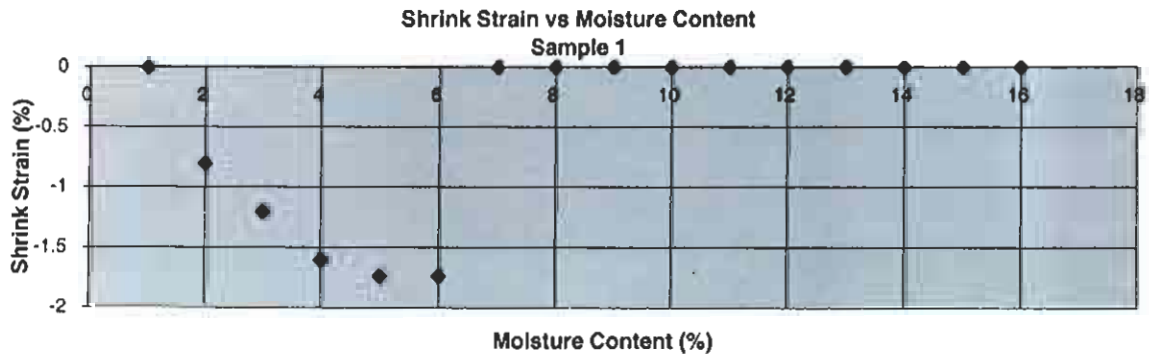
Sample No.	8
Date Sampled:	2/06/2009
Visual Description:	(CH) Sandy Silty CLAY, red/orange, m-h plas, fico sand with some lime gravel
Source location:	BH-12
Depth:	-0.6m

Sample Data

Extent of soil crumbling during shrinkage	Minor	
Extent of cracking of the shrinkage specimen	Minor	
Estimated Percentage of significant inert inclusion in the soil specimen %		10-15%
Sample inundated with	Distilled Water	

Shrink- Swell Index Data

Swelling Strain	%	-0.4
Initial Moisture content	%	22.6
Initial Pocket Penetrometer reading	(kPa)	150
Final Moisture content	%	22.4
Final Pocket Penetrometer reading	(kPa)	150
Shrinkage Strain(oven Dry Condition)	%	2.1
Initial Moisture content	%	20.2
Shrink Swell Index. Iss	%	1.0



Procedures Used: A, C, D

A. AS 1289. 1.3.1(Clause 3.1.3.2) Undisturbed Sampling using Thin walled sampler
B. AS 1289. 1.3.1(Clause 3.1.6.2) Auger core sampling
C. AS 1289. 7.1.1 Soil Reactivity Test - Determination of the Shrinkage index of a soil - Shrink swell index
D. AS 1289. 2.1.1 Determination of the Moisture Content of a Soil - Oven Drying Method (standard method)

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NATA Accredited Laboratory Number:14975

Authorised Signatory: Karl Dawes

Date: 23/6/09

LabMark
ENVIRONMENTAL LABORATORIES

Laboratory Report No: E043099
Client Name: Barker Harle (Aust) Pty Ltd
Contact Name: Mark Smith
Client Reference: RPS HSO - Wyee

Page: 1 of 12
plus cover page
Date: 10/06/09
This report supercedes reports issued on: N/A

Final
Certificate
of Analysis

Laboratory Identification		211350	211351	211352	211353	211354	211355	211356	211359	211362	211363
Sample Identification		BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH9	BH12	BH13
Depth (m)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sampling Date recorded on COC		1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09
Laboratory Extraction (Preparation) Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Laboratory Analysis Date		5/6/09	6/6/09	6/6/09	6/6/09	6/6/09	6/6/09	6/6/09	6/6/09	6/6/09	6/6/09
Method : E002.2											
BTEX by P&T	**EQL**										
Benzene	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Toluene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
meta- and para-Xylene	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ortho-Xylene	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Xylene	--	--	--	--	--	--	--	--	--	--	--
CDFB (Surr @ 10mg/kg)	--	*88%*	*96%*	*96%*	*89%*	*81%*	*90%*	*85%*	*85%*	*91%*	*94%*
Method : E003.2											
Volatile TPH by P&T (vTPH)	**EQL**										
C6 - C9 Fraction	10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E002.2: 8-10g soil extracted with 20ml methanol. Analysis by P&T/GC/PID/MSD.
E003.2: 8-10g soil extracted with 20ml methanol. Analysis by P&T/GC/FID.

Laboratory Identification		**211350d**	**211350r**	**211351s**	**lcs**	**mb**					
Sample Identification		QC	QC	QC	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		--	--	--	--	--					
Laboratory Extraction (Preparation) Date		5/6/09	--	5/6/09	5/6/09	5/6/09					
Laboratory Analysis Date		5/6/09	--	6/6/09	5/6/09	5/6/09					
Method : E002.2											
BTEX by P&T	**EQL**										
Benzene	0.2	<0.2	--	86%	101%	<0.2					
Toluene	0.5	<0.5	--	86%	103%	<0.5					
Ethylbenzene	0.5	<0.5	--	82%	101%	<0.5					
meta- and para-Xylene	1	<1	--	83%	106%	<1					
ortho-Xylene	0.5	<0.5	--	84%	108%	<0.5					
Total Xylene	--	--	--	--	--	--					
CDFB (Surr @ 10mg/kg)	--	*88%*	*0%*	*92%*	*107%*	*106%*					
Method : E003.2											
Volatile TPH by P&T (vTPH)	**EQL**										
C6 - C9 Fraction	10	<10	--	78%	105%	<10					

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E002.2: 8-10g soil extracted with 20ml methanol. Analysis by P&T/GC/PID/MSD.
E003.2: 8-10g soil extracted with 20ml methanol. Analysis by P&T/GC/FID.

Laboratory Identification		**211350**	**211351**	**211352**	**211353**	**211354**	**211355**	**211356**	**211359**	**211362**	**211363**
Sample Identification		BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH9	BH12	BH13
Depth (m)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sampling Date recorded on COC		1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09
Laboratory Extraction (Preparation) Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Laboratory Analysis Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Method : E006.2											
Petroleum Hydrocarbons (TPH)	**EQL**										
C10 - C14 Fraction	50	<50	<50	<50	<50	<50	<50	120	<50	<50	<50
C15 - C28 Fraction	100	<100	<100	<100	<100	120	<100	<100	<100	<100	<100
C29 - C36 Fraction	100	<100	<100	<100	<100	250	<100	130	130	<100	<100
Sum of TPH C10 - C36	--	--	--	--	--	370	--	250	130	--	--

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E006.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45). Analysis by GC/FID.

Laboratory Identification		211350d	211350r	211351s	lcs	mb					
Sample Identification		QC	QC	QC	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		--	--	--	--	--					
Laboratory Extraction (Preparation) Date		5/6/09	--	5/6/09	5/6/09	5/6/09					
Laboratory Analysis Date		5/6/09	--	5/6/09	5/6/09	5/6/09					
Method : E006.2											
Petroleum Hydrocarbons (TPH)	**EQL**										
C10 - C14 Fraction	50	<50	--	--	--	<50					
C15 - C28 Fraction	100	<100	--	79%	79%	<100					
C29 - C36 Fraction	100	<100	--	--	--	<100					
Sum of TPH C10 - C36	--	--	--	--	--	--					

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E006.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45). Analysis by GC/FID.

Laboratory Identification		211350	211351	211352	211353	211354	211355	211356	211359	211362	211363
Sample Identification		BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH9	BH12	BH13
Depth (m)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sampling Date recorded on COC		1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09
Laboratory Extraction (Preparation) Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Laboratory Analysis Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Method : E013.2											
Organochlorine Pesticides (OC)	**EQL**										
a-BHC	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Hexachlorobenzene	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
b-BHC	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
g-BHC (Lindane)	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
d-BHC	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aldrin	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Heptachlor epoxide	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
trans-chlordane	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan I	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
cis-chlordane	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dieldrin	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
4,4-DDE	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endrin	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan II	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
4,4-DDD	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Endosulfan sulphate	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
4,4-DDT	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Methoxychlor	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
DBC (Surr @ 0.2mg/kg)	--	*87%*	*85%*	*95%*	*90%*	*78%*	*76%*	*84%*	*75%*	*79%*	*85%*

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E013.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45). Analysis by GC/dual ECD.

Laboratory Identification		211350d	211350r	211351s	lcs	mb					
Sample Identification		QC	QC	QC	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		--	--	--	--	--					
Laboratory Extraction (Preparation) Date		5/6/09	--	5/6/09	5/6/09	5/6/09					
Laboratory Analysis Date		5/6/09	--	5/6/09	5/6/09	5/6/09					
Method : E013.2											
Organochlorine Pesticides (OC)	**EQL**										
a-BHC	0.05	<0.05	--	87%	97%	<0.05					
Hexachlorobenzene	0.05	<0.05	--	77%	88%	<0.05					
b-BHC	0.05	<0.05	--	94%	107%	<0.05					
g-BHC (Lindane)	0.05	<0.05	--	93%	103%	<0.05					
d-BHC	0.05	<0.05	--	105%	119%	<0.05					
Heptachlor	0.05	<0.05	--	94%	108%	<0.05					
Aldrin	0.05	<0.05	--	87%	100%	<0.05					
Heptachlor epoxide	0.05	<0.05	--	93%	102%	<0.05					
trans-chlordane	0.05	<0.05	--	93%	106%	<0.05					
Endosulfan I	0.05	<0.05	--	93%	106%	<0.05					
cis-chlordane	0.05	<0.05	--	93%	108%	<0.05					
Dieldrin	0.05	<0.05	--	107%	120%	<0.05					
4,4-DDE	0.05	<0.05	--	107%	120%	<0.05					
Endrin	0.05	<0.05	--	96%	114%	<0.05					
Endosulfan II	0.05	<0.05	--	93%	109%	<0.05					
4,4-DDD	0.05	<0.05	--	94%	110%	<0.05					
Endosulfan sulphate	0.05	<0.05	--	96%	116%	<0.05					
4,4-DDT	0.2	<0.2	--	93%	109%	<0.2					
Methoxychlor	0.2	<0.2	--	93%	114%	<0.2					
DBC (Surr @ 0.2mg/kg)	--	*95%*	*9%*	*91%*	*104%*	*102%*					

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E013.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45). Analysis by GC/dual ECD.

Laboratory Identification		**211350**	**211351**	**211352**	**211353**	**211354**	**211355**	**211356**	**211359**	**211362**	**211363**
Sample Identification		BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH9	BH12	BH13
Depth (m)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sampling Date recorded on COC		1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09
Laboratory Extraction (Preparation) Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Laboratory Analysis Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Method : E013.2											
Polychlorinated Biphenyls (PCB)	**EQL**										
Arochlor 1016	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arochlor 1232	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arochlor 1242	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arochlor 1248	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arochlor 1254	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arochlor 1260	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sum of reported PCBs	--	--	--	--	--	--	--	--	--	--	--
DBC (Surr @ 0.2mg/kg)	--	*87%*	*85%*	*95%*	*90%*	*78%*	*76%*	*84%*	*75%*	*79%*	*85%*

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E013.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45). Analysis by GC/dual ECD.

Laboratory Identification		**211350d**	**211350r**	**211351s**	**lcs**	**mb**					
Sample Identification		QC	QC	QC	QC	QC					
Depth (m)		--	--	--	--	--					
Sampling Date recorded on COC		--	--	--	--	--					
Laboratory Extraction (Preparation) Date		5/6/09	--	5/6/09	5/6/09	5/6/09					
Laboratory Analysis Date		5/6/09	--	5/6/09	5/6/09	5/6/09					
Method : E013.2											
Polychlorinated Biphenyls (PCB)	**EQL**										
Arochlor 1016	0.5	<0.5	--	--	--	<0.5					
Arochlor 1232	0.5	<0.5	--	--	--	<0.5					
Arochlor 1242	0.5	<0.5	--	--	--	<0.5					
Arochlor 1248	0.5	<0.5	--	--	--	<0.5					
Arochlor 1254	0.5	<0.5	--	110%	98%	<0.5					
Arochlor 1260	0.5	<0.5	--	--	--	<0.5					
Sum of reported PCBs	--	--	--	--	--	--					
DBC (Surr @ 0.2mg/kg)	--	*95%*	*9%*	*103%*	*105%*	*102%*					

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E013.2: 8-10g soil extracted with 20ml DCM/Acetone/Hexane (10:45:45). Analysis by GC/dual ECD.

Laboratory Identification		**211350**	**211351**	**211352**	**211353**	**211354**	**211355**	**211356**	**211359**	**211362**	**211363**
Sample Identification		BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH9	BH12	BH13
Depth (m)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sampling Date recorded on COC		1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09
Laboratory Extraction (Preparation) Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Laboratory Analysis Date		9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09
Method : E022.2											
Acid extractable metals (M7)	**EQL**										
Arsenic	1	1	<1	1	<1	1	3	1	<1	<1	<1
Cadmium	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	0.2	<0.1	0.1
Chromium	1	6	2	4	2	3	8	8	2	4	3
Copper	2	2	<2	<2	<2	<2	<2	2	<2	2	<2
Nickel	1	2	<1	<1	<1	<1	<1	<1	<1	2	<1
Lead	2	5	3	4	4	5	5	8	4	5	3
Zinc	5	15	<5	<5	<5	<5	<5	5	<5	10	<5

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E022.2: 0.5g digested in nitric/hydrochloric acid. Analysis by ICP-MS.

Laboratory Identification		211350d	211350r	211351s	crm	lcs	mb				
Sample Identification		QC	QC	QC	QC	QC	QC				
Depth (m)		--	--	--	--	--	--				
Sampling Date recorded on COC		--	--	--	--	--	--				
Laboratory Extraction (Preparation) Date		5/6/09	--	5/6/09	5/6/09	5/6/09	5/6/09				
Laboratory Analysis Date		9/6/09	--	9/6/09	9/6/09	9/6/09	9/6/09				
Method : E022.2											
Acid extractable metals (M7)	**EQL**										
Arsenic	1	1	0%	71%	94%	81%	<1				
Cadmium	0.1	<0.1	--	114%	96%	110%	<0.1				
Chromium	1	6	0%	98%	83%	76%	<1				
Copper	2	2	0%	71%	95%	78%	<2				
Nickel	1	1	67%	70%	86%	75%	<1				
Lead	2	4	22%	97%	100%	97%	<2				
Zinc	5	10	40%	80%	93%	81%	<5				

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E022.2: 0.5g digested in nitric/hydrochloric acid. Analysis by ICP-MS.

Laboratory Identification		211350	211351	211352	211353	211354	211355	211356	211359	211362	211363
Sample Identification		BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH9	BH12	BH13
Depth (m)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sampling Date recorded on COC		1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09
Laboratory Extraction (Preparation) Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Laboratory Analysis Date		9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09
Method : E026.2											
Acid extractable metals - mercury	**EQL**										
Mercury	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	<0.05	<0.05	<0.05

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E026.2: 0.5g digested with nitric/hydrochloric acid. Analysis by CV-ICP-MS or FIMS.

Laboratory Identification		211350d	211350r	211351s	crm	lcs	mb				
Sample Identification		QC	QC	QC	QC	QC	QC				
Depth (m)		--	--	--	--	--	--				
Sampling Date recorded on COC		--	--	--	--	--	--				
Laboratory Extraction (Preparation) Date		5/6/09	--	5/6/09	5/6/09	5/6/09	5/6/09				
Laboratory Analysis Date		9/6/09	--	9/6/09	9/6/09	9/6/09	9/6/09				
Method : E026.2											
Acid extractable metals - mercury	**EQL**										
Mercury	0.05	<0.05	--	94%	99%	94%	<0.05				

Results expressed in mg/kg dry weight unless otherwise specified

Comments:

E026.2: 0.5g digested with nitric/hydrochloric acid. Analysis by CV-ICP-MS or FIMS.

Laboratory Identification		211350	211351	211352	211353	211354	211355	211356	211359	211362	211363
Sample Identification		BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH9	BH12	BH13
Depth (m)		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sampling Date recorded on COC		1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09	1/6/09
Laboratory Extraction (Preparation) Date		5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
Laboratory Analysis Date		9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09	9/6/09
Method : E005.2											
Moisture	**EQL**										
Moisture	--	11	11	9	15	14	16	21	21	15	12

Results expressed in % w/w unless otherwise specified

Comments:

E005.2: Moisture by gravimetric analysis. Results are in % w/w.

Laboratory Identification		211350d	211350r								
Sample Identification		QC	QC								
Depth (m)		--	--								
Sampling Date recorded on COC		--	--								
Laboratory Extraction (Preparation) Date		5/6/09	--								
Laboratory Analysis Date		9/6/09	--								
Method : E005.2											
Moisture	**EQL**										
Moisture	--	12	9%								

Results expressed in % w/w unless otherwise specified

Comments:

E005.2: Moisture by gravimetric analysis. Results are in % w/w.

RESULTS OF ACID SULFATE SOIL ANALYSIS

6 samples supplied by Labmark on 5th June 2009 - Lab. Job No. A3777
Analysis requested by Leanne Boag - **Your Project: E043099**

Sample Site	Depth (m)	EAL lab code	Texture (note 7)	Moisture Content (% moisture)	Extractable sulfate sulfur $\%S_{kcl}$	Extractable Calcium $\%Ca_{kcl}$	Extractable Magnesium $\%Mg_{kcl}$	Oxidisable Sulfur $\%S_{pos}$ (as $\%S_p$ - $\%S_{kcl}$)	Oxidisable Sulfur S_{pos} mole H^+/tonne	Oxidisable Calcium $\%Ca_A$ (%Cap - %Cakcl)	Oxidisable Magnesium $\%Mg_A$ (%Mgp - %Mgkcl)	% ANC_{BT} $\%CaCO_3$	ANC_{BT} mole H^+/tonne
Method No.					*23C*	*23V*	*23S*	*23E*	*a-23E*	*23X*	*23U*	*19A2*	*a-19A2*
BH8	0.5	*A3777/1*	Medium	43.4	0.04	0.16	0.17	0.09	54	0.00	0.00	0.59	118
BH8	1.0	*A3777/2*	Medium	19.0	0.04	0.02	0.04	0.44	273	0.00	0.00	..	0
BH11	0.5	*A3777/3*	Medium	16.2	0.01	0.00	0.02	0.02	13	0.00	0.00	..	0
BH11	1.0	*A3777/4*	Medium	20.3	0.01	0.01	0.03	0.03	17	0.00	0.00	..	0
BH14	0.5	*A3777/5*	Medium	70.9	0.19	0.15	0.35	0.56	349	0.00	0.00	..	0
BH14	1.0	*A3777/6*	Medium	25.2	0.03	0.02	0.06	0.32	201	0.00	0.00	..	0

if pH_{KCL} >6.5

NOTE:

1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)
3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines.*** QLD DNRME.
4 - Bulk Density is required for liming rate calculations per soil volume. Lab. Bulk Density is no longer applicable - field bulk density rings can be used and dried/ weighed in the laboratory.
5 - **ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)**
6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)
7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
8 - .. denotes not requested or required
9 - SCREENING, CRS, TAA and ANC are NATA certified but other SPOCAS segments are currently not NATA certified
10- Results at or below detection limits are replaced with '0' for calculation purposes.
11 - **Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).**

(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H+/t; medium Scr≥0.06%S or 37mole H+/t; fine Scr≥0.1%S or 62mole H+/t)

checked: .....

TAA pH_{kcl}	Titratable Actual Acidity (TAA) mole H^+/tonne (to pH 6.5)	TPA pH_{ox}	TPA pH_{TPA}	Titratable Potential Acidity (TPA) mole H^+/tonne (to pH 6.5)	Titratable Sulphidic Acidity (TSA) mole H^+/tonne	NET ACIDITY SPOCAS Suite mole H^+/tonne (based on %Spos)	NET ACIDITY TPA Only mole H^+/tonne (based on TPA)	LIME CALCULATION SPOCAS Suite kg $CaCO_3$/tonne DW (includes 1.5 safety Factor)	LIME CALCULATION TPA Only kg $CaCO_3$/tonne DW (includes 1.5 safety Factor)
23A	*23F*	*23B*		*23G*	*23H*	*note 5*	*note 5*	*note 5*	*note 5*
7.03	0	5.77	6.14	3	3	-25	3	-2	0
5.39	17	2.05	2.24	589	572	290	589	22	44
4.45	22	3.26	4.22	28	6	35	28	3	2
4.42	31	3.45	4.09	38	7	48	38	4	3
5.15	70	2.04	2.34	1001	931	419	1001	31	75
5.11	17	2.45	2.59	197	180	218 Refer Note 6 & 7	197 Refer Note 6 & 7	16	15

checked: .....

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Monday, June 29, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW078094

Works Details (top)

GROUNDWATER NUMBER	GW078094
LIC-NUM	20BL166575
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Air
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1996-12-16
FINAL-DEPTH (metres)	30.40
DRILLED-DEPTH (metres)	30.40
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	5.00
SALINITY	500.00
YIELD	0.30

Site Details (top)

REGION	20 - HUNTER
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6331113.00
EASTING	360784.00
LATITUDE	33 8' 59"
LONGITUDE	151 30' 26"
GS-MAP	

AMG-ZONE	56
COORD-SOURCE	
REMARK	

Form-A (top)

COUNTY	NORTHUMBERLAND
PARISH	MORISSET
PORTION-LOT-DP	LOT 401 DP 787764

Licensed (top)

COUNTY	NORTHUMBERLAND
PARISH	MORISSET
PORTION-LOT-DP	401 787764

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	21.30	195			Rotary Air
1		Hole	Hole	21.30	30.40	165			Down Hole Hammer
1	1	Casing	PVC Class 9	-0.20	30.40	140			C: 0-1.5m; Glued; Seated on Bottom
1	1	Opening	Slots - Vertical	18.00	30.40	140			PVC Class 9; Sawn; A 2.5mm
1		Annulus	Waterworn/Rounded	1.50	30.40				(Unknown) GS: 7-10mm; Q: .6m³

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
21.30	22.00	0.70		5.00		0.20	23.00	1.00	480.00
25.00	25.50	0.50		5.00		0.30	27.00	1.00	500.00

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.50	0.50	Topsoil		
0.50	1.00	0.50	Clay, dry		

1.00	10.00	9.00	Sandstone Yellow, soft
10.00	12.00	2.00	White clay
12.00	15.00	3.00	Sandstone Grey
15.00	18.00	3.00	White clay
18.00	19.00	1.00	Sandstone Grey
19.00	21.30	2.30	Clay Small Gravel
21.30	30.40	9.10	Sandstone Grey

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Monday, June 29, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW078214

Works Details (top)

GROUNDWATER NUMBER	GW078214
LIC-NUM	20BL167477
AUTHORISED-PURPOSES	DOMESTIC STOCK
INTENDED-PURPOSES	DOMESTIC STOCK
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1999-03-03
FINAL-DEPTH (metres)	36.00
DRILLED-DEPTH (metres)	36.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details (top)

REGION	20 - HUNTER
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6330799.00
EASTING	360811.00
LATITUDE	33 9' 10"
LONGITUDE	151 30' 27"
GS-MAP	

AMG-ZONE	56
COORD-SOURCE	
REMARK	

Form-A (top)

COUNTY	NORTHUMBERLAND
PARISH	MORISSET
PORTION-LOT-DP	502/788556

Licensed (top)

COUNTY	NORTHUMBERLAND
PARISH	MORISSET
PORTION-LOT-DP	502 788556

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter; ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	17.50	210			Down Hole Hammer
1		Hole	Hole	17.50	36.00	150			Down Hole Hammer
1	1	Casing	PVC Class 9	-0.50	17.50	150			C: -.1-17.5m; Screwed and Glued; Seated on Bottom; Open End

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
9.80	20.70	10.90		12.00	25.00	0.63	25.00	0.50	Fresh
28.80	29.90	1.10		9.00	25.00	2.00	36.00	2.00	Fresh

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.10	0.10	Topsoil		
0.10	3.10	3.00	Clay Red		
3.10	15.80	12.70	Sandy Clays Grey/Red/Yellow		
15.80	19.80	4.00	Sandstone Grey		

19.80	20.70	0.90	Sandstone Grey WB
20.70	28.80	8.10	Sandstone/Clays Grey
28.80	29.90	1.10	Fractured Sandstone Grey
29.90	36.00	6.10	Sandstone Grey

Groundwater Works Summary

For information on the meaning of fields please see Glossary
Document Generated on Monday, June 29, 2009

Print Report

Works Details Site Details Form A Licensed Construction Water Bearing Zones Drillers Log

Work Requested -- GW078060

Works Details (top)

GROUNDWATER NUMBER	GW078060
LIC-NUM	20BL166816
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	DOMESTIC
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1998-03-17
FINAL-DEPTH (metres)	28.00
DRILLED-DEPTH (metres)	28.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	-
GW-ZONE	-
STANDING-WATER-LEVEL	15.00
SALINITY	
YIELD	1.25

Site Details (top)

REGION	20 - HUNTER
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6330898.00
EASTING	360787.00
LATITUDE	33 9' 6"
LONGITUDE	151 30' 26"
GS-MAP	

AMG-ZONE	56
COORD-SOURCE	
REMARK	

Form-A (top)

COUNTY	NORTHUMBERLAND
PARISH	MORISSET
PORTION-LOT-DP	LOT 501 DP 788556

Licensed (top)

COUNTY	NORTHUMBERLAND
PARISH	MORISSET
PORTION-LOT-DP	501 788556

Construction (top)

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter; ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	11.50	210			Down Hole Hammer
1		Hole	Hole	11.50	28.00	150			Down Hole Hammer
1	1	Casing	PVC Class 9	0.70	11.50	160	144		C: 1-11.5m; Screwed and Glued; Seated on Bottom

Water Bearing Zones (top)

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
21.50	23.50	2.00		15.00	28.00	1.25	28.00	2.00	Fresh

Drillers Log (top)

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.40	0.40	Topsoil		
0.40	8.80	8.40	Clay Grey		
8.80	21.50	12.70	Mudstone Grey		
21.50	23.50	2.00	Conglomerate WB		
23.50	28.00	4.50	Conglomerate		

Warning To Clients: This raw data has been supplied to the Department of Infrastructure, Planning and Natural Resources (DIPNR) by drillers, licensees and other sources. The DIPNR does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

General Notes

Introduction

These notes are supplied with all geotechnical reports from **Barker Harle** and therefore may contain information not necessarily relevant to this report.

The purpose of the report is set out in the introduction section of this report. It should not be used by any other party, or for any other purpose, as it may not contain adequate or appropriate information in these events.

Engineering Reports

Barker Harle engineering reports are prepared by qualified personnel and are based on information obtained, and on modern engineering standards of interpretation and analysis of that information. Where the report has been prepared for a specific design proposal the information and interpretation may not be relevant if the design proposal is changed. If the design proposal or construction methods do change, **Barker Harle** request that it be notified and will be pleased to review the report and the sufficiency of the investigation work.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, the report must be regarded as interpretative, rather than a factual document, limited, to some extent, by the scope of information on which it relies.

Barker Harle Pty Ltd *cannot accept responsibility for problems which may develop if it is not consulted after factors considered in the report's development have changed.*

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

- Unexpected variations in ground conditions – the potential for this will depend partly on bore spacing and sampling frequency.
- The actions of contractors responding to commercial pressures.

If these occur, **Barker Harle** will be pleased to assist with investigation or advice to resolve the matter.

A Geotechnical Engineering Report May Be Subject To Misinterpretation

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a geotechnical engineering report. To help avoid these problems, **Barker Harle** should be retained to review the adequacy of plans and specifications relative to geotechnical issues.

Engineering Logs Should Not Be Separated From The Engineering Report.

Final engineering logs are developed by the Geotechnical Engineer based upon interpretation of field logs and laboratory evaluation of field samples. Only final engineering logs are included in geotechnical engineering reports. To minimize the likelihood of engineering log misinterpretation, *give contractors ready access to the complete geotechnical engineering report*.

Site Inspection

Barker Harle will always be pleased to provide inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit, to full time engineering presence on site.

Change In Conditions

Subsurface conditions may be modified by constantly changing natural forces. Because a geotechnical engineering report is based on conditions, which existed at the time of subsurface exploration, *construction decisions should not be based on a geotechnical engineering report whose adequacy may have been affected by time*.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations may also affect subsurface conditions and thus, the continuing adequacy of a geotechnical report. **Barker Harle** should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

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

Ground Water

Unless otherwise indicated the water levels given on the engineering logs are levels of free water or seepage in the test hole recorded at the given time of measuring. This may not accurately represent actual ground water levels, due to one or more of the following:

- In low permeability soils, ground water although present may enter the hole slowly, or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent prior weather changes. They may not be the same at the time of construction as indicated at the time of investigation.

Accurate confirmation of levels can only be made by appropriate instrumentation techniques and monitoring programs.

General Notes – Continued

Foundation Depth

Where referred to in the report, the recommended depth of any foundation, (piles, caissons, footings etc) is an engineering estimate of the depth to which they should be constructed. The estimate is influenced and perhaps limited by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications based upon this report should provide for variations in the final depth depending upon the ground conditions at each point of support.

Engineering Logs

Engineering logs presented in the report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify economically. In any case, the boreholes or test pits represent only a very small sample of the subsurface profile.

Interpretation of information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling and the possibility of other than straight line variations between the test locations.

Drilling Methods

The following is a summary of drilling methods currently used by **Barker Harle**, and some comments on their use and application.

Continuous Sample Drilling: The soil sample is obtained by screwing a 75 or 100mm auger into the ground and withdrawing it periodically to remove the soil. This is the most reliable method of drilling in soils as the moisture content is unchanged and soil structure, strength, appearance etc. is only partially affected.

Test Pits: These are excavated using a backhoe or tracked excavator, allowing close examination of insitu soil if it is safe to descend into the pit. The depth of digging is limited to about 3 metres for a backhoe, and about 5 metres for an excavator. A potential disadvantage is the disturbance of the site caused by the excavation.

Hand Auger: The soil sample is obtained by screwing a 75mm Auger into the ground. This method is usually restricted to approximately 1.5 to 2 metres in depth, and the soil structure and strength is significantly disturbed.

Continuous Spiral Flight Augers: The soil sample is obtained by using a 90 – 115mm diameter continuous spiral flight auger which is withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays, and in sands above the water table. Samples, returned to the surface, are very disturbed and may be contaminated. Information from the drilling is of relatively lower reliability. SPT's or undisturbed sampling may be combined with this method of drilling for reasonably satisfactory sampling.

(wpfiles\geotech\generalnotesrev15-6-09)

Hand Penetrometers

Hand Penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and recording the number of blows for successive 50mm increments of penetration.

Two, relatively similar tests are used:

1. Perth Sand Penetrometer (AS 1289.5.3.3) – A 16mm flat ended rod is driven with a 9kg hammer, dropping 600mm. This test was developed for testing the density of sands and is mainly used in granular soils and loose fill.

2. Cone Penetrometer/Scale Penetrometer (AS 1289.5.3.2) – A 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm. The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio (CBR) have been published by various road authorities.

Sampling

Sampling is carried out during drilling to allow engineering examination, and laboratory testing of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending on the amount of disturbance during drilling, some information on strength and structure.

Undisturbed samples are taken by pushing a think walled sample tube into the soils and withdrawing this with a sample of soil in a relatively undisturbed state contained inside. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Details of the type and method of sampling are given in the report.

Laboratory Testing

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

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

Settlement due to construction

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

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

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

Erosion

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

Saturation

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

Seasonal swelling and shrinkage of soil

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

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

Shear failure

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

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

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

Seriousness of Cracking

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

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

Prevention/Cure

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

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

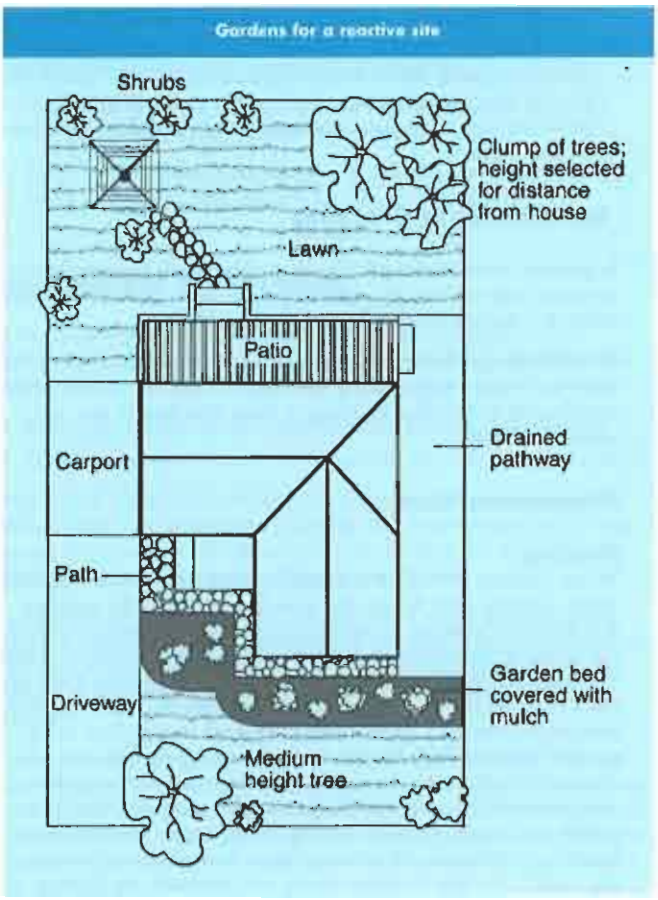
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

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

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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



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

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

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

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

Condensation

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

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

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

The garden

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

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

Existing trees

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

Information on trees, plants and shrubs

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

Excavation

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

Remediation

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

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

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Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

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APPENDIX D

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DESIGN AND SITE MANAGEMENT PRECAUTIONS FOR

CONSTRUCTION ON REACTIVE SOILS

GENERAL DESIGN PRECAUTIONS

These procedures generally apply to single storey, brick residential buildings, or as specified in the design/report, founded on reactive clay soils. Such soils are prone to heave/shrink movements due to moisture variations (either by natural or artificial causes). It must be accepted that some minor masonry cracking can occur with these soils, despite the listed precautions and associated foundation design. However, the basic design philosophy is to minimize any cracking and provide a serviceable structure. It is thus a compromise between economy and performance.

The following procedures are considered supplementary to any other foundation recommendations given in the design/report:-

* All surface water runoff must be directed away from the building by appropriate grading, in order to prevent ponding near foundations. Site drainage must form part of the building contract.

* Peripheral impermeable pathways should be provided around the building. This action supplements site drainage and assists in the stabilisation of moisture conditions near foundations.

* All brickwork should be suitably articulated into discrete units to accommodate the expected movements. In particular, brickwork over doors and windows should be avoided.

* Internal and external walls should be arranged along straight lines.

* All house drains and water pipes must be provided with sufficient flexibility to accommodate the expected differential movements (between foundation and uncovered outside area) at the level of the service.

* The extension of services through slabs should be avoided, where possible, in order to prevent hidden leaks under the slab area. Most plumbing fixtures can be arranged to exit through outside walls.

* Septic systems must not be located within any influence (preferably downhill) of the house or neighbouring foundations. Alternatively, a pump-out system must be employed.

* Subgrades beneath elevated and well ventilated floors should be covered with an impermeable liner (with protective soil blanket) to minimize excessive desiccation.

In addition, certain other 'site management' precautions must be adhered to during the life of the structure, as given on our standard sheet. These precautions generally relate to the control of abnormal moisture variations due to the effects of drainage and vegetation.

SITE MANAGEMENT PRECAUTIONS

These precautions are considered supplementary to any structural and/or foundation design measures for the subject building, and are intended for distribution to the prospective house Owner.

Reactive clays are prone to heave/shrink movements with changes in soil moisture content, due to natural or artificial means. The basic design philosophy employed for the dwelling, is to provide a foundation/superstructure adequate to accommodate ground movements, due to extreme seasonal moisture changes only. The possibility of other abnormal and/or localised moisture changes (the cause of most housing distress) has been assumed to be controlled by the following 'site management' procedures:-

* In particular, leaking plumbing or blocked drains should be repaired promptly and site grading maintained to prevent ponding near foundations. Garden watering, particularly by fixed systems, should be controlled carefully to avoid gross overwatering. On the other hand, proper garden maintenance should produce year round uniform moisture conditions.

* Trees and some shrubs can cause a substantial drying of the soil and associated shrinking of reactive clays. This effect is most likely to result in damage when added to the drying from a drought or a long dry spell. The problem can be minimized by planting trees at substantial distances from the house. The distance depends upon the species and soil conditions, but generally 3/4 of the mature tree height is a minimum.

* Problems during droughts can be minimized by extensive pruning (thus reducing water demand) and/or providing trees with adequate water. This watering can be achieved by boreholes or trenches dug well into the clay between the tree and the footing. To avoid any settlement problems, the holes or trenches should not be too close to the footing and should be filled with compacted coarse sand. Frequent moderate watering during dry periods should ensure that the tree does not extract excessive moisture from beneath the foundation of the house.

  This action should also be immediately undertaken by the Owner if brickwork cracking due to tree drying is noticed. Most reactive clay failures can be avoided or minimized by controlling the combined drying effects of trees and drought.

The Owner should also appreciate that on reactive clays it is virtually impossible to design an economic foundation system that will totally prevent movement. Some minor aesthetic cracking, while undesirable, will occur in a significant proportion of houses. In addition, some minor problems should be expected with jamming of windows and doors especially during the settling in period or following a major drought and any repairs should be regarded as part of normal house maintenance. Even significant masonry cracking with widths over 5mm usually has no influence on the function of the wall and only presents an aesthetic problem. Just as it is difficult to design an immovable footing system, it is almost impossible to provide remedial measures that will prevent further movements if distress does occur. Consequently, extreme remedial measures should not be undertaken for minor problems.

APPENDIX G

LANDSLIDE RISK ASSESSMENT – EXAMPLE OF QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

Qualitative Measures of Likelihood

Level	Descriptor	Description	Indicative Annual Probability
A	ALMOST CERTAIN	The event is expected to occur	$>\approx 10^{-1}$
B	LIKELY	The event will probably occur under adverse conditions	$\approx 10^{-2}$
C	POSSIBLE	The event could occur under adverse conditions	$\approx 10^{-3}$
D	UNLIKELY	The event might occur under very adverse circumstances	$\approx 10^{-4}$
E	RARE	The event is conceivable but only under exceptional circumstances.	$\approx 10^{-5}$
F	NOT CREDIBLE	The event is inconceivable or fanciful	$<10^{-6}$

Note: "≈" means that the indicative value may vary by say ±□ order of magnitude, or more.

Qualitative Measures of Consequences to Property

Level	Descriptor	Description
1	CATASTROPHIC	Structure completely destroyed or large scale damage requiring major engineering works for stabilisation.
2	MAJOR	Extensive damage to most of structure, or extending beyond site boundaries requiring significant stabilisation works.
3	MEDIUM	Moderate damage to some of structure, or significant part of site requiring large stabilisation works.
4	MINOR	Limited damage to part of structure, or part of site requiring some reinstatement/stabilisation works.
5	INSIGNIFICANT	Little damage.

Note: The "Description" may be edited to suit a particular case.

Qualitative Risk Analysis Matrix – Level of Risk to Property

LIKELIHOOD	CONSEQUENCES to PROPERTY				
	1: CATASTROPHIC	2: MAJOR	3: MEDIUM	4: MINOR	5: INSIGNIFICANT
A – ALMOST CERTAIN	VH	VH	H	H	M
B – LIKELY	VH	H	H	M	L-M
C – POSSIBLE	H	H	M	L-M	VL-L
D – UNLIKELY	M-H	M	L-M	VL-L	VL
E – RARE	M-L	L-M	VL-L	VL	VL
F – NOT CREDIBLE	VL	VL	VL	VL	VL

Risk Level Implications

Risk Level		Example Implications(1)
VH	VERY HIGH RISK	Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to acceptable levels; may be too expensive and not practical
H	HIGH RISK	Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels
M	MODERATE RISK	Tolerable provided treatment plan is implemented to maintain or reduce risks. May be accepted. May require investigation and planning of treatment options.
L	LOW RISK	Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

Note: (1) The implications for a particular situation are to be determined by all parties to the risk assessment; these are only given as a general guide.

(2) Judicious use of dual descriptors for Likelihood, Consequence and Risk to reflect the uncertainty of the estimate may be appropriate in some cases.

APPENDIX J

SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical consultant at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminant bulk earthworks.
CUTS	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
FILLS	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
ROCK OUTCROPS & BOULDERS	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
SURFACE	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
SUBSURFACE	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
SEPTIC & SULLAGE	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

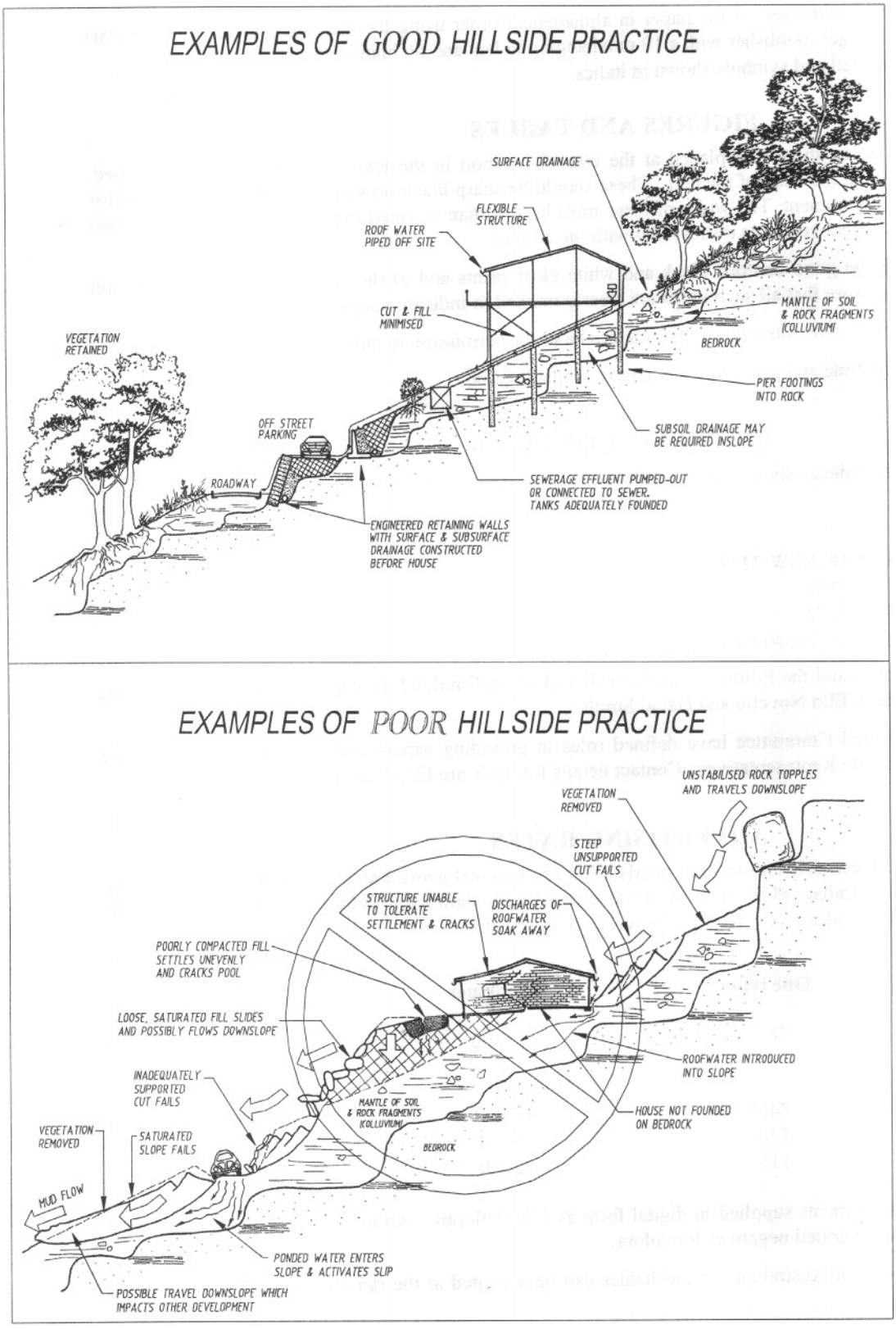

Figure J1: Illustrations of Good and Poor Hillside Practice