(FILE A)

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*With Compliments*

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WYONG SHIRE CCC.

Pete 4/11/05

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# PRELIMINARY GEOTECHNICAL INVESTIGATION

# WARNERVALE TOWN CENTRE

Prepared for

Bannister & Hunter Pty Ltd

Prepared by

RCA AUSTRALIA

RCA Ref: 5191-001/0

November 2005

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GEOTECHNICAL • ENVIRONMENTAL

RCA ref: 5191-001/0

3 November 2005

Bannister & Hunter Pty Ltd
75 Mann Street
GOSFORD NSW 2250

Attention: Mr Peter Barclay

Geotechnical Engineering
Engineering Geology
Hydrogeology
Contaminated Site Assesment
Contaminated Site Auditing
Construction Materials Testing
Construction Quality Control
QMS Auditing

# PRELIMINARY GEOTECHNICAL INVESTIGATION
# WARNERVALE TOWN CENTRE

## 1 INTRODUCTION

This correspondence presents the results of a preliminary geotechnical investigation at the site of the proposed Warnervale Town Center.

The investigation comprised the inspection of the site by an experienced geotechnical engineer and the excavation and logging of 12 test pits by a four wheeled drive backhoe.

The work was carried out at the request of Bannister & Hunter Pty Ltd.

The logs of the test holes are attached to this report. The test hole locations are shown on the attached Drawing 1. The test hole locations on the plan are based on a hand held GPS and therefore should be only regarded as being approximate. The test hole locations were pegged in the field for later survey pick up.

It is understood that development of the site will include major earthworks with cuttings up to in the order of 10m depth.

## 2 SITE CONDITIONS

The site is bounded by Sparks Road to the south, a school (under construction) to the east and the Sydney- Newcastle rail line to the west. The portion of the site under investigation slopes generally up to the north to the ridge/hilltop, which forms the limit of the area of interest. A disused landfill is situated at the top of the hill, however this area is not addressed in this report.

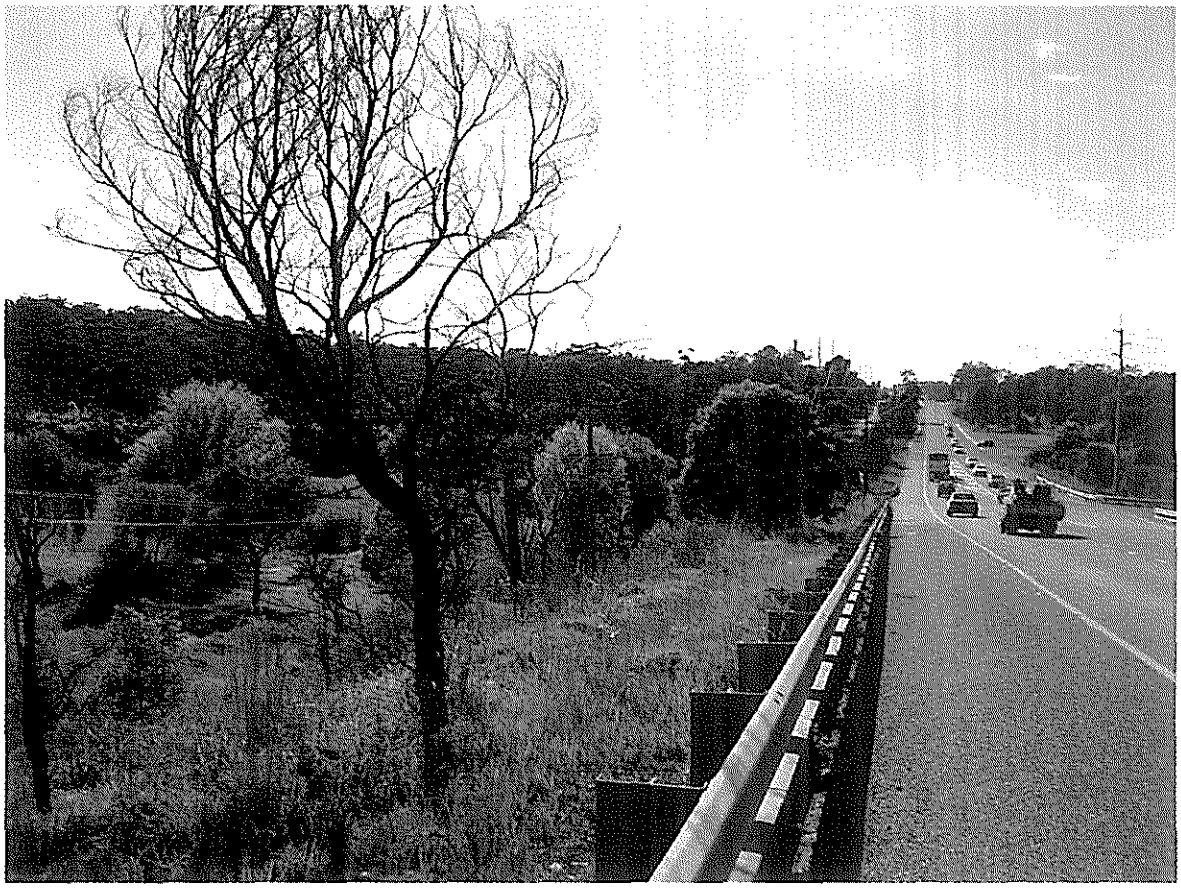

**Figure 1** *Looking east along Sparks Road with more heavily treed areas of the background slopes and more open country in the foreground*

The site is tree covered in the east and more cleared in the west. Both areas have been developed in a rural fashion. At the time of the investigation works a number of houses in the eastern portion of the site had been demolished.

## 3 SUBSURFACE CONDITIONS

Reference to available 1:250,000 geological series sheet S1 56-5 indicates the site overlies the Clifton Sub Group of the Narrabeen Group. This unit is reported to be composed of claystone, sandstone and shale.

Observations around the site confirm the interbedded nature of the sandstone, shale and claystone units as shown on **Figure 2**.

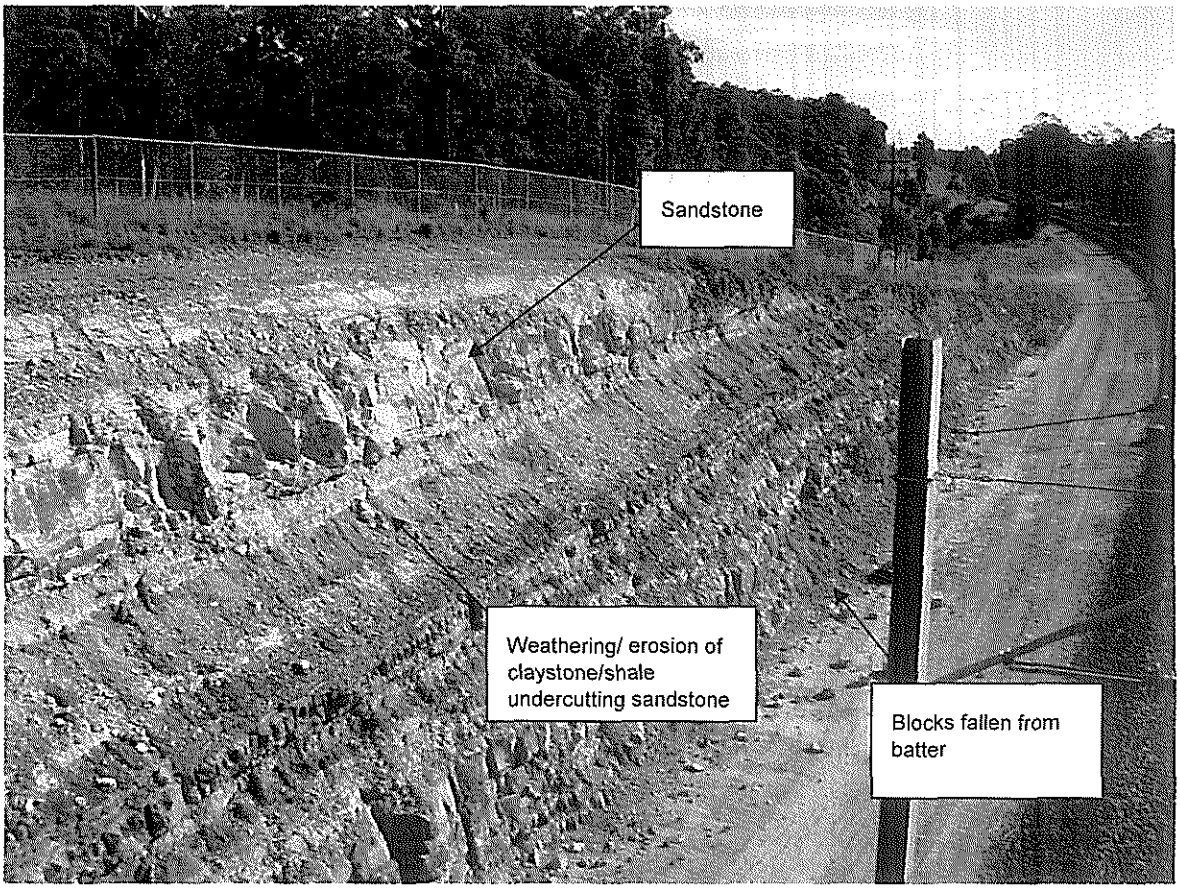


**Figure 2** *Railway cutting at the southwestern corner of the site*

Observation of the exposed conditions in cuts indicate the bedrock is shallow in the upper portions of the site. This expectation was generally supported by the findings from the test pitting except for pits 8 and 9 which were discontinued at the backhoe limit of reach without encountering material with a discernible rock structure.

The conditions encountered in the test pits are summarised in Table 1.

**Table 1** *Summary of Test Pit results*

| Pit | Depth of topsoil (m) | Generalised Soil Profile | Depth to top of weathered rock (m) | Depth to backhoe refusal (m) |
|---|---|---|---|---|
| 1 | 0.3 | Silty sand(loose)/sandy clay/clayey sand (stiff) | 0.55 | 0.6 |
| 2 | 0.3 | Silty Clay (stiff and very stiff) | 0.7 | 1.1 |
| 3 | 0.15 | Gravelly silty clay (stiff) | 0.6 | 1.5 |
| 4 | 0.2 | Silty clay (very stiff) | 0.45 | 0.45 |
| 5 | 0.2 | Silty clay (very stiff) | 0.4 | 1.2 |
| 6 | 0.2 | Silty & Sandy clay (stiff and very stiff) | 1.7 | 3.2 |
| 7 | 0.25 | Sandy clay (stiff to very stiff) | 0.8 | 0.9 |
| 8 | 0.3 | Thin layer of silty gravelly sand over silty sand clay/sandy clay (stiff and very stiff) | | >3.8 |
| 9 | 0.3 | Clayey sand/sandy clay/silty sand clay (stiff, very stiff & hard) | | >3.8 |
| 10 | 0.3 | Clayey silty sand/silty clay/sandy clay/clayey sand | 3.8 | 3.9 |
| 11 | 0.25 | Silty clay, firm | 1.2 | 1.4 |
| 12 | 0.35 | Sandy silty clay/sandy clay (stiff and very stiff) | 2 | 2.4 |

Groundwater was encountered in Pit 10 at a depth of 3.1m.

It is noted that groundwater levels may vary from time to time due to climatic conditions.

# 4 COMMENTS AND DISCUSSION

## 4.1 GENERAL

It is understood that the development of a Town Centre is proposed across the site.

It is understood that the development of the site will include significant cuts up to 10m in depth.

## 4.2 SLOPE STABILITY

No evidence of slope instability was observed on the site. The moderately slopes and the generally shallow depth to rock is conducive to the stability of the soil profile. It is suggested that this should be confirmed by a more detailed assessment across the site with a more intensive test pitting programme.

## 4.3 FOUNDATION CONDITIONS

The shallow depth to rock is conducive to stable foundation conditions for the development.

## 4.4 EXCAVATIONS

### *4.4.1 EXCAVATION CONDITIONS*

Determination of excavateability will require further investigation involving cored bores and seismic refraction profiling along proposed cuts. However, it is reasonably likely that the inter-bedded units will be rippable by heavy bulldozers provided the exposures in the rail lines are typical of those across the site.

### *4.4.2 BATTER STABILITY*

The pits and site observations indicate that excavations will encounter a variable depth of soil over profile of weathered rock comprising:

- Weathering resistant sandstone.
- Erosion prone finer grained rock types (ie shales and claystones).

The fine-grained soils are particularly prone to weathering as shown in the rail cutting. This weathering erosion will undercut the more resistant sandstone units resulting in local rock falls and instability.

As such it is expected that the deeper cutting in the rock will need to be either battered down to slopes (ie 2H: 1V max) that can be re-topsoiled and revegetated or if steeper batters are proposed treatment to stabilise the cutting in the long term against deterioration is expected to be required. Treatment is expected to include the covering of the batter to prevent weathering (ie, shotcreting or revetment type walls) and possible rock bolting of any potential unstable blocks or wedges identified.

### 4.5 SUITABILITY OF EXCAVATED MATERIALS FOR REUSE

Based on the materials encountered in the test pits and observed in adjacent cuttings the materials won from the excavations will be suitable for general filling.

The shales and claystones are expected to break down rapidly on exposure and yield low California bearing ratio (CBR) fill material.

The stronger sandstone units are expected to yield material that would provide select fill material with CBR's in the order 10% or more provided they are selectively won and separated from the finer grained sediments.

The carrying out of geomechanical laboratory testing (ie, plasticity testing, particle size analysis, dispersion testing and California bearing ratio testing) on samples of the rock profile retrieved from a heavy excavator would allow characterisation of the materials for earthworks and road works formation planning.

Yours faithfully
**RCA AUSTRALIA**

**Robert Carr**

# Appendix A

Drawing

# Appendix B

## Test Pit Logs

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# TEST PIT LOG
## PIT No: TP1

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.35 | | TOPSOIL, Sitly SAND, with grass and roots, loose, moist, fine grained sand, dark brown |
| | | 0.45 | | Silty SAND, slightly clayey, loose, very moist, fine grained sand, brown, COLLUVIAL |
| | | 0.55 | | Sandy CLAY/Clayey SAND, stiff, very moist, low plasticity, mottled yellow brown and grey, RESIDUAL |
| | | | | SANDSTONE, fresh, fine grained, yellow |
| | | | | End Test Pit TP1 at 0.6m at backhoe refusal |

0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

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# TEST PIT LOG
## PIT No: TP2

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.3 | | TOPSOIL, Silty SAND, with grass and roots, loose, fine grained sand, light grey |
| | | 0.7 | | Silty CLAY, stiff, moist, high plasticity, yellow brown and light grey, RESIDUAL |
| | | 1.0 | | Silty CLAY, stiff to very stiff, moist, high plasticity, red brown, some medium to coarse ironstone gravel, RESIDUAL |
| | | | | SANDSTONE, weathered, fine grained, yellow brown |
| | | | | End Test Pit TP2 at 1.1m at backhoe refusal |

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5

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# TEST PIT LOG
## PIT No: TP3

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.15 | | TOPSOIL, Silty SAND, with grass and roots, loose, dry, fine grained sand, grey brown |
| | | 0.6 | | Gravelly Silty CLAY, with fine to coarse rounded gravel, stiff, dry, medium plasticity, COLLUVIAL |
| | | 1.2 | | SILTSTONE, very weathered to weathered, yellow brown |
| | | | | SANDSTONE, very weathered to weathered, fine grained, yellow brown |
| | | | | End Test Pit TP3 at 1.5m at backhoe refusal |

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5

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# TEST PIT LOG
## PIT No: TP4

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.2 | | TOPSOIL, Silty SAND, with grass and tree roots, loose, dry, fine sand, brown |
| | | | | Silty CLAY, very stiff, moist, high to medium high plasticity, yellow brown mottled, RESIDUAL |
| | | | | End Test Pit TP4 at 0.45m at backhoe refusal in sandstone |

0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

| LOGGED: LM | CHECKED: | DATE: |
|---|---|---|

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# TEST PIT LOG
## PIT No: TP5

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.2 | | TOPSOIL, with grass and roots, loose, dry, fine grained sand, brown |
| | | 0.4 | | Silty CLAY, very stiff, moist, medium high plasticity, yellow brown mottled light grey, RESIDUAL |
| 0.5 | | | | SILTSTONE, very weathered to weathered, light grey |
| 1.0 | | | | Becoming to fresh siltstone rock |
| | | | | End Test Pit TP5 at 1.2m at backhoe refusal |
| 1.5 | | | | |
| 2.0 | | | | |
| 2.5 | | | | |
| 3.0 | | | | |
| 3.5 | | | | |
| 4.0 | | | | |
| 4.5 | | | | |

LOGGED: LM | CHECKED: | DATE: 3/11/05

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# TEST PIT LOG
## PIT No: TP6

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.2 | | TOPSOIL, Silty SAND, with grass and roots, loose, dry, fine grained sand, brown |
| | | 0.6 | | Silty CLAY, with occasional rounded fine to medium ironstone gravel, stiff, high plasticity, orange brown, mottled grey, COLLUVIAL |
| | | 1.2 | | Silty CLAY, with occasional coarse rounded ironstone gravel, stiff to very stiff, moist, high plasticity, light grey mottled yellow brown |
| | | 1.7 | | Sandy CLAY, very stiff, moist, medium plasticity, light grey mottled yellow brown |
| | | 2.6 | | Silty CLAY/SILTSTONE, with fine to medium ironstone gravel bands, extremely weathered, light grey mottled yellow brown, extremely weathered rock |
| | | 3.0 | | SILTSTONE/SANDSTONE, highly weathered, light grey, fine grained sandstone |
| | | | | SANDSTONE, weathered, yellow brown, fine grained sandstone |
| | | | | End Test Pit TP6 at 3.2m at backhoe refusal |

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5

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# TEST PIT LOG
## PIT No: TP7

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.25 | | Silty SAND, loose, dry, fine grained sand, light grey |
| | | | | Sandy CLAY, stiff to very stiff, medium plasticity, mottled light grey and orange brown, RESIDUAL |
| | | 0.8 | | SANDSTONE, weathered, fine grained, yellow brown |
| | | | | End Test Pit TP7 at 0.9m |

0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

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DATE: 3/11/05

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# TEST PIT LOG
## PIT No: TP8

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.3 | | TOPSOIL, Silty SAND, with grass and roots, loose, moist, fine grained sand, grey |
| | | 0.6 | | Silty Gravelly SAND with rounded fine to medium quartz gravel, dense, very moist, fine grained sand, brown, COLLUVIAL |
| | | 1.3 | | Sandy CLAY, very stiff, moist, medium plasticity, light grey |
| | | 1.8 | | Silty Sandy CLAY, with some fine to medium rounded quartz gravel, very stiff, moist, medium high plasticity, light grey mottled yellow brown |
| | | 2.6 | | Sandy CLAY, with some fine rounded quartz/ironstone gravel, very stiff, moist, medium plasticity, light grey mottled yellow brown |
| | | | | Sandy Silty CLAY, stiff to very stiff, moist to very moist, medium high plasticity, light grey blotched yellow brown |
| | | | | End Test Pit TP8 at 3.8m at limit of backhoe reach |

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5

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# TEST PIT LOG
## PIT No: TP9

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.3 | | TOPSOIL, Silty SAND, with grass and roots, loose, dry, fine grained sand, grey |
| 0.5 | | 0.6 | | Clayey SAND, with some fine to medium rounded gravel dense, moist, yellow brown, COLLUVIAL |
| 1.0 | | 1.2 | | Sandy CLAY, stiff to very stiff, moist, medium plasticity, light grey mottled yellow brown, COLLUVIAL |
| 1.5 | | | | Silty Sandy CLAY, with medium to coarse ironstone gravel, very stiff, moist, medium high plasticity, light grey mottled red brown |
| 2.0 | | 2.0 | | Clayey SAND/Sandy CLAY, with fine to medium rounded gravel, very stiff, moist, medium low plasticity light grey |
| 2.5 | | | | |
| 3.0 | | 3.1 | | Sandy CLAY, very stiff to hard, moist, medium plasticity |
| 3.5 | | | | |
| 4.0 | | | | End Test Pit TP9 at 3.8m at limit of backhoe reach |
| 4.5 | | | | |

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# TEST PIT LOG
## PIT No: TP10

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.3 | | TOPSOIL, Silty SAND, with grass and roots, loose, moist, fine grained sand, brown |
| | | 1.3 | | Clayey Silty SAND, with some fine to medium rounded gravel, dense, grey, very moist, ALLUVIAL |
| | | 2.2 | | Silty CLAY, stiff, moist to very moist, medium high plasticity, light grey mottled yellow brown |
| 3.1 ▽ | | 3.1 | | Sandy CLAY, stiff to very stiff, moist, medium plasticity, light grey mottled yellow brown |
| | | 3.8 | | Clayey SAND, very dense, very moist, fine to medium grained, light grey mottled yellow brown, RESIDUAL |
| | | | | SANDSTONE, highly weathered, fine grained, yellow brown |
| | | | | End Test Pit TP10 at 3.9m at backhoe refusal |

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5

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# TEST PIT LOG
## PIT No: TP11

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.25 | | TOPSOIL, Silty SAND, with grass and roots, loose, dry, fine grained |
| | | | | Silty CLAY, firm, very moist, light grey mottled yellow brown, RESIDUAL |
| | | 1.2 | | Becoming stiff |
| | | | | SANDSTONE, slightly weathered, fine grained, yellow brown |
| | | | | End Test Pit TP11 at 1.4m at backhoe refusal |

0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

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# TEST PIT LOG
## PIT No: TP12

CLIENT: Bannister & Hunter Pty Ltd
PROJECT: Warnervale Town Centre
LOCATION: Warnervale

PROJECT No: 5191
DATE: 7/10/05
SURFACE LEVEL: Existing
SHEET 1 of 1
METHOD OF ADVANCE: Backhoe

| GROUND WATER | SAMPLE TESTING AND DEPTH | DEPTH (m) | STRATA | DESCRIPTION (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN) |
|---|---|---|---|---|
| | | 0.35 | | TOPSOIL, Silty SAND, with grass and roots, dense, moist, fine grained sand, grey |
| | | 1.3 | | Sandy Silty CLAY, stiff, very moist to moist, medium high plasticity, light grey mottled orange brown, RESIDUAL |
| | | 2.0 | | Sandy CLAY, very stiff, moist, medium plasticity, light grey, RESIDUAL |
| | | | | SANDSTONE, very weathered, fine grained, light grey |
| | | | | End Test Pit TP12 at 2.4m at backhoe refusal |

0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

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# SYMBOLS INDEX SHEET

This sheet should be read in conjunction with all test hole log sheets and any idealised geological sections.

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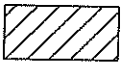
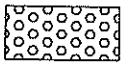
## SOIL SYMBOLS

### Primary Components

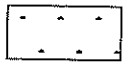

Clay

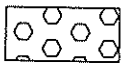

Silt


Sand


Gravel


Topsoil

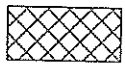

Peat/Organic Soil


Cobbles/boulders (>60mm in size)

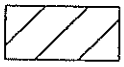

Ironstone gravel, laterite


Bitumen


Concrete/ road pavement


Fill

### Secondary Components


Clayey


Silty

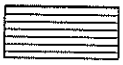

Sandy


Gravelly

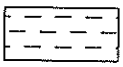
NOTE: Primary soil component shown in capitals and preceded by secondary components. Minor components noted in description. For example Sandy CLAY, with some gravel. The main component is clay with secondary sand and minor gravel. Laboratory classification testing should be undertaken where quantitative soil description is required.

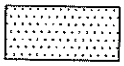
## ROCK SYMBOLS

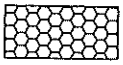
### Sedimentary


Claystone


Siltstone


Shale/Laminite


Sandstone

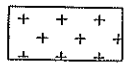

Conglomerate


Coal


Limestone

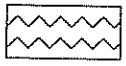
### Igneous


Volcanic (fine grained–basalt)


Plutonic (coarse grained–granite)

### Metamorphic


Low grade (slate, schist)


High grade (gneiss, quartzite)

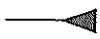
## SYMBOLS

### Testing and Sampling

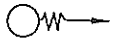
| | |
|---|---|
| D | Disturbed sample |
| B | Bulk sample |
| U50 | Undisturbed tube sample (50mm diameter) |
| SPT | Standard penetration test |
| N | SPT blows per 300mm |
| R | SPT refusal |
| PP | Pocket penetrometer value (kPa) |
| Sv | Shear vane, peak undrained shear strength (kPa) |
| O | Point load test (axial) |
| ● | Point load test (diametrical) |
| PID | Photoionisation detector reading (ppm) (note: comments regarding odour are based on olfactory evidence) |

### Groundwater


Groundwater level at time of measurement

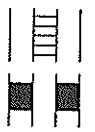

Water outflow (loss)


Water inflow (make)


Seepage

Groundwater levels unless otherwise indicated refer to the level of free water encountered in the bores or test holes at the time of measurement. The actual groundwater level may differ depending on material permeability, climate, tides etc.

### Well Construction


Screened interval


Bentonite seal


Filter zone


Lockable cover


Hole collapse

# GENERAL SOIL DESCRIPTION SHEET

This sheet should be read in conjunction with all test hole log sheets and any idealised geological sections.

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## SOIL DESCRIPTION

### Descriptive Terms

| | | |
|---|---|---|
| Cohesive | – | Soils that exhibit cohesion or bonding between particles (ie clay, silt). |
| Granular | – | Soils that have little cohesion or bonding between particles (ie sand, gravel). |
| Dry | – | Looks and feels dry. Dry cohesive soils are hard, friable or powdery and dry granular soils are cohesionless and free running. |
| Moist | – | Soil feels cool and looks dark in colour. Moist cohesive soils can be moulded and moist granular soils tend to cohere. |
| Wet | – | Free water present. |
| Cemented | – | Secondary bonding between soil particles. Weakly cemented soils are easily broken up by hand. |

## SOIL GRAIN SIZE

| CLAY | SILT | SAND | | | GRAVEL | | | COBBLES | BOULDERS |
|---|---|---|---|---|---|---|---|---|---|
| | | Fine | Medium | Coarse | Fine | Medium | Coarse | | |
| 0.002mm | 0.06mm | 0.2mm | 0.6mm | 2mm | 6mm | 20mm | 60mm | 200mm | |

## SOIL STRENGTH

### Consistency of Cohesive Soils[1]

| Term | Pocket Penetrometer Value (kPa) | Field Guide |
|---|---|---|
| Very soft | <25 | Surface Penetrated by fist |
| Soft | 25-50 | Easily penetrated by thumb |
| Firm | 50-100 | Penetrated by thumb with effort |
| Stiff | 100-200 | Indented by thumb |
| Very stiff | 200-400 | Surface only marked by thumbnail |
| Hard | >400 | |

### Density of Granular Soils[2]

| Term | Density Index (%) |
|---|---|
| Very loose | <15 |
| Loose | 15-35 |
| Medium dense | 35-65 |
| Dense | 65-85 |
| Very dense | 85-100 |

NOTE: 1. Consistency can be assessed based on insitu testing or laboratory testing on undisturbed samples. Undrained shear strengths can be estimated from field pocket penetrometer values by dividing by 2. Quantification of undrained shear strength should be based on insitu or laboratory testing.

2. Density can only be assessed on the basis of insitu testing

## SOIL ORIGIN

### Weathered in Place Soils

| | | |
|---|---|---|
| Residual soil | – | Rock completely broken down to soil, no rock structure visible. |
| Extremely weathered material | – | Rock predominantly broken down to soil with some relict rock structure present. |

### Transported Soils

| | | |
|---|---|---|
| Alluvial soil | – | Deposited by streams and rivers. |
| Slopewash soils | – | Deposited on slopes by gravity and sheet flow. |
| Aeolian soils | – | Deposited by wind. |
| Lacustrine soils | – | Deposited in lakes. |
| Marine soils | – | Deposited in bays, beaches and estuaries. |
| Slide debris | – | Deposited by mass movement (colluvium). |
| Fill | – | Deposited by man. |

# GENERAL ROCK DESCRIPTION SHEET

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The following rock description is intended for the geotechnical logging of diamond drill core and is also applicable for the mapping of natural exposures and cuttings.

In most rocks the presence of defects and the effects of weathering have a significant influence on the engineering behaviour of the rock mass.

The term **rock substance** refers to the description of material characteristics such as rock type, grain size, colour, strength and weathering.

The term **rock mass** refers to the properties of the overall rock mass/body and involves description of defects (discontinuities or fractures in the rock substance such as joints, faults bedding partings etc), weathering and structure.

## ROCK SUBSTANCE – DESCRIPTIVE TERMS

**Rock name** : Simple rock names are used rather than precise geological classifications.

**$I_s(50)$** : Point load strength index.

**Grain size/ type** : The grains of a rock can be described in terms of size (mm) and shape on the basis of appropriate terms used in the General Soil Description Sheet. Where identified, individual minerals should be described.

**Strength** : Strength is estimated on the basis of tactile appraisal and confirmed by point load strength testing where shown. The rock strength description refers to the strength of the rock material and not to the strength of the rock mass which may be considerably weaker due to the effect of rock defects. Unconfined compressive strength testing should be undertaken where rock strengths need to be quantified.

| Term | Symbol | $I_s(50)$ MPa | Field Guide (The core refers to 150mm long x 50mm dia. sample) |
|---|---|---|---|
| Extremely Low | EL | <0.03 | Soil strength property description appropriate |
| Very Low | VL | 0.03-0.1 | May be crumbled in the hand. Sandstone is 'sugary' and friable. |
| Low | L | 0.1-0.3 | The core may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling. |
| Medium | M | 0.3-1.0 | The core may be broken by hand with considerable difficulty. Readily scored with knife |
| High | H | 1.0-3.0 | The core cannot be broken by unaided hands, can be slightly scratched or scored with knife. |
| Very High | VH | 3.0-10.0 | The core may be broken with hand held hammer. Cannot be scratched with knife. |
| Extremely High | EH | >10.0 | The core is difficult to break with hand held hammer. Rings when struck with hammer. |

*$I_s(50)$ = Point load strength index

**Weathering** :

| Term | Symbol | Definition |
|---|---|---|
| Extremely Weathered | EW | The rock exhibits soil-like properties though the texture of the original rock is still evident. |
| Highly Weathered | HW | Limonite staining or colour change affects the whole of the rock mass. Signs of chemical or physical decomposition is evident throughout the whole of the rock mass. |
| Moderately Weathered | MW | Staining extends throughout the whole of the rock mass and the original colour is no longer recognisable. |
| Slightly Weathered | SW | Partial staining or decolouration of the rock mass, usually by limonite, has taken place. |
| Fresh | F | Rock mass unaffected by weathering. |

The assignment of rock weathering terms is subjective and is used for identification purposes only

# GENERAL ROCK DESCRIPTION SHEET

This sheet should be read in conjunction with all test hole log sheets and any idealised geological sections.

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## ROCK MASS – DESCRIPTIVE TERMS

**Defects** : **Defects** are fractures in the rock mass and include joints, faults, shear planes, cleavages and bedding partings. Description of defects is important as defects generally control the overall engineering behaviour of the rock mass.

**Defect spacing** refers to the degree of fracturing or spacing of all natural fractures. Artificial fractures induced by drilling, boxing or transport of rock core are not included in the defect spacing log. The delineation of artificial fractures is subjective.

**Defect Description**

| | | | |
|---|---|---|---|
| Type | : | Parting | (along rock layering/bedding) |
| | | Joint | (across rock layering/bedding) |
| | | Shear | (zone or seam of rock movement resulting in crushing/fracturing) |
| | | Clayey seam | (infilled or extremely weathered layer) |
| | | Vein | (secondary mineralisation along a fracture) |
| Shape | : | Planar | |
| | | Curved | |
| | | Undulose/Stepped | |
| | | Irregular | |
| Roughness | : | Rough | |
| | | Smooth | |
| | | Striated | (slickenside, indicative of shear movement) |
| Infill | : | Clean | (defect surfaces clean) |
| | | Stained | (surfaces stained by limonite (iron–oxide) or similar) |
| | | Veneer | (thin surface coating ≤1mm thick) |
| | | Coating | (surface coating 1mm–5mm thick) |
| | | Seam | (5mm–100mm thick) |
| | | Zone | (>100mm thick) |

Orientation of defects is described relative to the horizontal.

Dip = the maximum angle of a defect plane relative to the horizontal surface

Strike = orientation relative to magnetic north of the line of intersection of a defect plane and the horizontal surface

**Structure** : Structure refers to larger scale rock mass features such as bedding, folding, lineation and flow banding etc. Where no structure is discernible the term massive is used.
In sedimentary rocks the following terms can be used to describe the spacing of bedding/stratification.

| Term | Spacing of Bedding (mm) |
|---|---|
| Laminated | <20 |
| Thinly bedded | 20–200 |
| Medium bedded | 200–600 |
| Thickly bedded | 600–2000 |
| Very thickly bedded | >2000 |