

# Geotechnical Hazards – Preliminary Assessment Proposed Mt Cardrona Station Private Plan Change

Report prepared for:

Brown and Company Planning Group

Report prepared by:

GeoSolve Ltd

Distribution:

Brown and Company Planning Group

GeoSolve Limited (File)

October 2016

GeoSolve Ref: 160677



## Table of Contents

|     |   |   |
|-----|---|---|
| 1   | Introduction .....                                  | 1 |
| 2   | Site Description .....                              | 1 |
| 2.1 | Topography and Surface Drainage.....                | 2 |
| 3   | Site Investigation Data .....                       | 3 |
| 3.1 | Site Investigations .....                           | 3 |
| 3.2 | Geological Setting .....                            | 3 |
| 3.3 | Stratigraphy .....                                  | 3 |
| 3.4 | Groundwater .....                                   | 4 |
| 4   | Natural Hazard Assessment .....                     | 5 |
| 4.1 | General .....                                       | 5 |
| 4.2 | Alluvial Fan Flooding and Debris Flow Hazards ..... | 5 |
| 4.3 | Landslide Hazards .....                             | 6 |
| 4.4 | Seismic Hazard – Active Fault .....                 | 6 |
| 4.5 | Liquefaction .....                                  | 6 |
| 4.6 | Historic Mining Activity .....                      | 6 |
| 4.7 | Groundwater and Surface Drainage .....              | 7 |
| 5   | Conclusions and Recommendations.....                | 8 |
| 6   | Applicability.....                                  | 8 |

# 1 Introduction

This report presents the results of an assessment and historic site investigations carried out by GeoSolve Ltd in the context of a proposed private plan change to incorporate a golf course to the proposed development. The objective is to assess the suitability of the subject area, in terms of geotechnical hazards, for the proposed plan change and new development.

## 2 Site Description

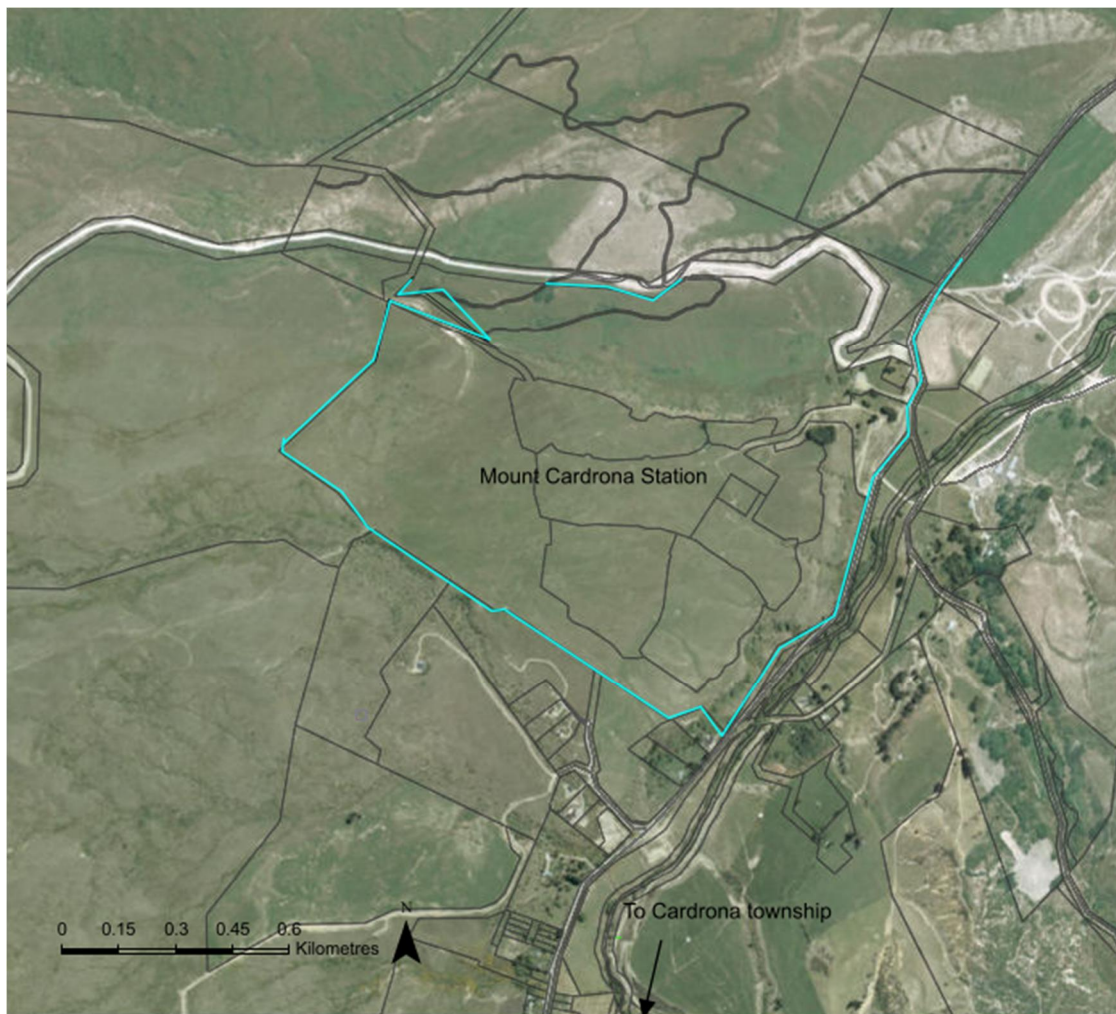


Figure 1: Locality Plan

The property is located on the western side of Cardrona Valley Rd (Figure 1), south of the existing Cardrona Skifield access road.

Access to the site is off the Cardrona Valley Road. Several structures currently exist in the eastern extents of the site, including remnants of the site's only farmhouse, sheds and a wool shed.

The site is covered in grassed paddocks and sparse scrub and trees. The Cardrona Skifield access runs beyond the northeast corner of the site. Several farm tracks and a driveway to the farmhouse site also exist.

The site has a predominantly easterly aspect.

## 2.1 Topography and Surface Drainage

The site has been surveyed and topographic contours are shown in Appendix A.

The site topography can be generalised as a gently sloping (~5-10°) alluvial fan surface.

Upslope and west of the main fan surface is a pronounced increase in gradient (slopes of up to 25°) which coincides roughly with the alignment of the Cardrona Water Race. This escarpment is considered to be a geomorphological expression of the NW Cardrona Fault Zone. A second water race (Little's Water Race) follows the approximate level of the 610 m contour and bisects the terrace surface.

The alluvial fan surface has been offset by the NW Cardrona Fault Zone, and upslope of the escarpment has a similar orientation and slope as the fan surface below. A minor ephemeral creek dissects the upper escarpment, and is directed down the escarpment and over the lower terrace surface (swampy in places) before joining with a small creek.

The southwest margin of the site area is aligned with part of Pringles Creek, a major watercourse that has caused considerable incision of the terrace surface. The valley slopes of Pringles Creek are moderate to steep (up to 35°).

The eastern boundary of the site area adjoins Cardrona Valley Road and corresponds to a steep slope (~35°) that represents an erosional terrace edge formed by the Cardrona River. This has subsequently been partially modified by quarrying activity adjacent to Cardrona Valley Road.

The development area (as shown in Figure 1, Appendix A) is a gently sloping alluvial fan surface that is relatively unmodified by incision. It is essentially a planar topographical feature that slopes at a gentle grade (~5-10°) to the east with minor undulations resulting from eastward flowing ephemeral drainage paths. These would be expected to act as overland flow paths only during periods of extended heavy rainfall.

The fan surface has been incised by two significant creeks beyond the site proximity. North of the site Homestead Creek flows in a west to east direction. In its lower reaches constitutes a sub-horizontal, swampy valley floor with a slight inclination towards the east. The upper reaches of the creek have an increased gradient and some flow was observed. Homestead Creek has caused incision of the alluvial fan terrace and the resulting valley sides slope at around 20° adjacent to the northern boundary of the development area. Similarly, Pringles Creek has incised the fan surface towards the southwest of the site.



## 3 Site Investigation Data

### 3.1 Site Investigations

Sufficient subsurface investigations have been undertaken to ascertain the required information for the purposes of the plan change report.

Site investigations have included the excavation of twenty-nine test pits to a maximum depth of 5 m. A number of these test pits cover the proposed development area.

An engineering geological appraisal has also been undertaken to assess geomorphology and surface conditions. Geomorphological mapping was completed, including outcrop mapping of the exposed soil materials (see Figure 2, Appendix A).

Scala penetrometer tests were undertaken to determine strength parameters for the subsurface soils. Test results are contained in Appendix B.

Locations of test pits are shown in Figure 1, Appendix A. All test pit logs are contained in Appendix B.

We understand that the Otago Regional Council has previously raised concerns about hazards associated with the Pringles Creek catchment and the Nevis Cardrona Fault Zone, and that these aspects have been investigated independently by Royden Thomson, Geologist (Appendix C).

### 3.2 Geological Setting

The regional basement rock comprises the ice-scoured Haast Schist Group. Sedimentary cover consists of Early Quaternary outwash gravels overlain by alluvial fan deposits. More recent alluvial sediments have been deposited from the Cardrona River and smaller local watercourses. The alluvial deposits have been eroded and deposited during post-glacial times.

Published geological maps show the Nevis-Cardrona Fault in close proximity to the west of the site but it does not traverse the plan change area. This fault is considered to be positioned upslope of the water race. The Nevis-Cardrona Fault is a major active fault system with a reverse sense of movement and a 5,000-10,000 year recurrence interval. The date of the most recent surface rupture has not been established but field investigations found no evidence to suggest any recent movement locally. A report by Mr Royden Thomson (Geologist) also found no evidence that the alluvial fan has been tectonically deformed since its formation (assessed as 23,000 years before present).

A more significant seismic risk exists in this district from potentially strong ground shaking, likely to be associated with a rupture of the Alpine Fault, located along the West Coast of the South Island.

There is a high probability that an earthquake with an expected magnitude of over 7.5 will occur along the Alpine Fault within the next 50 years, which will subject the site area to strong, prolonged ground shaking.

### 3.3 Stratigraphy

The plan change area is situated on a large alluvial fan surface with only minor modification to the existing morphology by ephemeral stream activity. Consequently, alluvial deposits dominate the subsurface in this area with overlying surficial topsoil and loess.

The topsoil comprises soft brown organic silt.

The loess comprises firm silt with some loose fine sand. Loess was typically observed to depths no greater than 0.5 m, however in one location loess was observed to 1.1 m indicating that pockets of deeper loess may be locally present on the terrace.

The alluvial fan deposits are typical of such environments of deposition and comprise interbedded fine and coarse-grained alluvium. The following soil types are represented within the interbedded sequence:

Alluvial silt and sand – firm to very stiff silt with rare to some clay, silt with minor gravel and gravelly pockets, firm to stiff/loose to medium dense silty fine sand, gravelly silt with minor sand, sandy silt, etc.

Alluvial gravel – medium dense to dense sandy gravel with cobbles and boulders, silty gravel with minor cobbles, dense large boulders in a silt matrix with lenses of silty gravels, etc.

Additional stratigraphic data was obtained from engineering geological mapping. A gravel quarry situated on the eroded margins of the alluvial fan northeast of the Golf Course Villas observed sandy, fine to coarse gravel with minor silt and rare boulders composed of angular to sub-angular schist and quartz.

Further detailed description of the alluvial fan deposits can be obtained in the test pit logs contained in Appendix B.

### 3.4 Groundwater

Test pits observed that the alluvial terrace deposits are generally in a moist condition with no seepage (i.e. percolation of water through soil).

Some seepage was noted on the ground surface and in test pits (TP 26 & 27), excavated near the base of the upper escarpment. Seepage is occurring on the face of the escarpment and is probably related to the proximity of the Nevis-Cardrona Fault.

The static watertable is likely to be at depth (15 m+) in the development area. However, local surface seepages have been observed as above.

## 4 Natural Hazard Assessment

### 4.1 General

Current QLDC and ORC mapping identifies alluvial fan hazard and active faulting hazards within and near the proposed site area (Figure 3, Appendix A). Detailed geological mapping has also identified shallow landslide and mining hazards in the site area (Figure 2, Appendix A).

Owing to the terrain and the site location, it is appropriate to assess for a range of geotechnical hazards including landslide, liquefaction, erosion, debris flow, and flooding.

A site inspection and mapping was undertaken with relevant features observed and mapped (Figure 2, Appendix A).

### 4.2 Alluvial Fan Flooding and Debris Flow Hazards

Watercourses run either side of the site, Pringles Creek to the south and the smaller Homestead Creek to the north, with catchment areas of 435 ha and 86 ha and estimated (NIWA) 100-year flows of 4.6 m<sup>3</sup>/s and 1.8 m<sup>3</sup>/s respectively. Two small artificial water races traverse the upper site, flowing from north to south.

The modern watercourses are well incised, with the site generally elevated by at least 5 to 10 m above the streambeds. The channels are hydraulically steep and it is estimated that Pringles Creek can convey its 100 year flow at a typical depth of about 1 m. Thus, it is clear that there is negligible probability of storm runoff alone causing flooding onto the site from these streams. However, the possibility must be addressed of debris events causing channel avulsion, which might direct floodwater and debris onto the site. The site is shown as 'stabilised/isolated' and 'inactive' alluvial fan in ORC/QLDC hazard mapping. This classification is supported by observed alluvial fan deposits underlying most of the site; these are ancient as indicated by overlying horizons of loess and topsoil.

Royden Thomson, Geologist (June 2006 report attached as Appendix C) has undertaken a comprehensive geological and hydrological investigation into this site with particular reference to alluvial fan hazards including debris flow. Thomson concluded that the fan surface has last experienced alluvial activity approximately 23,000 years ago under a substantially different geological setting than that of today. Thomson notes *"...the major 1999 storm event had no significant influence on the active channel and no impact at all... downstream from the Skifield Road crossing. It can be assumed, therefore, that... no debris flows were generated... existing landslides are not particularly susceptible..."*

Thomson also references an ORC assessment (April 2006) which involved modelling of a dam break scenario for a proposed snow making pond associated with the Cardrona Skifield in the upstream catchment. Based on the ORC results and his own interpretation, Thomson concludes that in this vicinity: *"A worst case scenario would generate a maximum flood/debris flow level 2m above the channel thalweg... When the overall channel dimensions are considered this is a negligible impact... No incursion onto the flood plain is depicted... The risk of channel overtopping and stream avulsion on the left bank is considered to be effectively zero..."*

Thomson's work is considered thorough and his conclusions robust, therefore our position is that there is negligible risk to the site from flooding and debris flow.

Small seepages and locally sourced runoff may affect the site; these will be minor and easily addressed with local drainage arrangements.

#### 4.3 Landslide Hazards

Geological mapping has identified active landslides on steeper slopes north and south of Homestead Creek and on the face of the upper escarpment west of the proposed development area (see Figure 2, Appendix A).

These are considered to be slowly creeping slides, probably developed in underlying Early Quaternary Gravels. Movement appears to be associated with groundwater seepages.

It is recommended that development be avoided in these areas, and that detailed landslide investigations be carried out for any proposed developments in their immediate vicinity.

#### 4.4 Seismic Hazard – Active Fault

This issue has been addressed in detail in a report by Royden Thomson (Appendix C).

A north/south trending active fault scarp associated with the Northwest Cardrona Fault has been identified crossing the upper escarpment west of the proposed development area (see Thomson, Figure 3a, Appendix C). It has undergone multiple phases of movement in the past 140,000 years, and has an uncertain relationship with the Northwest Cardrona Fault. The timing of the last movement is unknown.

The average return period on the NW Cardrona Fault is in the range of 5,000-10,000 years. It is recommended that development be avoided in the immediate vicinity of the fault scarp shown on the Thomson Figure 3a, Appendix C.

#### 4.5 Liquefaction

Seismic liquefaction occurs when excess pore pressures are generated in loose, saturated, generally cohesionless soil during earthquake shaking, causing the soil to undergo a partial to complete loss of shear strength. Such a loss of shear strength can result in settlement and/or horizontal movement (lateral spreading) of the soil mass. The occurrence of liquefaction is dependent on several factors, including the intensity and duration of ground shaking, soil density, particle size distribution, and elevation of the groundwater table.

Within this site, the potential for liquefaction under seismic shaking is considered relatively low. The vulnerable combination of fine grained sandy/silty soils with a shallow groundwater table is unlikely to be extensive within the development area. The low liquefaction risk is due to the combination of a deep static water table and coarse granular deposits associated with the alluvial fan deposits.

Investigations to confirm soil type and groundwater depths will be required at detailed design phase to assess foundation options.

#### 4.6 Historic Mining Activity

A gold mining tunnel hosted by Early Quaternary Gravel was observed northeast of the Golf Course Villas (see Figure 2, Appendix A). There is a possibility that further tunnels are present as the interface between the Early Quaternary Gravel and the overlying alluvial fan deposits was a widely targeted gold-bearing horizon during the gold rush era. The tunnels are however likely to be of limited length (perhaps 10 m maximum) and restricted to the incised margins of the fan deposits. Tunnels are therefore not expected to present any geotechnical concerns for the plan change area (subject to localised verification and checking of final plans).

The mining tunnel east of the Golf Course Villas will need to be traced to confirm its extent (including any drives that feed from it). If construction is proposed in the tunnel the area it should be

backfilled to the required foundation level using suitable engineered fill placed in accordance with NZS 4431:1989.

#### 4.7 Groundwater and Surface Drainage

Good natural drainage of the development area is expected and no major remedial drainage measures are expected. If future development extends to the vicinity of the upper escarpment drainage will be required.

If groundwater or springs are identified during construction, then subsoil drainage or similar remediation will be required.

Flow within ephemeral watercourses in the development area is expected in times of high rainfall and consequently cut off drains upslope of the development is recommended.



## 5 Conclusions and Recommendations

Based on this preliminary assessment, the majority of the site is considered to be acceptably safe from geotechnical hazards. A minor level of geotechnical hazard may be present at isolated locations within the proposed development area, and site-specific investigation will be required to assess building platform locations. However, we consider that the extent and degree of any such hazards will be minor, such that they can be readily mitigated by standard planning and engineering measures.

We conclude that, from a natural hazards perspective, the area is suitable for the proposed land use; noting that site-specific assessments will be required and localised mitigation measures may be necessary.

## 6 Applicability

This report has been prepared for the benefit of Brown and Company Planning Group with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Further geotechnical investigations and reporting will be required at the detailed design phase after development plans are completed.

Report prepared by:



.....  
Hank Stocker  
Senior Engineer



.....  
Graeme Halliday  
Senior Engineering Geologist

Reviewed for GeoSolve Ltd by:



.....  
Fraser Wilson  
Senior Engineering Geologist

## Appendix A: Site Plans

- Figure 1 – Site Investigation Plan
- Figure 2 – Geological Site Plan
- Figure 3 – QLDC Hazard Map
- Figure 4 – Aerial Site Plan
- Figure 5 and 6 – Site Photos





Legend

|                   |                                   |            |
|-------------------|-----------------------------------|------------|
|                   | Hill Side Lots                    | 30         |
|                   | Residential Lots                  | 110        |
|                   | Medium Density Lots               | 124        |
|                   | Golf Frontage Lots                | 26         |
|                   | Golf Frontage Medium Density Lots | 09         |
|                   | Golf Course Villas                | 33         |
| <b>Total Lots</b> |                                   | <b>332</b> |

|  |                       |
|--|-----------------------|
|  | Hotel                 |
|  | Hotel Villas          |
|  | Golf Buildings        |
|  | Retail                |
|  | Proposed Horse Trails |

Scale 1:5000  
0 50 100 150 200(m)

Key

- = Test Pit location
- = Scala Penetrometer location

**GEO SOLVE**  
GEOTECHNICAL ENGINEERING • GEOHYDROLOGY & HYDROLOGY  
ENGINEERING GEOLOGY • PAVEMENT STRUCTURAL TESTING  
70 Macandrew Road, PO Box 2427,  
South Dunedin 9044. ph 03 466 4024

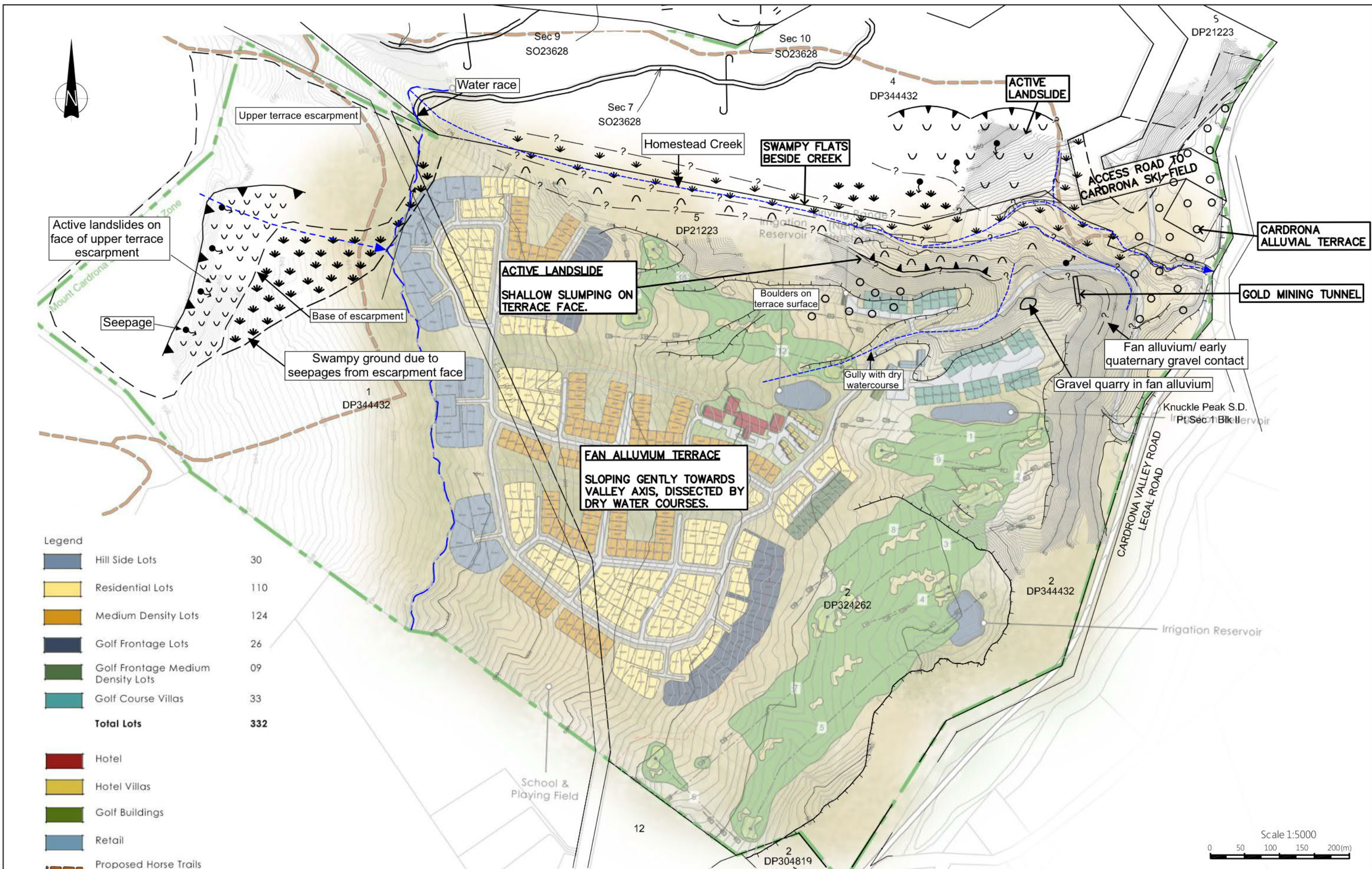
|                     |          |       |
|---------------------|----------|-------|
| DRAWN               | GXS      | 10/16 |
| DRAFTING CHECKED    | FAW      | 10/16 |
| APPROVED            | FAW      | 10/16 |
| FILE :              | PDF      |       |
| SCALE: (AT A3 SIZE) | As Shown |       |
| PROJECT No.         | 160677   |       |

BROWN AND COMPANY PLANNING GROUP  
Geotechnical Assessment  
Mt Cardrona Station Plan Change  
Site Investigation Plan

FIG No. Appendix A - Figure 1

REV. 0





**GEO SOLVE**

GEOTECHNICAL ENGINEERING • GEOPHYSICS & HYDROLOGY  
ENGINEERING GEOLOGY • PAVEMENT STRUCTURAL TESTING  
70 Macandrew Road, PO Box 2427,  
South Dunedin 9044. ph 03 466 4024

|                  |     |       |
|------------------|-----|-------|
| DRAWN            | GSH | 10/16 |
| DRAFTING CHECKED | FAW | 10/16 |
| APPROVED         | FAW | 10/16 |

FILE :  
PDF  
SCALE: (AT A3 SIZE)  
As Shown

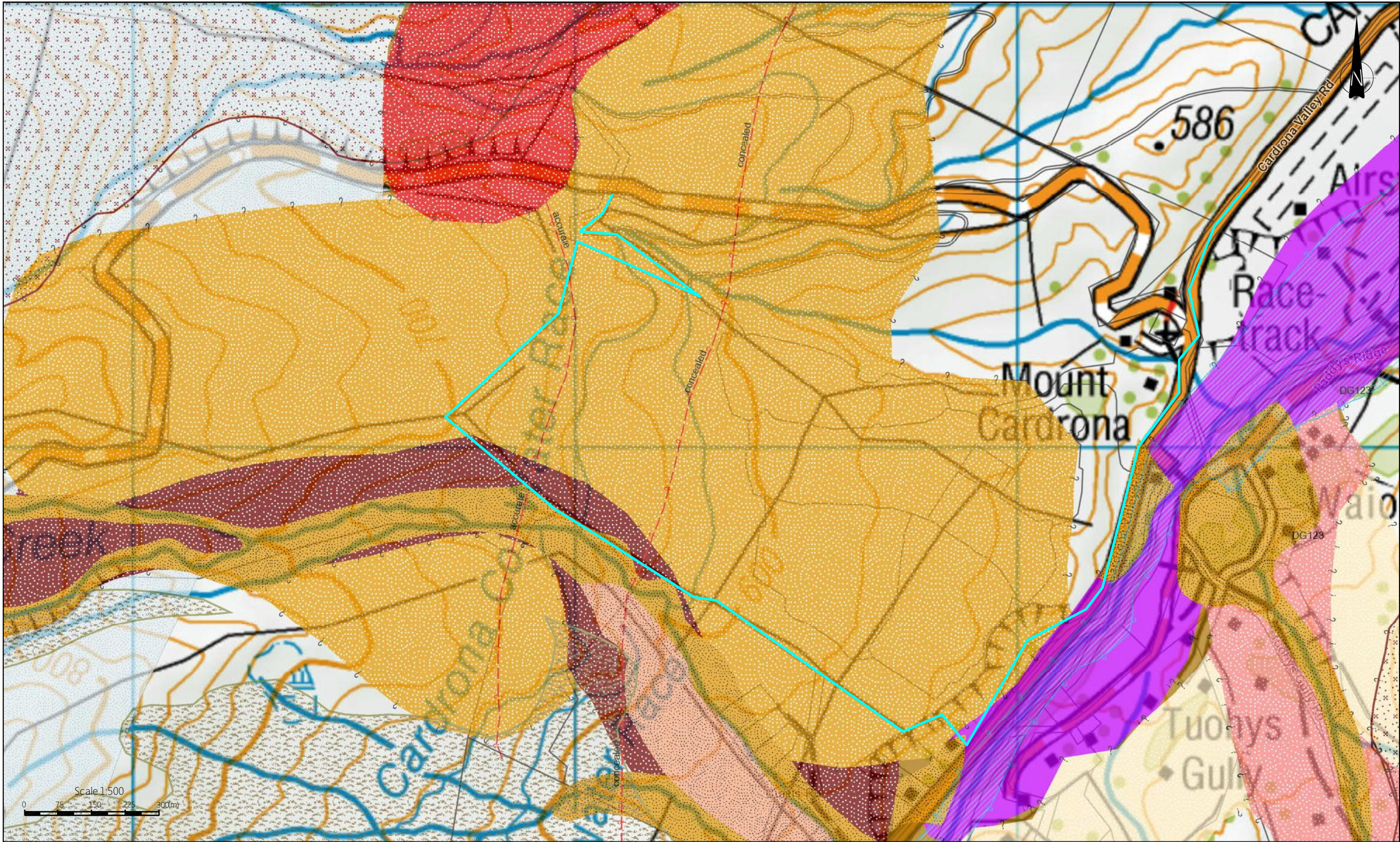
PROJECT No.  
160677

BROWN AND COMPANY PLANNING GROUP  
Geotechnical Assessment  
Mt Cardrona Plan Change  
Geological Site Plan

FIG No. Appendix A - Figure 2

REV. 0





Key

- = Active Fault - Location Approximate
- = Alluvial Fan, Inactive Composite (Regional Scale)
- = Alluvial Fan, Active Composite (Regional Scale)

**GEO SOLVE**  
GEOTECHNICAL ENGINEERING • GEOMORPHOLOGY & HYDROLOGY  
ENGINEERING GEOLOGY • PAVEMENT STRUCTURAL TESTING  
70 Macandrew Road, PO Box 2427,  
South Dunedin 9044. ph 03 466 4024

|                                 |     |       |
|---------------------------------|-----|-------|
| DRAWN                           | GSH | 10/16 |
| DRAFTING CHECKED                | FAW | 10/16 |
| APPROVED                        | FAW | 10/16 |
| FILE :<br>PDF                   |     |       |
| SCALE: (AT A3 SIZE)<br>As Shown |     |       |
| PROJECT No.<br>160677           |     |       |

BROWN AND COMPANY PLANNING GROUP  
Geotechnical Assessment  
Mt Cardrona Station Plan Change  
QLDC Hazard Map

FIG No. Appendix A- Figure 3

REV. 0





**GEO SOLVE**

GEOTECHNICAL ENGINEERING • GEOHYDROLOGY & HYDROLOGY  
ENGINEERING GEOLOGY • PAVEMENT STRUCTURAL TESTING

70 Macandrew Road, PO Box 2427,  
South Dunedin 9044. ph 03 466 4024

|                                 |     |       |
|---------------------------------|-----|-------|
| DRAWN                           | GXS | 10/16 |
| DRAFTING CHECKED                | FAW | 10/16 |
| APPROVED                        | FAW | 10/16 |
| FILE :<br>PDF                   |     |       |
| SCALE: (AT A3 SIZE)<br>As Shown |     |       |
| PROJECT No.<br>160677           |     |       |

BROWN AND COMPANY PLANNING GROUP  
Geotechnical Assessment  
Mt Cardrona Plan Change  
Aerial Site Plan

FIG No. Appendix A - Figure 4

REV. 0



Figure 5 - Site Photo





Figure 6 - Site Photo



## Appendix B: Test Pit Logs and Scala Penetrometer Logs








# GeoSolve Ltd

## EXCAVATION LOG

EXCAVATION NUMBER:

### TP 1

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195291 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5586114 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   |   | GEOLOGICAL                            |  |  |  |
|-------------------------|-----------------------|-----------|---|---|---------------------------------------|--|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT                         | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |  |  |
|                         |                       | 0.4       |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | moist                                 | TOPSOIL  |  |  |
|                         |                       | 0.8       |   | Tan brown, SILT with rare sand and gravel. Sand is fine, gravel is fine to medium. Uniform, stiff. Parallel to slope profile that dips to the east.   | moist                                 | LOESS  |  |  |
|                         |                       | 1.2       |   | Brown, gravelly SILT with some sand. Slightly weathered, sand is fine, gravel is fine to coarse, clasts are schist dominant. Poorly graded, firm. Dips slightly to the southeast.   | wet, saturated at position of seepage | ALLUVIAL DEPOSIT   |  |  |
|                         |                       | 1.6       |   |   |                                       |  |  |  |
|                         |                       | 2.0       |   |   |                                       |  |  |  |
|                         |                       | 2.4       |  | Grey brown, silty SAND with gravel, cobbles and minor boulders. Sand is fine to coarse, gravel is fine to coarse, boulders to 300mm, clasts are subangular to subrounded. Poorly graded, dense. Dips slightly to the southeast.                                   | moist                                 | GLACIAL TILL   |  |  |
|                         |                       | 2.8       |   |   |                                       |  |  |  |
|                         |                       | 3.2       |   | Grey brown, silty SAND to sand with minor silt and minor gravel. Sand is fine to medium, gravel is fine. Poorly graded, medium dense. Dips slightly to the southeast.   | moist                                 | GLACIAL POND SEDIMENT  |  |  |
|                         |                       | 3.6       |   |   |                                       |  |  |  |
|                         |                       | 4.0       |   | Red, brown with black, sandy GRAVEL with minor cobbles and boulders. Sand is fine to coarse, gravel is fine to coarse, boulders to 250mm, clasts are metasediment dominant, highly weathered. Well graded, loose to medium dense. Dips slightly to the southeast. | wet                                   | EARLY QUATERNARY GRAVEL  |  |  |
|                         |                       | 4.4       |  | Total Depth = 4 m   |                                       |  |  |  |
|                         |                       | 4.8       |   |   |                                       |  |  |  |
|                         |                       | 5.2       |   |   |                                       |  |  |  |
|                         |                       | 5.6       |   |   |                                       |  |  |  |
|                         |                       | 6.0       |   |   |                                       |  |  |  |
| 6.4                     |                       |           |   |   |                                       |  |  |  |

|  |  |                |  |
|--|--|----------------|--|
| COMMENT: Minor seepage @ 2m-2.4m, 20L pooled in the base of the test pit after 10 mins |  | Logged By: FAW |  |
| PHOTO REF.: N/A  |  | Checked Date:  |  |
|  |  | Sheet: 1 of 1  |  |





# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 2**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195313 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5586227 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |             | GEOLOGICAL  |                         |  |
|-------------------------|-----------------------|-----------|-------------|---|-------------------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT           | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.4       |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips slightly to the east.   | moist                   | TOPSOIL  |
|                         |                       | 0.8       |             | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.   | moist                   | LOESS  |
|                         |                       | 1.2       |             | Tan brown, SILT with minor sand, gravel and boulders. Sand is fine, gravel is fine, sub-angular to sub-rounded boulders to 200mm. Poorly graded, dense. Dips slightly to the east.  | moist                   | GLACIAL TILL   |
|                         |                       | 1.6       |             |   |                         |  |
|                         |                       | 2.0       |             | slightly moist  | EARLY QUATERNARY GRAVEL |  |
|                         |                       | 2.4       |             |   |                         |  |
|                         |                       | 2.8       |             | Tan brown, silty GRAVEL with some sand and rare cobbles. Sand is fine to coarse, gravel is fine to coarse, cobbles to 150mm, clasts are sub-rounded to sub-angular, metasediment dominant, moderately weathered. Poorly graded, dense. Dips slightly to the east. | slightly moist          | EARLY QUATERNARY GRAVEL  |
|                         |                       | 3.2       |             |   |                         |  |
|                         |                       | 3.6       |             | Total Depth = 3.9 m   |                         |  |
|                         |                       | 4.0       |             |   |                         |  |
|                         |                       | 4.4       |             |   |                         |  |
|                         |                       | 4.8       |             |   |                         |  |
|                         |                       | 5.2       |             |   |                         |  |
|                         |                       | 5.6       |             |   |                         |  |
|                         |                       | 6.0       |             |   |                         |  |
|                         |                       | 6.4       |             |   |                         |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |












# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 3**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195205 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5586091 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   |  | GEOLOGICAL     |  |  |
|-------------------------|-----------------------|-----------|---|--|----------------|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT  | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |  |
| NO SEEPAGE              |                       | 0.4       |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | moist          | TOPSOIL  |  |
|                         |                       | 0.8       |    | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.  | moist          | LOESS  |  |
|                         |                       | 1.2       |    |  |                |  |  |
|                         |                       | 1.6       |  | Tan brown with orange tinge, silty GRAVEL with minor sand. Sand is fine, gravel is fine to medium, moderately weathered, clasts are sub-rounded to angular, sub-rounded to sub-angular schist boulders to 700mm. Poorly graded, dense. Dips slightly to the east.  | slightly moist | EARLY QUATERNARY GRAVEL  |  |
|                         |                       | 2.0       |  | Tan brown, silty GRAVEL with some sand and minor cobbles. Sand is fine to coarse, gravel is fine to coarse, cobbles to 150mm, clasts are sub-rounded to sub-angular, metasediment dominant, moderately weathered. Poorly graded, dense. Dips slightly to the east. | slightly moist | EARLY QUATERNARY GRAVEL  |  |
|                         |                       | 2.4       |  |  |                |  |  |
|                         |                       | 2.8       |  |  |                |  |  |
|                         |                       | 3.2       |  | Tan brown, GRAVEL with some silt and minor sand. Sand is fine to coarse, gravel is fine to coarse, clasts are sub-rounded to sub-angular, metasediment dominant, moderately weathered. Poorly graded, dense. Dips slightly to the east.                            | slightly moist | EARLY QUATERNARY GRAVEL  |  |
|                         |                       | 3.6       |  |  |                |  |  |
|                         |                       |           | Total Depth = 3.6 m   |  |                |  |  |
|                         |                       |           | 4.0   |  |                |  |  |
|                         |                       |           | 4.4   |  |                |  |  |
|                         |                       |           | 4.8   |  |                |  |  |
|                         |                       |           | 5.2   |  |                |  |  |
|                         |                       |           | 5.6   |  |                |  |  |
|                         |                       |           | 6.0   |  |                |  |  |
|                         |                       |           | 6.4   |  |                |  |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |



# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 4**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195280 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585859 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |                     |  | GEOLOGICAL                    |  |
|-------------------------|-----------------------|-----------|---------------------|--|-------------------------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG         | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT                 | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|                         |                       |           |                     | Brown, organic S&T with some sand, minor silt, minor gravel and rare rootlets. Sand is fine, gravel is fine. Poorly graded, loose. Sub-parallel to slope profile that dips to the east.  |                               | TOPSOIL  |
|                         |                       | 0.4       |                     | Grey/brown, sandy GRAVEL with minor cobbles and boulders. Sand is fine to coarse, gravel is fine to coarse, clasts are sub-rounded to sub-angular, boulders to 300mm, clasts are schist dominant. Well graded, medium dense. Sub-angular to slope profile that dips to the east. | moist                         | ALLUVIAL FAN GRAVEL  |
|                         |                       | 0.8       |                     |  |                               |  |
|                         |                       | 1.2       |                     |  |                               |  |
|                         |                       | 1.6       |                     |  |                               |  |
|                         |                       | 2.0       |                     |  |                               |  |
|                         |                       | 2.4       |                     |  |                               |  |
|                         |                       | 2.8       |                     | Grey to tan/brown, GRAVEL with some sand and minor silt and minor cobbles. Sand is fine to coarse, gravel is fine to coarse, cobbles to 150mm, metasediment dominant, moderately weathered. Poorly graded, dense. Dips slightly to the west.                                     | wet, saturated at water level | EARLY QUATERNARY GRAVEL  |
|                         |                       | 3.2       |                     |  |                               |  |
|                         |                       | 3.6       | Total Depth = 3.8 m |  |                               |  |
|                         |                       | 4.0       |                     |  |                               |  |
|                         |                       | 4.4       |                     |  |                               |  |
|                         |                       | 4.8       |                     |  |                               |  |
|                         |                       | 5.2       |                     |  |                               |  |
| 5.6                     |                       |           |                     |  |                               |  |
| 6.0                     |                       |           |                     |  |                               |  |
| 6.4                     |                       |           |                     |  |                               |  |

|  |  |                |
|--|--|----------------|
| COMMENT: seepage @ 2.7m, fast seepage, water pouring in at 30L/min |  | Logged By: FAW |
| PHOTO REF.: N/A  |  | Checked Date:  |
|  |  | Sheet: 1 of 1  |





# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 5A**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: west of pit        |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195244 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585762 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |  |  | GEOLOGICAL    |  |
|-------------------------|-----------------------|-----------|--|--|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG  | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.4       |   | Brown, organic SILT with some sand, minor silt, minor gravel and rare rootlets. Sand is fine, gravel is fine. Poorly graded, loose. Sub-parallel to slope profile that dips to the east.                     |               | TOPSOIL  |
|                         |                       | 0.8       |  | Light brown, silty sandy GRAVEL with minor cobbles. Sand is fine to coarse, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, 0.4-0.7 medium dense, 0.7-3 dense, stands well. |               | EARLY QUATERNARY GRAVEL  |
|                         |                       | 1.2       |  |  |               |  |
|                         |                       | 1.6       |  |  |               |  |
|                         |                       | 2.0       |  |  |               |  |
|                         |                       | 2.4       |  |  |               |  |
|                         |                       | 2.8       |  |  |               |  |
|                         |                       | 3.2       |  |  |               |  |
|                         | Total Depth = 3.2 m   |           |  |  |               |  |
|                         |                       | 3.6       |  |  |               |  |
|                         |                       | 4.0       |  |  |               |  |
|                         |                       | 4.4       |  |  |               |  |
|                         |                       | 4.8       |  |  |               |  |
|                         |                       | 5.2       |  |  |               |  |
|                         |                       | 5.6       |  |  |               |  |
|                         |                       | 6.0       |  |  |               |  |
|                         |                       | 6.4       |  |  |               |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |







# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 5B**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: east of pit        |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195244 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585762 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |  |   | GEOLOGICAL    |  |
|-------------------------|-----------------------|-----------|--|---|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG  | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.2       |   | Brown, organic SILT with some sand, minor silt, minor gravel and rare rootlets. Sand is fine, gravel is fine. Poorly graded, loose. Sub-parallel to slope profile that dips to the east.  |               | TOPSOIL  |
|                         |                       | 0.4       |  |   |               |  |
|                         |                       | 0.6       |  | Grey, sandy GRAVEL with sand and gravel dominant pockets and some boulders. Sand is fine coarse, gravel is fine to coarse, boulders to 1m. Poorly graded, loose to medium dense, fretting, stands poorly in localised zones due to boulders and loose gravel. Wedge of alluvial gravel pinches out to the west. |               | CARDRONA ALLUVIAL DEPOSIT  |
|                         |                       | 0.8       |  |   |               |  |
|                         |                       | 1.0       |  |   |               |  |
|                         |                       | 1.2       |  |   |               |  |
|                         |                       | 1.4       |  |   |               |  |
|                         |                       | 1.6       |  |   |               |  |
|                         |                       | 1.8       |  |   |               |  |
|                         |                       | 2.0       |  |   |               |  |
|                         |                       | 2.2       |  |   |               |  |
|                         |                       | 2.4       |  |   |               |  |
|                         |                       | 2.6       |  |   |               |  |
|                         |                       | 2.8       |  |   |               |  |
|                         |                       | 3.0       |  |   |               |  |
|                         |                       | 3.2       |  | Light brown, silty sandy GRAVEL with minor cobbles. Sand is fine to coarse, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, 0.4-0.7 medium dense, 0.7-3 dense, stands well.  |               | EARLY QUATERNARY GRAVEL  |
| Total Depth = 3.1 m     |                       |           |  |   |               |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |








# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 6**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195240 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585891 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   |  | GEOLOGICAL     |  |
|-------------------------|-----------------------|-----------|---|--|----------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT  | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.2       |    | Brown, organic SILT with some sand and gravel and minor roots. Sand is fine, gravel is fine. Poorly graded, loose. Sub-parallel to slope profile that dips to the east.                                |                | TOPSOIL  |
|                         |                       | 0.4       |   |  |                |  |
|                         |                       | 0.6       |    | Sandy GRAVEL. Sand is fine to medium, gravel is fine to medium. Poorly graded, medium dense. Dips slightly to the east.  | slightly moist | ALLUVIAL FAN GRAVEL  |
|                         |                       | 0.8       |   |  |                |  |
|                         |                       | 1.0       |   |  |                |  |
|                         |                       | 1.2       |  | White/brown, silty GRAVEL with minor cobbles and boulders, rare large boulders. Moderately weathered, boulders to 300mm, one boulder at 1m in size. Poorly graded, medium dense to dense, stands well. | dry            | EARLY QUATERNARY GRAVEL  |
|                         |                       | 1.4       |   |  |                |  |
|                         |                       | 1.6       |   |  |                |  |
|                         |                       | 1.8       |   |  |                |  |
|                         |                       | 2.0       |   |  |                |  |
|                         |                       | 2.2       |   |  |                |  |
|                         |                       | 2.4       |   |  |                |  |
|                         |                       | 2.6       |   |  |                |  |
|                         |                       | 2.8       |   |  |                |  |
|                         |                       | 3.0       |   |  |                |  |
|                         |                       | 3.2       |   |  |                |  |
| Total Depth = 3.1 m     |                       |           |   |  |                |  |

|                 |                |  |
|-----------------|----------------|--|
| COMMENT:        | Logged By: FAW |  |
|                 | Checked Date:  |  |
|                 | Sheet: 1 of 1  |  |
| PHOTO REF : N/A |                |  |



# GeoSolve Ltd

## EXCAVATION LOG

EXCAVATION NUMBER:

**TP 7**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195159 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5586004 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| PENETRATION (SPT) | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION  | WATER CONTENT  | GEOLOGICAL   |
|-------------------|-----------------------|-----------|-------------|--|----------------|--|
|                   |                       |           |             | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  |                | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|                   |                       | 0.2       |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | moist          | TOPSOIL  |
|                   |                       | 0.4       |             | Light brown, silty SAND with rare gravel. Sand is fine, gravel is fine. Uniform, soft to firm. Sub-parallel to slope profile that dips to the east.  | moist          | FILL   |
|                   |                       | 0.6       |             | Dark brown, organic SILT with minor sand and gravel and minor roots. Sand is fine, gravel is fine. Uniform, firm. Sub-parallel to slope profile that dips to the east.   | moist          | BURIED TOPSOIL   |
|                   |                       | 0.8       |             | SILT with some sand. Sand is fine. Uniform, firm to stiff. Sub-parallel to slope profile that dips to the east.  | moist          | LOESS  |
|                   |                       | 1.0       |             | Grey, sandy GRAVEL. Sand is fine to coarse, gravel is fine. Poorly graded, loose to medium dense. Sub-parallel to slope profile that dips to the east.   | wet            | ALLUVIAL DEPOSIT   |
|                   |                       | 1.2       |             | Grey/brown, SAND with some silt. Sand is fine to medium. Uniform, loose. Sub-parallel to slope profile that dips to the east.  | wet            | ALLUVIAL DEPOSIT   |
|                   |                       | 1.4       |             | Grey, sandy SILT with minor gravel. Sand is fine, gravel is fine. Uniform, firm. Sub-parallel to slope profile that dips to the east.  | moist          | ALLUVIAL DEPOSIT   |
|                   |                       | 1.6       |             | Blue/grey, silty sandy GRAVEL with minor cobbles and boulders. Sand is fine to medium, gravel is fine to coarse, boulders to 300mm. Poorly graded, loose to medium dense. Sub-parallel to slope profile that dips to the east. | wet, saturated | ALLUVIAL DEPOSIT   |
|                   |                       | 1.8       |             | Orange/brown, gravelly SILT with rare cobbles, boulders and sand. Sand is fine, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, medium dense to dense, slightly plastic.                      | moist          | EARLY QUATERNARY DEPOSIT   |
|                   |                       | 2.0       |             | Orange/brown, gravelly SILT with rare cobbles, boulders and sand. Sand is fine, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, medium dense to dense, slightly plastic.                      | moist          | EARLY QUATERNARY DEPOSIT   |
|                   |                       | 2.2       |             | Orange/brown, gravelly SILT with rare cobbles, boulders and sand. Sand is fine, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, medium dense to dense, slightly plastic.                      | moist          | EARLY QUATERNARY DEPOSIT   |
|                   |                       | 2.4       |             | Orange/brown, gravelly SILT with rare cobbles, boulders and sand. Sand is fine, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, medium dense to dense, slightly plastic.                      | moist          | EARLY QUATERNARY DEPOSIT   |
|                   |                       | 2.6       |             | Orange/brown, gravelly SILT with rare cobbles, boulders and sand. Sand is fine, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, medium dense to dense, slightly plastic.                      | moist          | EARLY QUATERNARY DEPOSIT   |
|                   |                       | 2.8       |             | Orange/brown, gravelly SILT with rare cobbles, boulders and sand. Sand is fine, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, medium dense to dense, slightly plastic.                      | moist          | EARLY QUATERNARY DEPOSIT   |
|                   |                       | 3.0       |             | Orange/brown, gravelly SILT with rare cobbles, boulders and sand. Sand is fine, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, medium dense to dense, slightly plastic.                      | moist          | EARLY QUATERNARY DEPOSIT   |
|                   |                       | 3.2       |             | Orange/brown, gravelly SILT with rare cobbles, boulders and sand. Sand is fine, gravel is fine to coarse, cobbles to 200mm, moderately weathered. Poorly graded, medium dense to dense, slightly plastic.                      | moist          | EARLY QUATERNARY DEPOSIT   |

Total Depth = 3.2 m

|  |                |
|--|----------------|
| COMMENT: Seepage settled at 1.8m, filled bottom of test pit, perched water on top of the Early Quaternary Gravel | Logged By: FAW |
|  | Checked Date:  |
| PHOTO REF.: N/A  | Sheet: 1 of 1  |



# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 8**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195088 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5586065 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| PENETRATION (SPT) | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION  | WATER CONTENT | GEOLOGICAL   |
|-------------------|-----------------------|-----------|-------------|--|---------------|--|
|                   |                       |           |             | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  |               | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|                   |                       | 0.2       |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the SE @ 5-10°.   | moist         | TOPSOIL  |
|                   |                       | 0.4       |             | SILT with minor sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips to the SE @ 5-10°.  | moist         | LOESS  |
|                   |                       | 0.6       |             | Light blue, grey, mottled orange, gravelly SILT, silty lense @ 1-1.1m. Gravel is fine to medium, slightly weathered. Poorly graded, medium dense, slightly plastic. Parallel to slope profile that dips to the SE @ 5-10°.   |               | ALLUVIAL DEPOSITS  |
|                   |                       | 0.8       |             |  |               |  |
|                   |                       | 1.0       |             |  |               |  |
|                   |                       | 1.2       |             | Light brown, grey, mottled orange, silty GRAVEL with rare sand. Sand is fine, gravel is fine to coarse, slightly weathered. Poorly graded, medium dense. Parallel to slope profile that dips to the SE @ 5-10°.  |               | ALLUVIAL DEPOSITS  |
|                   |                       | 1.4       |             |  |               |  |
|                   |                       | 1.6       |             |  |               |  |
|                   |                       | 1.8       |             |  |               |  |
|                   |                       | 2.0       |             |  |               |  |
|                   |                       | 2.2       |             | Orange brown, silty GRAVEL with some sand and rare cobbles. Sand is fine to coarse, gravel is fine to coarse, cobbles to 150mm, clasts are sub-rounded to sub-angular, metasediment dominant, moderately weathered. Poorly graded, dense. Dips slightly to the east. |               | EARLY QUATERNARY GRAVEL  |
|                   |                       | 2.4       |             |  |               |  |
|                   |                       | 2.6       |             |  |               |  |
|                   |                       | 2.8       |             |  |               |  |
|                   |                       | 3.0       |             |  |               |  |
|                   |                       | 3.2       |             |  |               |  |
|                   |                       |           |             | Total Depth = 3.1 m  |               |  |
|                   |                       |           |             | Total Depth = 3.2 m  |               |  |

|  |                |
|--|----------------|
| COMMENT: Minor seepage @ 0.8m, slow seep | Logged By: FAW |
|  | Checked Date:  |
|  | Sheet: 1 of 1  |
| PHOTO REF.: N/A                          |                |





# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 9**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195021 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585942 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| PENETRATION (SPT) | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION   | WATER CONTENT | GEOLOGICAL   |
|-------------------|-----------------------|-----------|-------------|---|---------------|--|
|                   |                       |           |             | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   |               | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|                   |                       | 0.4       |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | 11            | TOPSOIL  |
|                   |                       | 0.8       |             | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.   | 10            | LOSS   |
|                   |                       | 1.2       |             | Light blue, grey, mottled orange, gravelly SILT. Gravel is fine to medium, slightly weathered. Poorly graded, medium dense, slightly plastic. Sub-horizontal.   |               | ALLUVIAL DEPOSITS  |
|                   |                       | 1.6       |             | Light brown, orange, silty GRAVEL with rare sand. Sand is fine, gravel is fine to coarse, slightly weathered. Poorly graded, medium dense. Sub-horizontal.  |               | ALLUVIAL DEPOSITS  |
|                   |                       | 2.0       |             | Orange brown, sandy SILT. Sand is fine. Very stiff. Sub-horizontal.   |               | ALLUVIAL DEPOSITS  |
|                   |                       | 2.4       |             | Tan brown, silty GRAVEL with some sand and rare cobbles. Sand is fine to coarse, gravel is fine to coarse, cobbles to 150mm, clasts are sub-rounded to sub-angular, metasediment dominant, moderately weathered. Poorly graded, dense. Dips slightly to the east. |               | EARLY QUATERNARY GRAVEL  |
|                   |                       | 2.8       |             | Total Depth = 3.8 m   |               |  |
|                   |                       | 3.2       |             | Total Depth = 3.2 m   |               |  |
|                   |                       | 3.6       |             | Total Depth = 3.2 m   |               |  |
|                   |                       | 4.0       |             | Total Depth = 3.2 m   |               |  |
|                   |                       | 4.4       |             | Total Depth = 3.2 m   |               |  |
|                   |                       | 4.8       |             | Total Depth = 3.2 m   |               |  |
|                   |                       | 5.2       |             | Total Depth = 3.2 m   |               |  |
|                   |                       | 5.6       |             | Total Depth = 3.2 m   |               |  |
|                   |                       | 6.0       |             | Total Depth = 3.2 m   |               |  |
|                   |                       | 6.4       |             | Total Depth = 3.2 m   |               |  |

Total Depth = 3.2 m

|   |                |
|---|----------------|
| COMMENT: Three minor seepages from 1-1.8m | Logged By: FAW |
|   | Checked Date:  |
|   | Sheet: 1 of 1  |
| PHOTO REF.: N/A                           |                |

















# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 10**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194900 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585925 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |   |           |   | GEOLOGICAL   |  |  |
|-------------------------|---|-----------|---|--|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE   | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT  | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION   |
|                         |   | 0.4       |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | mois   | TOPSOIL  |
|                         |   |           |   | SILT with minor sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips to the SE @ 5-10°.  | mois   | LOESS  |
|                         |   | 0.8       |    | Red/brown, SILT with some clay. Slightly weathered. Uniform, firm, slightly plastic. Sub-horizontal.   | wet  | ALLUVIAL SILT  |
|                         |   |           |   | Blue/grey, SILT with some clay. Uniform, firm, slightly plastic. Sub-horizontal.   | wet  | ALLUVIAL SILT  |
|                         |   | 1.2       |    | Grey, gravelly SILT with minor cobbles and boulders and rare sand. Sand is fine, gravel is fine to coarse, boulders to 250mm. Poorly graded, medium dense. Sub-horizontal. | wet  | ALLUVIAL DEPOSITS  |
|                         |   |           |   | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal.   | wet  | ALLUVIAL DEPOSITS  |
|                         |   | 2.0       |   | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal.   |  |  |
|                         |   |           |   | 2.4  |  |  |
|                         |   | 2.8       |  |  | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal. |  |
|                         |   |           |   | 3.2  |                                   | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal. |
|                         |   | 3.6       |  |  |  | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal. |
|                         |   |           |   | 4.0  |                                   | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal. |
|                         |   | 4.4       |  |  |  | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal. |
|                         |   |           |   | 4.8  |                                   | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal. |
|                         |   | 5.2       |  |  |  | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal. |
| 5.6                     |  |           |   | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal.   |  |  |
|                         |   | 6.0       |  | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal.   |  |  |
| 6.4                     |  |           |   | Blue/grey, gravelly sandy SILT. Sand is fine, gravel is fine to coarse. Poorly graded, medium dense. Sub-horizontal.   |  |  |

Total Depth = 3.2 m

|                                  |  |                |  |
|----------------------------------|--|----------------|--|
| COMMENT: Minor seepage from 4.3m |  | Logged By: FAW |  |
| PHOTO REF.: N/A                  |  | Checked Date:  |  |
|                                  |  | Sheet: 1 of 1  |  |







# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 11**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194808 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585901 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   |   | GEOLOGICAL    |  |
|-------------------------|-----------------------|-----------|---|---|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.4       |    | Brown, organic SILT with minor sand and gravel. Uniform, soft. Parallel to slope profile that dips to the east.   | mols          | TOPSOIL  |
|                         |                       | 0.8       |    | Brown, organic SILT with some sand and gravel. Uniform, soft. Parallel to slope profile that dips to the east.  | mols          | TOPSOIL  |
|                         |                       | 1.2       |   | Tan/brown, gravelly SILT with some sand. Sand is fine, gravel is fine to medium. Poorly graded, medium dense. Dips 5° to NE, thickens to the south with the slope angle.  |               | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 1.6       |  | Light brown, sandy GRAVEL with minor cobbles and silt. Sand is fine to coarse, gravel is fine to coarse, cobbles to 200mm, clasts are schist dominant, sub-rounded to angular. Well graded, medium dense @ 1.2-2.4m, dense @ 2.4-4m. Dips slightly to the NE. |               | ALLUVIAL FAN GRAVEL  |
|                         |                       | 2.0       |   |   |               |  |
|                         |                       | 2.4       |   |   |               |  |
|                         |                       | 2.8       |   |   |               |  |
|                         |                       | 3.2       |   |   |               |  |
|                         |                       | 3.6       |   |   |               |  |
|                         |                       | 4.0       |   |   |               |  |
|                         |                       | 4.4       |   | Total Depth = 4 m   |               |  |
|                         |                       | 4.8       |   |   |               |  |
|                         |                       | 5.2       |   |   |               |  |
|                         |                       | 5.6       |   |   |               |  |
|                         |                       | 6.0       |   |   |               |  |
|                         |                       | 6.4       |   |   |               |  |

Total Depth = 3.2 m

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |





# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 12**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194700 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585884 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 25-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 25-Aug-05 |

| PENETRATION (SPT) | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION   | WATER CONTENT | GEOLOGICAL   |
|-------------------|-----------------------|-----------|-------------|---|---------------|--|
|                   |                       |           |             | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   |               | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE        |                       | 0.4       |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | moist         | TOPSOIL  |
|                   |                       | 0.8       |             | SILT with some sand. Sand is fine. Uniform, firm. Sub-horizontal.   | moist         | LOESS  |
|                   |                       | 1.2       |             | Tan/brown, gravelly SILT with some sand. Sand is fine, gravel is fine to medium. Poorly graded, medium dense. Dips 5° to NE, thickens to the south with the slope angle.  |               | ALLUVIAL FAN DEPOSIT   |
|                   |                       | 1.6       |             | Light brown, sandy GRAVEL with minor cobbles, minor boulders and silt. Sand is fine to coarse, gravel is fine to coarse, cobbles to 200mm, clasts are schist dominant, sub-rounded to angular. Well graded, dense, hard to excavate. Dips slightly to the east. |               | ALLUVIAL FAN GRAVEL  |
|                   |                       | 2.0       |             |   |               |  |
|                   |                       | 2.4       |             | Light brown, SILT with minor/some sand. Sand is fine. Uniform. Dips slightly to the east.   |               | ALLUVIAL FAN DEPOSIT   |
|                   |                       | 2.8       |             |   |               |  |
|                   |                       | 3.2       |             |   |               |  |
|                   |                       | 3.6       |             |   |               |  |
|                   |                       | 4.0       |             | Total Depth = 3.7 m   |               |  |
|                   |                       | 4.4       |             |   |               |  |
|                   |                       | 4.8       |             |   |               |  |
|                   |                       | 5.2       |             |   |               |  |
|                   |                       | 5.6       |             |   |               |  |
|                   |                       | 6.0       |             |   |               |  |
|                   |                       | 6.4       |             |   |               |  |

Total Depth = 3.2 m

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |



# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 13**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194710 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585767 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |                   |             | GEOLOGICAL  |                |  |  |
|-------------------------|-----------------------|-------------------|-------------|---|----------------|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m)         | GRAPHIC LOG | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT  | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |  |
| NO SEEPAGE              |                       | 0.2               |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | moist          | TOPSOIL  |  |
|                         |                       | 0.4               |             | SILT. Uniform, firm. Sub-horizontal.  | slightly moist | ALLUVIAL DEPOSIT   |  |
|                         |                       | 0.6               |             |   |                |  |  |
|                         |                       | 0.8               |             |   |                |  |  |
|                         |                       | 1.0               |             | SILT with minor clay. Uniform, stiff. Thickens to the south.  | slightly moist | ALLUVIAL DEPOSIT   |  |
|                         |                       | 1.2               |             |   |                |  |  |
|                         |                       | 1.4               |             |   |                |  |  |
|                         |                       | 1.6               |             | Brown, silty GRAVEL with some cobbles and boulders and minor sand. Sand is fine to coarse, gravel is fine to coarse, boulders to 1m, clasts are schist dominant, clasts are angular to sub-angular, minor sub-rounded clasts. Poorly graded, dense to very dense, hard to excavate. Dips to the east. | moist          | ALLUVIAL FAN GRAVEL  |  |
|                         |                       | 1.8               |             |   |                |  |  |
|                         |                       | 2.0               |             |   |                |  |  |
|                         |                       | 2.2               |             |   |                |  |  |
|                         |                       | 2.4               |             |   |                |  |  |
|                         |                       | 2.6               |             |   |                |  |  |
|                         |                       | 2.8               |             |   |                |  |  |
|                         |                       | 3.0               |             |   |                |  |  |
|                         |                       | Total Depth = 3 m |             |   |                |  |  |
|                         |                       | 3.2               |             |   |                |  |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |



# GeoSolve Ltd

## EXCAVATION LOG

EXCAVATION NUMBER:

### TP 14

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194845 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585777 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |                     |   | GEOLOGICAL     |  |  |
|-------------------------|-----------------------|-----------|---------------------|---|----------------|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG         | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT  | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |  |
| NO SEEPAGE              |                       | 0.4       |                     | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | mols           | TOPSOIL  |  |
|                         |                       |           |                     | SILT with some sand. Sand is fine. Uniform, firm. Sub-horizontal.   | mols           | LOESS  |  |
|                         |                       | 0.8       |                     | Brown, silty GRAVEL with some boulders and cobbles and minor sand. Sand is fine to coarse, gravel is fine to coarse, boulders to 1m, sub-rounded to angular clasts. Well graded, medium dense. Dips 5° to the east. | slightly moist | ALLUVIAL FAN GRAVEL  |  |
|                         |                       | 1.2       |                     |   |                |  |  |
|                         |                       | 1.6       |                     | Brown, sandy GRAVEL with some boulders, cobbles and minor silt. Boulders to 500mm. Well graded, medium dense to dense. Dips 5° to the east.   | slightly moist | ALLUVIAL FAN GRAVEL  |  |
|                         |                       | 2.0       |                     |   |                |  |  |
|                         |                       | 2.4       |                     |   |                |  |  |
|                         |                       | 2.8       |                     |   |                |  |  |
|                         |                       | 3.2       |                     |   |                |  |  |
|                         |                       | 3.6       |                     |   |                |  |  |
|                         |                       |           | Total Depth = 3.5 m |   |                |  |  |
|                         |                       | 4.0       |                     |   |                |  |  |
|                         |                       | 4.4       |                     |   |                |  |  |
|                         |                       | 4.8       |                     |   |                |  |  |
|                         |                       | 5.2       |                     |   |                |  |  |
|                         |                       | 5.6       |                     |   |                |  |  |
|                         |                       | 6.0       |                     |   |                |  |  |
|                         | 6.4                   |           |                     |   |                |  |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |



# GeoSolve Ltd

## EXCAVATION LOG

EXCAVATION NUMBER:

### TP 15

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194967 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585845 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |  |             |  | GEOLOGICAL     |  |
|-------------------------|-----------------------|--|-------------|--|----------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m)  | GRAPHIC LOG | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT  | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.4  |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | m<br>moist     | TOPSOIL  |
|                         |                       | SILT. Uniform, firm. Parallel to slope profile that dips slightly to the east. |             | moist  | LOESS          |  |
|                         |                       | 0.8  |             | Brown, sandy GRAVEL with some cobbles and boulders and rare silt. Sand is fine to coarse, gravel is fine to coarse, boulders to 500mm, clasts are angular to sub-rounded, schist dominated. Well graded, medium dense to dense. Dips 3° to the east. | slightly moist | ALLUVIAL FAN GRAVEL  |
|                         |                       | 1.2  |             |  |                |  |
|                         |                       | 1.6  |             |  |                |  |
|                         |                       | 2.0  |             |  |                |  |
|                         |                       | 2.4  |             |  |                |  |
|                         |                       | 2.8  |             | Light brown, sandy GRAVEL with minor cobbles and silt. Sand is fine to coarse, gravel is fine to coarse, cobbles to 200mm, clasts are schist dominant, sub-rounded to angular. Well graded, dense. Dips slightly to the E.                           |                | ALLUVIAL FAN GRAVEL  |
|                         |                       | 3.2  |             |  |                |  |
|                         |                       | 3.6  |             |  |                |  |
|                         |                       | 4.0  |             |  |                |  |
|                         |                       | 4.4  |             | Total Depth = 3.7 m  |                |  |
|                         |                       | 4.8  |             |  |                |  |
|                         |                       | 5.2  |             |  |                |  |
|                         |                       | 5.6  |             |  |                |  |
|                         |                       | 6.0  |             |  |                |  |
| 6.4                     |                       | Total Depth = 3.7 m  |             |  |                |  |
| 6.8                     |                       |  |             |  |                |  |
| 7.2                     |                       |  |             |  |                |  |
| 7.6                     |                       |  |             |  |                |  |
| 8.0                     |                       |  |             |  |                |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |





# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 16**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194970 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585756 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| PENETRATION (SPT) | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION   | WATER CONTENT  | GEOLOGICAL   |
|-------------------|-----------------------|-----------|-------------|---|----------------|--|
|                   |                       |           |             | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   |                | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE        |                       | 0.4       |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | moist          | TOPSOIL  |
|                   |                       | 0.8       |             | SILT. Uniform, firm. Parallel to slope profile that dips slightly to the east.  | moist          | LOESS  |
|                   |                       | 1.2       |             | Grey/brown, sandy SILT. Sand is fine. Uniform, firm. Sub-horizontal.  | moist          | ALLUVIAL SILT  |
|                   |                       | 1.6       |             | Grey/brown, SILT with rare clay. Uniform, firm to stiff. Sub-horizontal.  | moist          | ALLUVIAL SILT  |
|                   |                       | 2.0       |             | Sandy GRAVEL with minor cobbles and rare boulders. Sand is fine to coarse, gravel is fine to coarse, boulders to 250mm, clasts are schist dominated, sub-rounded to sub-angular. Poorly graded, medium dense. Sub-horizontal. | slightly moist | ALLUVIAL FAN GRAVEL  |
|                   |                       | 2.4       |             | SAND. Sandy lense. Uniform, loose. Sub-horizontal.  | slightly       | ALLUVIAL FAN DEPOSIT   |
|                   |                       | 2.8       |             | Sandy GRAVEL with minor cobbles. Sand is fine to coarse, gravel is fine to coarse, clasts are sub-rounded to angular, cobbles to 150mm. Poorly graded, medium dense. Sub-horizontal.  | slightly moist | ALLUVIAL FAN GRAVEL  |
|                   |                       | 3.2       |             |   |                |  |
|                   |                       | 3.6       |             |   |                |  |
|                   |                       | 4.0       |             |   |                |  |
|                   |                       | 4.4       |             | Total Depth = 4 m   |                |  |
|                   |                       | 4.8       |             |   |                |  |
|                   |                       | 5.2       |             |   |                |  |
|                   |                       | 5.6       |             |   |                |  |
|                   |                       | 6.0       |             |   |                |  |
|                   |                       | 6.4       |             |   |                |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |









# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 17**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195099 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585740 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |                     |   |  | GEOLOGICAL       |  |  |  |
|-------------------------|-----------------------|---------------------|---|--|------------------|--|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m)           | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT    | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |  |  |
| NO SEEPAGE              |                       | 0.4                 |  | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | m <sub>dis</sub> | TOPSOIL  |  |  |
|                         |                       | 0.4                 |  | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.  | m <sub>dis</sub> | LOESS  |  |  |
|                         |                       | 0.8                 |  | Brown, silty GRAVEL with minor sand, organics and rare rootlets. Sand is fine to coarse, gravel is fine to coarse. Poorly graded, loose. Sub-horizontal.   | moist            | ALLUVIAL FAN DEPOSIT   |  |  |
|                         |                       | 0.8                 |  | Brown, sandy GRAVEL with rare/minor cobbles and boulders. Sand is fine to coarse, gravel is fine to coarse, boulders to 200mm, clasts are subangular to subrounded, schist dominant. Well graded, medium dense. Dips 2° to the east. |                  | ALLUVIAL FAN GRAVEL  |  |  |
|                         |                       | 1.2                 |   |  |                  |  |  |  |
|                         |                       | 1.6                 |   |  |                  |  |  |  |
|                         |                       | 2.0                 |   |  |                  |  |  |  |
|                         |                       | 2.4                 |   |  |                  |  |  |  |
|                         |                       | 2.8                 |   |  |                  |  |  |  |
|                         |                       | 3.2                 |   |  |                  |  |  |  |
|                         |                       | 3.6                 |   |  |                  |  |  |  |
|                         |                       | Total Depth = 3.6 m |   |  |                  |  |  |  |
|                         |                       | 4.0                 |   |  |                  |  |  |  |
|                         |                       | 4.4                 |   |  |                  |  |  |  |
|                         |                       | 4.8                 |   |  |                  |  |  |  |
|                         |                       | 5.2                 |   |  |                  |  |  |  |
|                         |                       | 5.6                 |   |  |                  |  |  |  |
|                         |                       | 6.0                 |   |  |                  |  |  |  |
|                         |                       | 6.4                 |   |  |                  |  |  |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |



# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 18**

|                              |                            |                           |                |
|------------------------------|----------------------------|---------------------------|----------------|
| PROJECT: Mt Cardrona Station |                            | Job Number: 160677        |                |
| LOCATION: see site map       |                            | Inclination: see site map | Direction: N/A |
| EASTING: 2195055 mE          | EQUIPMENT: 12T Digger      | OPERATOR: Joe             |                |
| NORTHING: 5585602 mN         | INFOMAP NO.                | COMPANY: Workable Earth   |                |
| ELEVATION: see site map m    | DIMENSIONS:                | HOLE STARTED: 26-Aug-05   |                |
| METHOD: N/A                  | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05  |                |

| PENETRATION (SPT) | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | ENGINEERING DESCRIPTION  | WATER CONTENT | GEOLOGICAL   |
|-------------------|-----------------------|-----------|-------------|--|---------------|--|
|                   |                       |           |             | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  |               | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE        |                       | 0.4       |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | moist         | TOPSOIL  |
|                   |                       |           |             | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.  | moist         | LOESS  |
|                   |                       | 0.8       |             | Grey brown, sandy SILT. Sand is fine. Uniform, firm. Dips slightly to the south east.  | moist         | ALLUVIAL SILT  |
|                   |                       | 1.2       |             |  |               |  |
|                   |                       | 1.6       |             | Grey brown, SILT with rare clay. Uniform, firm to stiff. Dips slightly to the south east.  | moist         | ALLUVIAL SILT  |
|                   |                       | 2.0       |             | Brown, sandy GRAVEL with rare cobbles and boulders. Sand is fine to coarse, gravel is fine to coarse, boulders to 300mm, sub-rounded to angular clasts. Well graded, medium dense. Dips slightly to the east.                        | moist         | ALLUVIAL FAN GRAVEL  |
|                   |                       | 2.4       |             | Brown, sandy GRAVEL with rare/minor cobbles and boulders. Sand is fine to coarse, gravel is fine to coarse, boulders to 400mm, clasts are subangular to subrounded, schist dominant. Well graded, medium dense. Dips 2° to the east. | moist         | ALLUVIAL FAN GRAVEL  |
|                   |                       | 2.8       |             |  |               |  |
|                   |                       | 3.2       |             |  |               |  |
|                   |                       | 3.6       |             |  |               |  |
|                   |                       | 4.0       |             |  |               |  |
|                   |                       | 4.4       |             |  |               |  |
|                   |                       |           |             | Total Depth = 4.3 m  |               |  |
|                   |                       | 4.8       |             |  |               |  |
|                   |                       | 5.2       |             |  |               |  |
|                   |                       | 5.6       |             |  |               |  |
|                   |                       | 6.0       |             |  |               |  |
|                   |                       | 6.4       |             |  |               |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |










# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 19**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: see site map       |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194935 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585657 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |   |   |   |   | GEOLOGICAL    |  |  |
|-------------------------|---|---|---|---|---------------|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE   | DEPTH (m)   | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |  |
|                         |   | 0.4   |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | m             | TOPSOIL  |  |
|                         |   |   |   | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.   | moist         | LOESS  |  |
|                         |   | 0.8   |    | Grey, sandy SILT. Sand is fine. Uniform, firm to stiff. Sub-horizontal.   | moist         | ALLUVIAL SILT  |  |
|                         |   |   |   | Grey brown, SILT. Uniform, firm to stiff. Thickens to the southwest.  | moist         | ALLUVIAL SILT  |  |
|                         |   | 1.2   |    |   |               |  |  |
|                         |   |   |   |   |               |  |  |
|                         |   | 1.6   |   | Brown, silty GRAVEL with some cobbles and boulders and minor sand. Sand is fine to coarse, gravel is fine to coarse, boulders to 500mm, clasts are schist dominant, clasts are angular to sub-angular, minor sub-rounded clasts. Poorly graded, dense to very dense, hard to excavate. Thickens to the south. | moist         | ALLUVIAL FAN GRAVEL  |  |
|                         |   |   |   |   |               |  |  |
|                         |   | 2.0   |  |   |               |  |  |
|                         |   |   |   |   |               |  |  |
|                         |   | 2.4   |  | Grey brown, SAND with rare gravel and some bands of silt. Sand is fine to medium, gravel is fine to medium. Uniform, medium dense. Sub-horizontal.  | moist         | ALLUVIAL FAN DEPOSIT   |  |
|                         |   |   |   |   |               |  |  |
|                         |   | 2.8   |   |   |               |  |  |
|                         |   | 3.2   |   |   |               |  |  |
|                         |   | 3.6   |   |   |               |  |  |
| 4.0                     |   |   |   |   |               |  |  |
| 4.4                     |  | Grey brown, sandy GRAVEL with some cobbles and boulders. Sand is fine to coarse, gravel is fine to coarse, boulders to 500mm, clasts are angular to sub-rounded, schist dominated. Poorly graded, medium dense to dense. Dips slightly to the east. | moist   | ALLUVIAL FAN DEPOSIT  |               |  |  |
|                         |   |   |   |   |               |  |  |
| 4.8                     |   | Total Depth = 4.6 m   |   |   |               |  |  |
| 5.2                     |   |   |   |   |               |  |  |
| 5.6                     |   |   |   |   |               |  |  |
| 6.0                     |   |   |   |   |               |  |  |
| 6.4                     |   |   |   |   |               |  |  |

|                                  |  |                |
|----------------------------------|--|----------------|
| COMMENT: Minor, slow seep @ 2.6m |  | Logged By: FAW |
| PHOTO REF.: N/A                  |  | Checked Date:  |
|                                  |  | Sheet: 1 of 1  |








# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 20**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: (cut)              |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195215 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585931 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   |   | GEOLOGICAL    |  |
|-------------------------|-----------------------|-----------|---|---|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.2       |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | m             | TOPSOIL  |
|                         |                       | 0.4       |   | Grey brown, silty GRAVEL with minor cobbles and sand and rare gravel. Sand is fine, gravel is fine to coarse, boulders to 300mm. Poorly graded, medium dense. Dips to the east. | dry           | ALLUVIAL FAN GRAVEL  |
|                         |                       | 0.6       |   |   |               |  |
|                         |                       | 0.8       |   |   |               |  |
|                         |                       | 1.0       |   |   |               |  |
|                         |                       | 1.2       |   |   |               |  |
|                         |                       | 1.4       |   |   |               |  |
|                         |                       | 1.6       |  | Light brown, silty GRAVEL with minor cobbles and boulders. Gravel is fine to coarse, boulders to 300mm. Poorly graded, dense. Dips 5° to the east.                              | dry           | EARLY QUATERNARY GRAVEL  |
|                         |                       | 1.8       |   |   |               |  |
|                         |                       | 2.0       |   |   |               |  |
|                         |                       | 2.2       |   |   |               |  |
|                         |                       | 2.4       |   |   |               |  |
|                         |                       | 2.6       |   |   |               |  |
|                         |                       | 2.8       |   | Total Depth = 2.6 m   |               |  |
|                         |                       | 3.0       |   |   |               |  |
|                         |                       | 3.2       |   |   |               |  |

COMMENT: Standing @ 70°-80°, old weathered cut in road track

Logged By: FAW

Checked Date:

PHOTO REF.: N/A

Sheet: 1 of 1



# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 21**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: (cut)              |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2195093 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585900 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |             | GEOLOGICAL   |  |
|-------------------------|-----------------------|-----------|-------------|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT  |
|                         |                       |           |             |  | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|                         |                       | 0.4       |             | Brown, organic S&T with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | TOPSOIL  |
|                         |                       | 0.8       |             | Light grey, brown, silty GRAVEL with some sand, minor cobbles and boulders. Sand is fine, gravel is fine to coarse, boulders to 300mm, clasts are sub-angular to sub-rounded quartz dominated gravel. Well graded, medium dense to dense. Dips 5° to the east. | ALLUVIAL FAN GRAVEL  |
|                         |                       | 1.2       |             |  |  |
|                         |                       | 1.6       |             |  |  |
|                         |                       | 2.0       |             |  |  |
|                         |                       | 2.4       |             |  |  |
|                         |                       | 2.8       |             |  |  |
|                         |                       | 3.2       |             |  |  |
|                         |                       | 3.6       |             |  |  |
|                         |                       | 4.0       |             |  |  |
|                         |                       | 4.4       |             |  |  |
|                         |                       | 4.8       |             |  |  |
|                         |                       | 5.2       |             | Total Depth = 5 m  |  |
|                         |                       | 5.6       |             |  |  |
|                         |                       | 6.0       |             |  |  |
|                         |                       | 6.4       |             |  |  |

|  |  |                |
|--|--|----------------|
| COMMENT: Standing vertical to 80° in cut |  | Logged By: FAW |
| PHOTO REF.: N/A                          |  | Checked Date:  |
|  |  | Sheet: 1 of 1  |















# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 22**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: N/A                |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194978 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585410 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   | GEOLOGICAL   |               |  |
|-------------------------|-----------------------|-----------|---|--|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.4       |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | moist         | TOPSOIL  |
|                         |                       | 0.8       |    | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.  | moist         | LOESS  |
|                         |                       | 1.2       |   | Grey/brown, SILT with rare clay. Uniform, firm to stiff. Dips slightly to the southeast.   | moist         | ALLUVIAL SILT  |
|                         |                       | 1.6       |  |  |               |  |
|                         |                       | 2.0       |  |  |               |  |
|                         |                       | 2.4       |  | Grey/brown, SILT with minor / some clay. Uniform, stiff. Dips slightly to the southeast.   | moist         | ALLUVIAL SILT  |
|                         |                       | 2.8       |  | Brown, sandy GRAVEL with cobbles and boulders. Sand is fine to coarse, gravel is fine to coarse, clasts are schist dominant, sub-rounded to angular, boulders to 700mm. Poorly graded, medium dense to dense. Dips 5° to the east. |               | ALLUVIAL FAN GRAVEL  |
|                         |                       | 3.2       |  |  |               |  |
|                         |                       | 3.6       |  |  |               |  |
|                         |                       | 4.0       |  |  |               |  |
|                         |                       | 4.4       |   | Total Depth = 4.1 m  |               |  |
|                         |                       | 4.8       |   |  |               |  |
|                         |                       | 5.2       |   |  |               |  |
|                         |                       | 5.6       |   |  |               |  |
|                         |                       | 6.0       |   |  |               |  |
|                         |                       | 6.4       |   |  |               |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |







# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 23**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: N/A                |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194765 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585136 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   | GEOLOGICAL  |               |  |
|-------------------------|-----------------------|-----------|---|---|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.2       |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | moist         | TOPSOIL  |
|                         |                       | 0.4       |    | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.   | moist         | LOESS  |
|                         |                       | 0.6       |    | Tan/brown, SILT with minor clay. Uniform, stiff. Sub-horizontal.  | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 0.8       |   |   |               |  |
|                         |                       | 1.0       |  | Grey/brown, large BOULDERS in a silt matrix with minor lenses of silty gravel. Gravel is fine to coarse in the lenses, boulders to 2m of sub-angular schist. Poorly graded, medium dense to dense. Dips slightly to the east. | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 1.2       |   |   |               |  |
|                         |                       | 1.4       |   |   |               |  |
|                         |                       | 1.6       |   |   |               |  |
|                         |                       | 1.8       |   |   |               |  |
|                         |                       | 2.0       |   |   |               |  |
|                         |                       | 2.2       |   |   |               |  |
|                         |                       | 2.4       |   |   |               |  |
|                         |                       | 2.6       |   |   |               |  |
|                         |                       | 2.8       |   |   |               |  |
|                         |                       | 3.0       |   |   |               |  |
|                         |                       | 3.2       |   |   |               |  |
| Total Depth = 2.1 m     |                       |           |   |   |               |  |

|   |                |
|---|----------------|
| COMMENT: Digger refusal due to large boulders | Logged By: FAW |
|   | Checked Date:  |
|   | Sheet: 1 of 1  |
| PHOTO REF.: N/A                               |                |





# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 24**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: N/A                |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194501 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585307 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |             |   | GEOLOGICAL    |  |
|-------------------------|-----------------------|-----------|-------------|---|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.4       |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | moist         | TOPSOIL  |
|                         |                       |           |             | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.   | m             | LOESS  |
|                         |                       | 0.8       |             | Tan/brown, silty SAND. Sand is fine. Uniform, firm to stiff. Dips at 2° to the east.  | moist         | ALLUVIAL SILT  |
|                         |                       | 1.2       |             | Grey/brown, silty GRAVEL with minor cobbles. Gravel is fine to coarse, cobbles to 200mm, clasts are sub-angular to sub-rounded. Poorly graded, medium dense. Dips at 2° to the east.  | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 1.6       |             | Brown, SILT with minor gravel and rare cobbles and boulders. Gravel is fine to coarse, boulders to 400mm. Uniform, stiff to very stiff. Dips at 2° to the east.   | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 2.0       |             | Gravelly SILT with minor sand. Sand is fine to medium, gravel is fine to coarse. Poorly graded, stiff to very stiff. Dips at 2° to the east.  | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 2.4       |             | Brown, SILT with minor gravel and rare cobbles and boulders. Gravel is fine to coarse, boulders to 400mm. Uniform, stiff to very stiff. Dips at 2° to the east.   | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 2.8       |             | Grey/brown, large BOULDERS in a silt matrix with minor lenses of silty gravel. Gravel is fine to coarse in the lenses, boulders to 2m of sub-angular schist. Poorly graded, medium dense to dense. Dips slightly to the east. | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 3.2       |             | Total Depth = 3.2 m   |               |  |
|                         |                       | 3.6       |             |   |               |  |
|                         |                       | 4.0       |             |   |               |  |
|                         |                       | 4.4       |             |   |               |  |
|                         |                       | 4.8       |             |   |               |  |
|                         |                       | 5.2       |             |   |               |  |
|                         |                       | 5.6       |             |   |               |  |
|                         |                       | 6.0       |             |   |               |  |
|                         |                       | 6.4       |             |   |               |  |

|   |                |
|---|----------------|
| COMMENT: Digger refusal due to large boulders | Logged By: FAW |
|   | Checked Date:  |
|   | Sheet: 1 of 1  |
| PHOTO REF.: N/A                               |                |



# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 25**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: N/A                |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194256 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585501 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |                     |             | GEOLOGICAL   |               |  |
|-------------------------|-----------------------|---------------------|-------------|--|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m)           | GRAPHIC LOG | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |                       | 0.2                 |             | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | moist         | TOPSOIL  |
|                         |                       | 0.4                 |             | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.  | moist         | LOESS  |
|                         |                       | 0.6                 |             | Grey/brown, sandy SILT. Sand is fine. Uniform, stiff. Sub-horizontal.  | moist         | ALLUVIAL SILT  |
|                         |                       | 0.8                 |             |  |               |  |
|                         |                       | 1.0                 |             |  |               |  |
|                         |                       | 1.2                 |             |  |               |  |
|                         |                       | 1.4                 |             |  |               |  |
|                         |                       | 1.6                 |             | Brown, SILT with minor clay. Uniform, very stiff. Sub-horizontal.  | moist         | ALLUVIAL SILT  |
|                         |                       | 1.8                 |             |  |               |  |
|                         |                       | 2.0                 |             | Grey/brown, large BOULDERS in a silt matrix with minor lenses of silty gravel. Gravel is fine to coarse, in the lenses, boulders to 3m. Poorly graded, medium dense to dense. Dips slightly to the east. | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 2.2                 |             |  |               |  |
|                         |                       | Total Depth = 2.2 m |             |  |               |  |
|                         |                       | 2.4                 |             |  |               |  |
|                         |                       | 2.6                 |             |  |               |  |
|                         |                       | 2.8                 |             |  |               |  |
|                         |                       | 3.0                 |             |  |               |  |
| 3.2                     |                       |                     |             |  |               |  |

|  |                |
|--|----------------|
| COMMENT: Refusal of digger due to boulders | Logged By: FAW |
|  | Checked Date:  |
|  | Sheet: 1 of 1  |
| PHOTO REF.: N/A                            |                |






# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 26**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: N/A                |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2193955 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585763 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

|                   |                       | ENGINEERING DESCRIPTION |   |   |               | GEOLOGICAL   |                                       |
|-------------------|-----------------------|-------------------------|---|---|---------------|--|---------------------------------------|
| PENETRATION (SPT) | GROUNDWATER / SEEPAGE | DEPTH (m)               | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |                                       |
| →                 |                       | 0.2                     |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.                        | moist         | TOPSOIL  |                                       |
|                   |                       | 0.4                     |   | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.                 | moist         | LOESS  |                                       |
|                   |                       | 0.6                     |   | Tan/brown, SILT with minor boulders. Boulders to 500mm. Poorly graded, firm to stiff. Dips to the east 5-10°.               | moist to wet  | ALLUVIAL FAN DEPOSIT   |                                       |
|                   |                       | 0.8                     |   |   |               |  |                                       |
|                   |                       | 1.0                     |   |   |               |  |                                       |
|                   |                       | 1.2                     |   |   |               |  |                                       |
|                   |                       | 1.4                     |   |   |               |  |                                       |
|                   |                       | 1.6                     |   |   |               |  |                                       |
|                   |                       | 1.8                     |   |   |               |  |                                       |
|                   |                       | 2.0                     | Grey/brown, gravelly SILT with some cobbles and boulders, rare sand, rare gravelly lenses acting as conduit for water. Sand is fine to medium, gravel is fine to coarse, boulders to 2-3m, clasts are sub-rounded to angular. Poorly graded, firm (becoming weak with seepage influence). Dips to the east 5-10°. |   |               |  | wet, saturated at position of seepage |
|                   |                       | 2.2                     |   |   |               |  |                                       |
|                   |                       | 2.4                     |   |   |               |  |                                       |
|                   |                       | 2.6                     |   |   |               |  |                                       |
|                   |                       | 2.8                     |   |   |               |  |                                       |
| 3.0               | Total Depth = 2.8 m   |                         |   |   |               |  |                                       |
| 3.2               |                       |                         |   |   |               |  |                                       |

|  |                |
|--|----------------|
| COMMENT: Minor to moderate seepage @ 1.9m, 20L in test pit base after 10 minutes | Logged By: FAW |
|  | Checked Date:  |
|  | Sheet: 1 of 1  |
| PHOTO REF.: N/A  |                |






# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 27**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: N/A                |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194150 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585988 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   | GEOLOGICAL  |                                       |  |
|-------------------------|-----------------------|-----------|---|---|---------------------------------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT                         | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
|                         |                       | 0.2       |   | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | m                                     | TOPSOIL  |
|                         |                       |           |   | SILT. Uniform, firm. Parallel to slope profile that dips to the east.   | moist                                 | LOESS  |
|                         |                       | 0.4       |   |   |                                       |  |
|                         |                       | 0.6       |   |   |                                       |  |
|                         |                       | 0.8       |   |   |                                       |  |
|                         |                       | 1.0       |   |   |                                       |  |
|                         |                       | 1.2       |  | Grey/brown, SILT with minor gravel. Gravel is fine to medium. Poorly graded, firm. Dips to the east.  | m                                     | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 1.4       |   | Red/brown, SILT with some clay and minor sandy gravelly pockets, pockets are saturated, weak, act as a conduit for water. Sand is fine to medium, gravel is fine to medium. Poorly graded, silt is stiff, slightly plastic with moisture, gravel is medium dense, loose with water influence. Dips to the east. | wet, saturated at position of seepage | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 1.6       |   |   |                                       |  |
|                         |                       | 1.8       |   |   |                                       |  |
|                         |                       | 2.0       |  | Red/brown, silty GRAVEL with some boulders and rare sand. Gravel is fine to coarse, sand is fine, boulders to 2m. Poorly graded, medium dense. Dips to the east.  | moist                                 | ALLUVIAL FAN DEPOSIT   |
|                         |                       | 2.2       |   |   |                                       |  |
|                         |                       | 2.4       |   |   |                                       |  |
|                         |                       | 2.6       |   |   |                                       |  |
|                         |                       | 2.8       | Total Depth = 2.5 m   |   |                                       |  |
| 3.0                     |                       |           |   |   |                                       |  |
| 3.2                     |                       |           |   |   |                                       |  |

|  |                |
|--|----------------|
| COMMENT: Minor seepages from 1.7 - 2.1m, refusal of digger due to boulders | Logged By: FAW |
|  | Checked Date:  |
|  | Sheet: 1 of 1  |
| PHOTO REF.: N/A  |                |





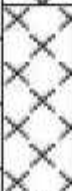



# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 28**

|                              |                |                            |                          |
|------------------------------|----------------|----------------------------|--------------------------|
| PROJECT: Mt Cardrona Station |                | Job Number: 160677         |                          |
| LOCATION: N/A                |                | Inclination: see site map  | Direction: N/A           |
| EASTING:                     | 2194427 mE     | EQUIPMENT: 12T Digger      | OPERATOR: Joe            |
| NORTHING:                    | 5585873 mN     | INFOMAP NO.                | COMPANY: Workable Earth  |
| ELEVATION:                   | see site map m | DIMENSIONS:                | HOLE STARTED: 26-Aug-05  |
| METHOD:                      | N/A            | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05 |

| ENGINEERING DESCRIPTION |                       |           |   |   | GEOLOGICAL     |  |  |
|-------------------------|-----------------------|-----------|---|---|----------------|--|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS   | WATER CONTENT  | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |  |
| NO SEEPAGE              |                       | 0.2       |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.  | moist          | TOPSOIL  |  |
|                         |                       | 0.4       |    | Tan/brown, SILT. Uniform, firm. Parallel to slope profile that dips slightly to the east.   | moist          | LOESS  |  |
|                         |                       | 0.6       |   | Red/brown, SILT with some to minor gravel, minor clay. Gravel is fine to coarse. Poorly graded, firm. Dips to the east.   | wet            | ALLUVIAL DEPOSIT   |  |
|                         |                       | 0.8       |   |   |                |  |  |
|                         |                       | 1.0       |   |   |                |  |  |
|                         |                       | 1.2       |   |   |                |  |  |
|                         |                       | 1.4       |  | Grey/brown, sandy GRAVEL with some boulders & cobbles and rare silt. Sand is fine to coarse, gravel is fine to coarse, clasts are schist dominant angular to sub-angular, boulders to 2m. Poorly graded, dense. Dips to the east. | slightly moist | ALLUVIAL FAN GRAVEL  |  |
|                         |                       | 1.6       |   |   |                |  |  |
|                         |                       | 1.8       |   |   |                |  |  |
|                         |                       | 2.0       |   |   |                |  |  |
|                         |                       | 2.2       |   |   |                |  |  |
|                         |                       | 2.4       |   |   |                |  |  |
|                         |                       | 2.6       |   |   |                |  |  |
|                         |                       | 2.8       |   |   |                |  |  |
|                         |                       | 3.0       | Total Depth = 2.8 m   |   |                |  |  |
|                         |                       | 3.2       |   |   |                |  |  |

|  |                |
|--|----------------|
| COMMENT: Refusal of digger due to boulders | Logged By: FAW |
|  | Checked Date:  |
|  | Sheet: 1 of 1  |
| PHOTO REF.: N/A                            |                |









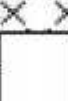







# GeoSolve Ltd EXCAVATION LOG

EXCAVATION NUMBER:

**TP 29**

|                              |                            |                           |                |
|------------------------------|----------------------------|---------------------------|----------------|
| PROJECT: Mt Cardrona Station |                            | Job Number: 160677        |                |
| LOCATION: N/A                |                            | Inclination: see site map | Direction: N/A |
| EASTING: 2194704 mE          | EQUIPMENT: 12T Digger      | OPERATOR: Joe             |                |
| NORTHING: 5585585 mN         | INFOMAP NO.                | COMPANY: Workable Earth   |                |
| ELEVATION: see site map m    | DIMENSIONS:                | HOLE STARTED: 26-Aug-05   |                |
| METHOD: N/A                  | EXCAV. DATUM: Ground Level | HOLE FINISHED: 26-Aug-05  |                |

| ENGINEERING DESCRIPTION |   |           |   |  | GEOLOGICAL    |  |
|-------------------------|---|-----------|---|--|---------------|--|
| PENETRATION (SPT)       | GROUNDWATER / SEEPAGE   | DEPTH (m) | GRAPHIC LOG   | SOIL / ROCK CLASSIFICATION, PLASTICITY OR PARTICLE SIZE CHARACTERISTICS, COLOUR, WEATHERING, SECONDARY AND MINOR COMPONENTS  | WATER CONTENT | SOIL / ROCK TYPE, ORIGIN, MINERAL COMPOSITION, DEFECTS, STRUCTURE, FORMATION |
| NO SEEPAGE              |   | 0.2       |    | Brown, organic SILT with rare roots. Uniform, soft. Parallel to slope profile that dips to the east.   | moist         | TOPSOIL  |
|                         |   | 0.4       |    | SILT with some sand. Sand is fine. Uniform, firm. Parallel to slope profile that dips slightly to the east.  | m             | LOESS  |
|                         |   | 0.6       |   | Grey/brown, SILT. Uniform, very stiff. Dips slightly to the east.  | moist to wet  | ALLUVIAL FAN DEPOSIT   |
|                         |   | 0.8       |  | Tan/brown, SILT with minor/some boulders. Boulders to 800mm. Poorly graded, very stiff. Dips slightly to the east.   | moist to wet  | ALLUVIAL FAN DEPOSIT   |
|                         |   | 1.0       |  | Tan/brown, SILT with some/minor gravel, cobbles, boulders and minor sand, silt lenses from 1.5 to 2m. Sand is fine, gravel is fine to coarse, boulders to 500mm, clasts are sub-rounded to sub-angular schist dominated. Poorly graded, very stiff. Dips slightly to the east. | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |   | 1.2       |  |  |               |  |
|                         |   | 1.4       |  |  |               |  |
|                         |   | 1.6       |  |  |               |  |
|                         |   | 1.8       |  |  |               |  |
|                         |   | 2.0       |  |  |               |  |
|                         |   | 2.2       |  |  |               |  |
|                         |   | 2.4       |  |  |               |  |
|                         |   | 2.6       |  | Grey/brown, BOULDERS with silt matrix and cobbles. Boulders to 2-3m. Poorly graded, dense. Dips slightly to the east.  | moist         | ALLUVIAL FAN DEPOSIT   |
|                         |   | 2.8       |  | Total Depth = 2.8 m  |               |  |
|                         |   | 3.0       |  |  |               |  |
|                         |   | 3.2       |  |  |               |  |
|                         |  |           |   |  |               |  |

|                 |                |
|-----------------|----------------|
| COMMENT:        | Logged By: FAW |
|                 | Checked Date:  |
|                 | Sheet: 1 of 1  |
| PHOTO REF.: N/A |                |



**SCALA PENETROMETER LOG**

Job No: 160677  
Project: Mt Cardrona Station

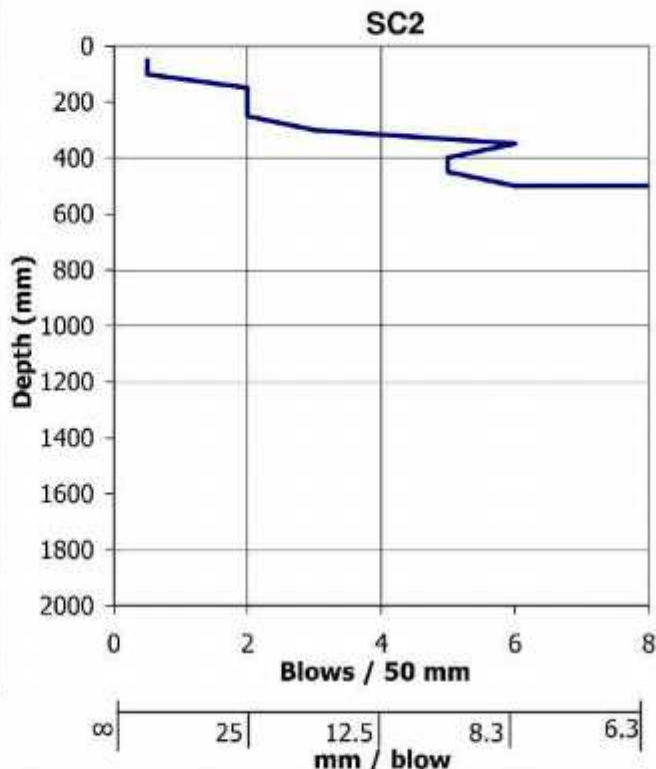
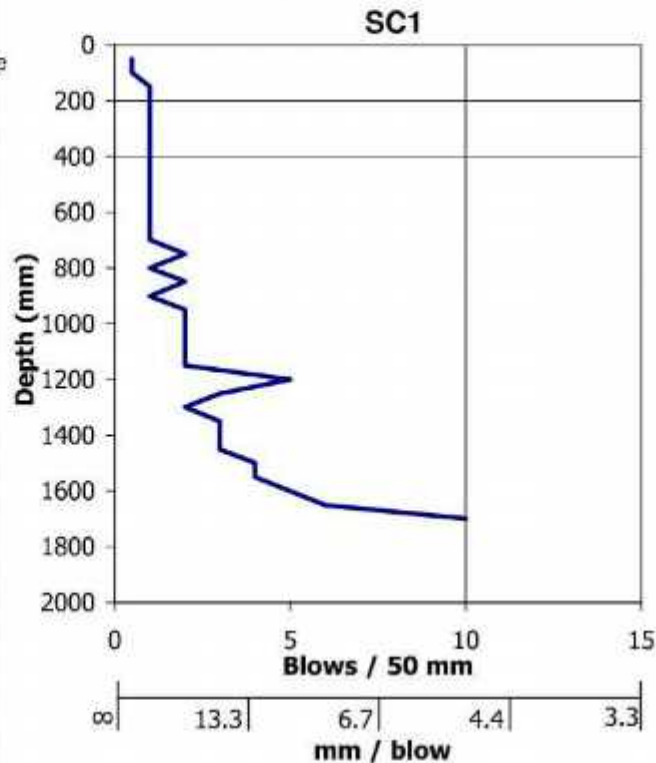
Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC1 & SC2**

Sheet of 1  
of 1

| SC1                  |              |
|----------------------|--------------|
| Location: Beside TP1 |              |
| RL: From Surface     |              |
| mm Driven            | No. of Blows |
| 50                   | 0.5          |
| 100                  | 0.5          |
| 150                  | 1            |
| 200                  | 1            |
| 250                  | 1            |
| 300                  | 1            |
| 350                  | 1            |
| 400                  | 1            |
| 450                  | 1            |
| 500                  | 1            |
| 550                  | 1            |
| 600                  | 1            |
| 650                  | 1            |
| 700                  | 1            |
| 750                  | 2            |
| 800                  | 1            |
| 850                  | 2            |
| 900                  | 1            |
| 950                  | 2            |
| 1000                 | 2            |
| 1050                 | 2            |
| 1100                 | 2            |
| 1150                 | 2            |
| 1200                 | 5            |
| 1250                 | 3            |
| 1300                 | 2            |
| 1350                 | 3            |
| 1400                 | 3            |
| 1450                 | 3            |
| 1500                 | 4            |
| 1550                 | 4            |
| 1600                 | 5            |
| 1650                 | 6            |
| 1700                 | 10           |
| 1750                 |              |
| 1800                 |              |
| 1850                 |              |
| 1900                 |              |
| 1950                 |              |
| 2000                 |              |

| SC2                  |              |
|----------------------|--------------|
| Location: Beside TP4 |              |
| RL: From Surface     |              |
| mm Driven            | No. of Blows |
| 50                   | 0.5          |
| 100                  | 0.5          |
| 150                  | 2            |
| 200                  | 2            |
| 250                  | 2            |
| 300                  | 3            |
| 350                  | 6            |
| 400                  | 5            |
| 450                  | 5            |
| 500                  | 6            |
| 550                  | Refusal      |
| 600                  |              |
| 650                  |              |
| 700                  |              |
| 750                  |              |
| 800                  |              |
| 850                  |              |
| 900                  |              |
| 950                  |              |
| 1000                 |              |
| 1050                 |              |
| 1100                 |              |
| 1150                 |              |
| 1200                 |              |
| 1250                 |              |
| 1300                 |              |
| 1350                 |              |
| 1400                 |              |
| 1450                 |              |
| 1500                 |              |
| 1550                 |              |
| 1600                 |              |
| 1650                 |              |
| 1700                 |              |
| 1750                 |              |
| 1800                 |              |
| 1850                 |              |
| 1900                 |              |
| 1950                 |              |
| 2000                 |              |



# SCALA PENETROMETER LOG

Job No: 160677  
Project: Mt Cardrona Station

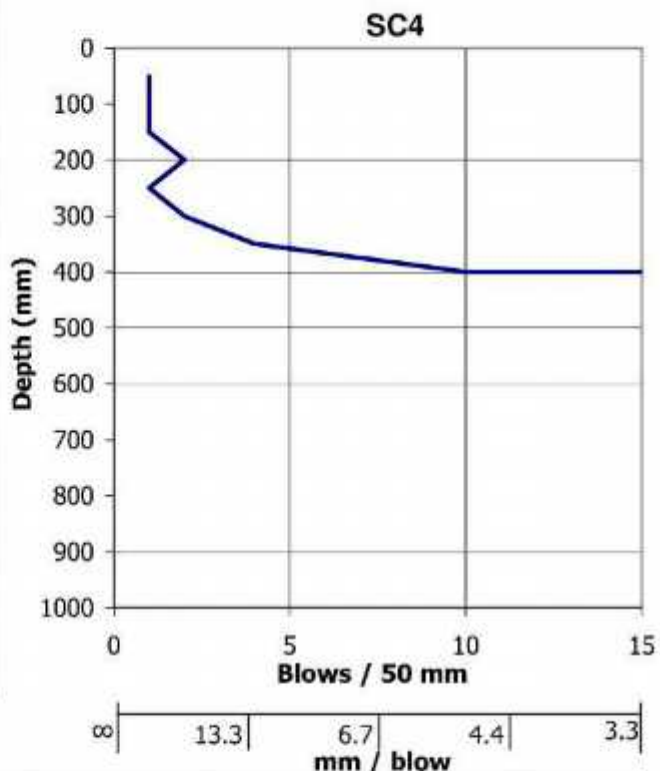
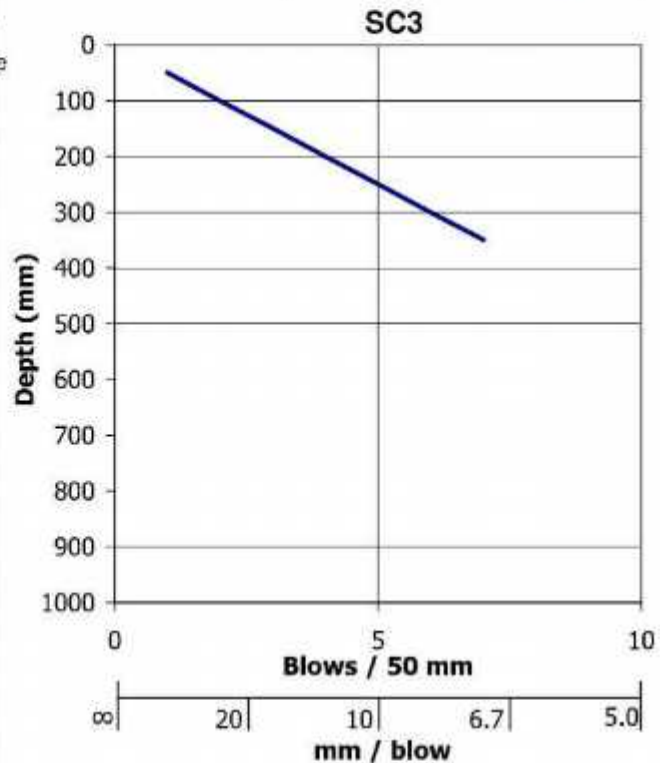
Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC3 & SC4**

Sheet of 1  
of 1

| SC3                  |              |
|----------------------|--------------|
| Location: Beside TP5 |              |
| RL: From Surface     |              |
| mm Driven            | No. of Blows |
| 50                   | 1            |
| 100                  | 0.5          |
| 150                  | 0.5          |
| 200                  | 3            |
| 250                  | 4            |
| 300                  | 6            |
| 350                  | Refusal      |
| 400                  |              |
| 450                  |              |
| 500                  |              |
| 550                  |              |
| 600                  |              |
| 650                  |              |
| 700                  |              |
| 750                  |              |
| 800                  |              |
| 850                  |              |
| 900                  |              |
| 950                  |              |
| 1000                 |              |

| SC4                     |              |
|-------------------------|--------------|
| Location: See Site Plan |              |
| RL: From Surface        |              |
| mm Driven               | No. of Blows |
| 50                      | 1            |
| 100                     | 1            |
| 150                     | 1            |
| 200                     | 2            |
| 250                     | 1            |
| 300                     | 2            |
| 350                     | 4            |
| 400                     | 10           |
| 450                     | Refusal      |
| 500                     |              |
| 550                     |              |
| 600                     |              |
| 650                     |              |
| 700                     |              |
| 750                     |              |
| 800                     |              |
| 850                     |              |
| 900                     |              |
| 950                     |              |
| 1000                    |              |





## SCALA PENETROMETER LOG

Job No: 160677  
Project: Mt Cardrona Station

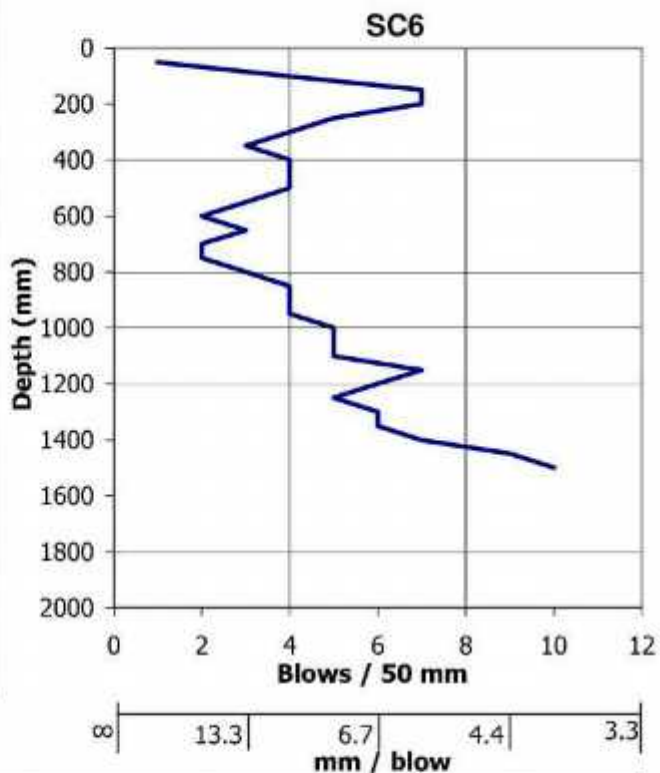
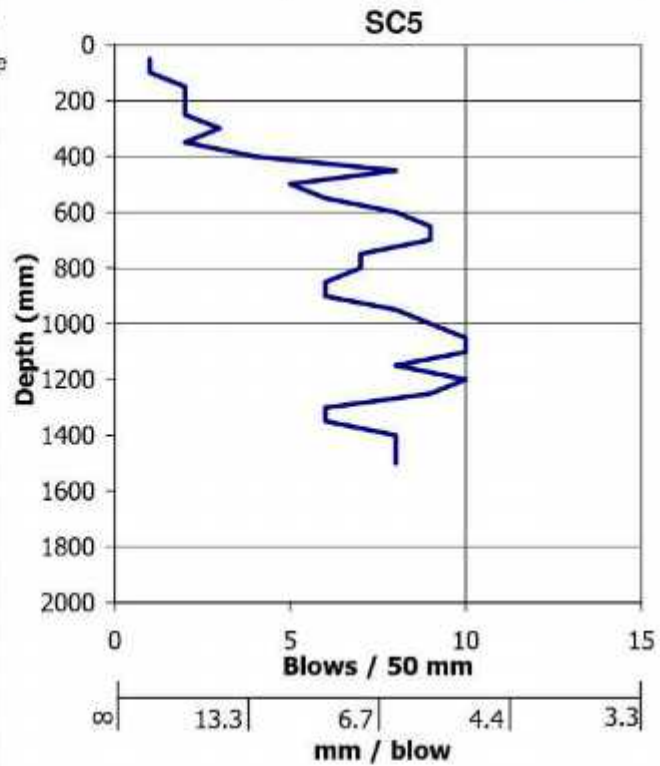
Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC5 & SC6**

Sheet of 1  
of 1

| SC5                  |              |
|----------------------|--------------|
| Location: Beside TP6 |              |
| RL: From Surface     |              |
| mm Driven            | No. of Blows |
| 50                   | 1            |
| 100                  | 1            |
| 150                  | 2            |
| 200                  | 2            |
| 250                  | 2            |
| 300                  | 3            |
| 350                  | 2            |
| 400                  | 4            |
| 450                  | 8            |
| 500                  | 5            |
| 550                  | 6            |
| 600                  | 8            |
| 650                  | 9            |
| 700                  | 9            |
| 750                  | 7            |
| 800                  | 7            |
| 850                  | 6            |
| 900                  | 6            |
| 950                  | 8            |
| 1000                 | 9            |
| 1050                 | 10           |
| 1100                 | 10           |
| 1150                 | 8            |
| 1200                 | 10           |
| 1250                 | 9            |
| 1300                 | 6            |
| 1350                 | 6            |
| 1400                 | 8            |
| 1450                 | 8            |
| 1500                 | 8            |
| 1550                 |              |
| 1600                 |              |
| 1650                 |              |
| 1700                 |              |
| 1750                 |              |
| 1800                 |              |
| 1850                 |              |
| 1900                 |              |
| 1950                 |              |
| 2000                 |              |

| SC6                     |              |
|-------------------------|--------------|
| Location: See Site Plan |              |
| RL: From Surface        |              |
| mm Driven               | No. of Blows |
| 50                      | 1            |
| 100                     | 4            |
| 150                     | 7            |
| 200                     | 7            |
| 250                     | 5            |
| 300                     | 4            |
| 350                     | 3            |
| 400                     | 4            |
| 450                     | 4            |
| 500                     | 4            |
| 550                     | 3            |
| 600                     | 2            |
| 650                     | 3            |
| 700                     | 2            |
| 750                     | 2            |
| 800                     | 3            |
| 850                     | 4            |
| 900                     | 4            |
| 950                     | 4            |
| 1000                    | 5            |
| 1050                    | 5            |
| 1100                    | 5            |
| 1150                    | 7            |
| 1200                    | 6            |
| 1250                    | 5            |
| 1300                    | 6            |
| 1350                    | 6            |
| 1400                    | 7            |
| 1450                    | 9            |
| 1500                    | 10           |
| 1550                    |              |
| 1600                    |              |
| 1650                    |              |
| 1700                    |              |
| 1750                    |              |
| 1800                    |              |
| 1850                    |              |
| 1900                    |              |
| 1950                    |              |
| 2000                    |              |



## SCALA PENETROMETER LOG

Job No: 160677  
Project: Mt Cardrona Station

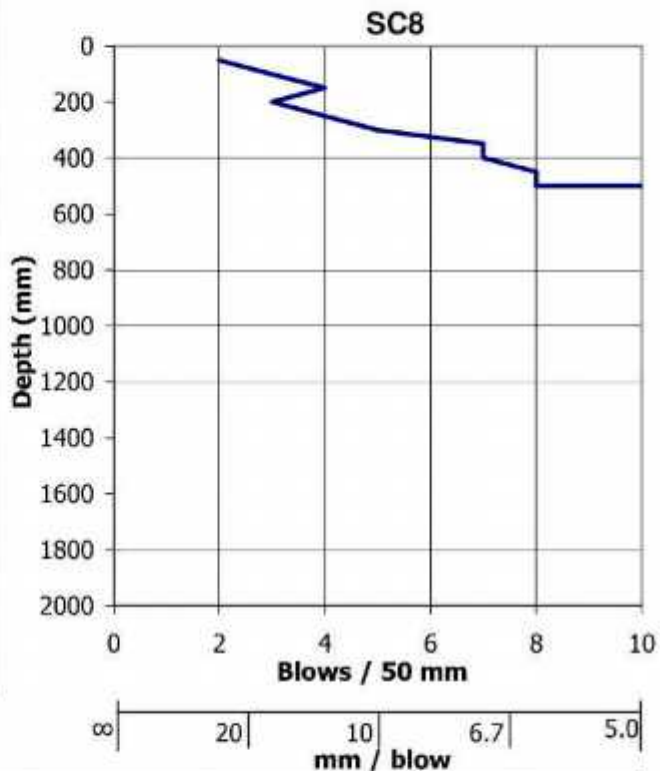
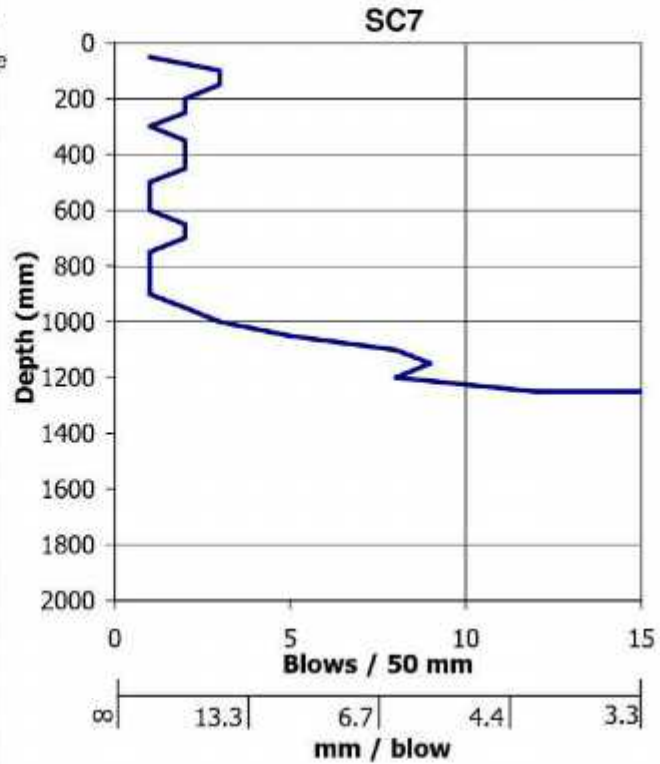
Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC7 & SC8**

Sheet of 1  
of 1

| SC7                     |              |
|-------------------------|--------------|
| Location: See Site Plan |              |
| RL: From Surface        |              |
| mm Driven               | No. of Blows |
| 50                      | 1            |
| 100                     | 3            |
| 150                     | 3            |
| 200                     | 2            |
| 250                     | 2            |
| 300                     | 1            |
| 350                     | 2            |
| 400                     | 2            |
| 450                     | 2            |
| 500                     | 1            |
| 550                     | 1            |
| 600                     | 1            |
| 650                     | 2            |
| 700                     | 2            |
| 750                     | 1            |
| 800                     | 1            |
| 850                     | 1            |
| 900                     | 1            |
| 950                     | 2            |
| 1000                    | 3            |
| 1050                    | 5            |
| 1100                    | 8            |
| 1150                    | 9            |
| 1200                    | 8            |
| 1250                    | 12           |
| 1300                    | Refusal      |
| 1350                    |              |
| 1400                    |              |
| 1450                    |              |
| 1500                    |              |
| 1550                    |              |
| 1600                    |              |
| 1650                    |              |
| 1700                    |              |
| 1750                    |              |
| 1800                    |              |
| 1850                    |              |
| 1900                    |              |
| 1950                    |              |
| 2000                    |              |

| SC8                     |              |
|-------------------------|--------------|
| Location: See Site Plan |              |
| RL: From Surface        |              |
| mm Driven               | No. of Blows |
| 50                      | 2            |
| 100                     | 3            |
| 150                     | 4            |
| 200                     | 3            |
| 250                     | 4            |
| 300                     | 5            |
| 350                     | 7            |
| 400                     | 7            |
| 450                     | 8            |
| 500                     | 8            |
| 550                     | Refusal      |
| 600                     |              |
| 650                     |              |
| 700                     |              |
| 750                     |              |
| 800                     |              |
| 850                     |              |
| 900                     |              |
| 950                     |              |
| 1000                    |              |
| 1050                    |              |
| 1100                    |              |
| 1150                    |              |
| 1200                    |              |
| 1250                    |              |
| 1300                    |              |
| 1350                    |              |
| 1400                    |              |
| 1450                    |              |
| 1500                    |              |
| 1550                    |              |
| 1600                    |              |
| 1650                    |              |
| 1700                    |              |
| 1750                    |              |
| 1800                    |              |
| 1850                    |              |
| 1900                    |              |
| 1950                    |              |
| 2000                    |              |





# SCALA PENETROMETER LOG

Job No: 160677  
Project: Mt Cardrona Station

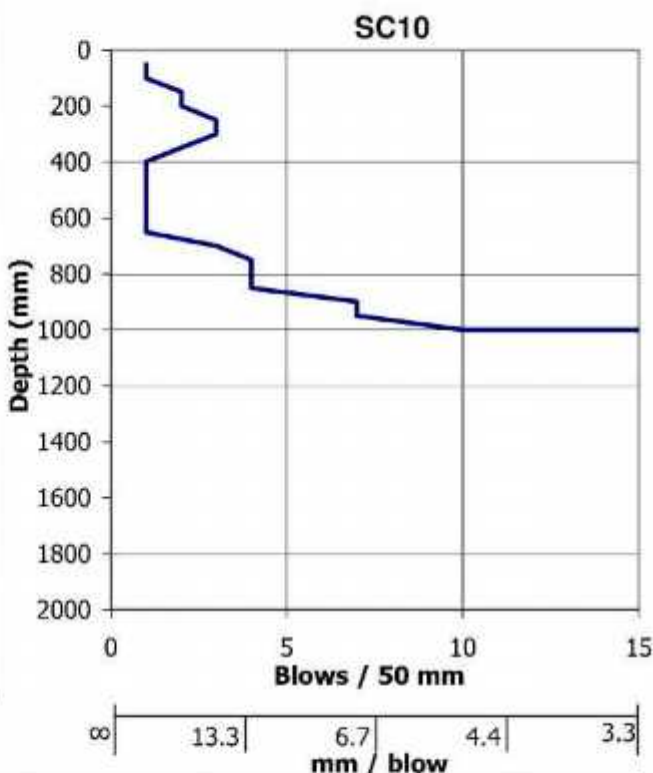
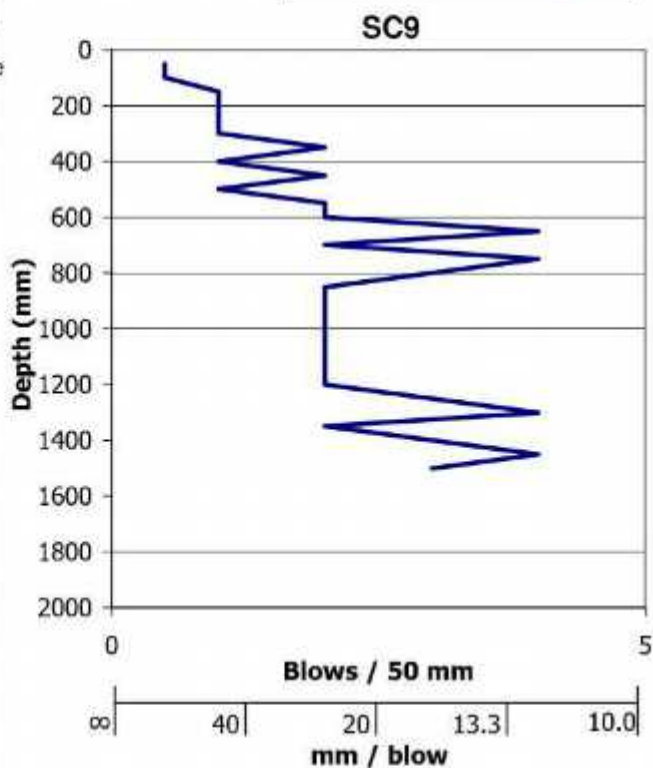
Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC9 & SC10**

Sheet of 1  
of 1

| SC9                  |              |
|----------------------|--------------|
| Location: Beside TP9 |              |
| RL: From Surface     |              |
| mm Driven            | No. of Blows |
| 50                   | 0.5          |
| 100                  | 0.5          |
| 150                  | 1            |
| 200                  | 1            |
| 250                  | 1            |
| 300                  | 1            |
| 350                  | 2            |
| 400                  | 1            |
| 450                  | 2            |
| 500                  | 1            |
| 550                  | 2            |
| 600                  | 2            |
| 650                  | 4            |
| 700                  | 2            |
| 750                  | 4            |
| 800                  | 3            |
| 850                  | 2            |
| 900                  | 2            |
| 950                  | 2            |
| 1000                 | 2            |
| 1050                 | 2            |
| 1100                 | 2            |
| 1150                 | 2            |
| 1200                 | 2            |
| 1250                 | 3            |
| 1300                 | 4            |
| 1350                 | 2            |
| 1400                 | 3            |
| 1450                 | 4            |
| 1500                 | 3            |
| 1550                 |              |
| 1600                 |              |
| 1650                 |              |
| 1700                 |              |
| 1750                 |              |
| 1800                 |              |
| 1850                 |              |
| 1900                 |              |
| 1950                 |              |
| 2000                 |              |

| SC10                    |              |
|-------------------------|--------------|
| Location: See Site Plan |              |
| RL: From Surface        |              |
| mm Driven               | No. of Blows |
| 50                      | 1            |
| 100                     | 1            |
| 150                     | 2            |
| 200                     | 2            |
| 250                     | 3            |
| 300                     | 3            |
| 350                     | 2            |
| 400                     | 1            |
| 450                     | 1            |
| 500                     | 1            |
| 550                     | 1            |
| 600                     | 1            |
| 650                     | 1            |
| 700                     | 3            |
| 750                     | 4            |
| 800                     | 4            |
| 850                     | 4            |
| 900                     | 7            |
| 950                     | 7            |
| 1000                    | 10           |
| 1050                    | Refusal      |
| 1100                    |              |
| 1150                    |              |
| 1200                    |              |
| 1250                    |              |
| 1300                    |              |
| 1350                    |              |
| 1400                    |              |
| 1450                    |              |
| 1500                    |              |
| 1550                    |              |
| 1600                    |              |
| 1650                    |              |
| 1700                    |              |
| 1750                    |              |
| 1800                    |              |
| 1850                    |              |
| 1900                    |              |
| 1950                    |              |
| 2000                    |              |



# SCALA PENETROMETER LOG

Job No: 160677  
Project: Mt Cardrona Station

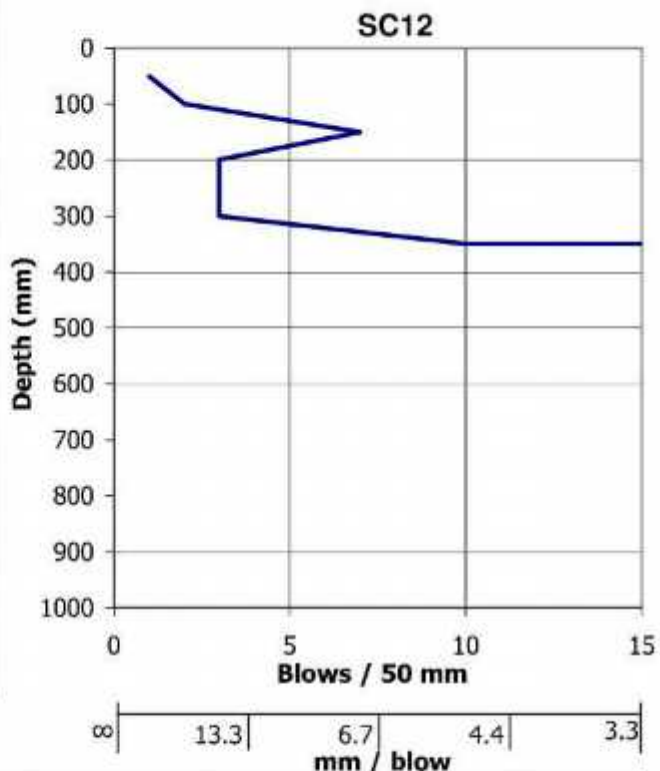
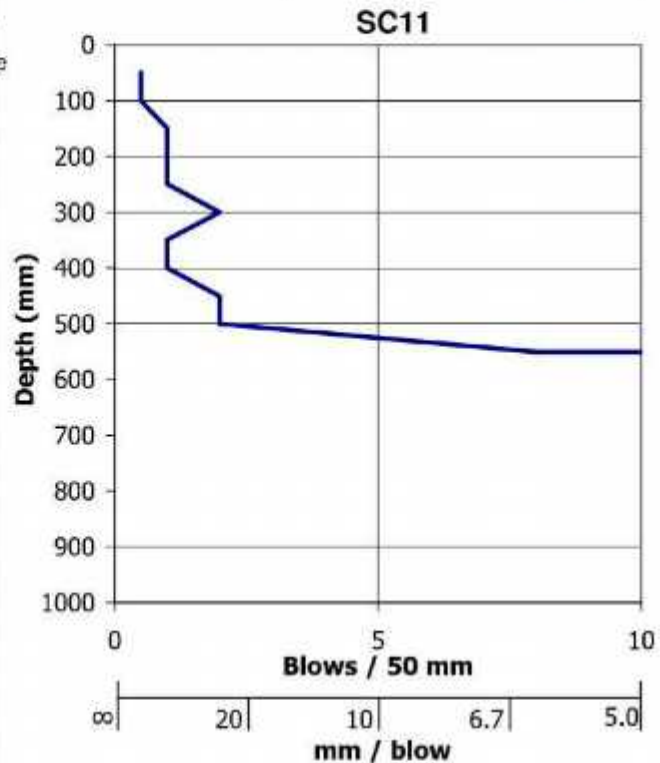
Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC11 & SC12**

Sheet of 1  
1

| SC11                  |              |
|-----------------------|--------------|
| Location: Beside TP15 |              |
| RL: From Surface      |              |
| mm Driven             | No. of Blows |
| 50                    | 0.5          |
| 100                   | 0.5          |
| 150                   | 1            |
| 200                   | 1            |
| 250                   | 1            |
| 300                   | 2            |
| 350                   | 1            |
| 400                   | 1            |
| 450                   | 2            |
| 500                   | 2            |
| 550                   | 8            |
| 600                   | Refusal      |
| 650                   |              |
| 700                   |              |
| 750                   |              |
| 800                   |              |
| 850                   |              |
| 900                   |              |
| 950                   |              |
| 1000                  |              |

| SC12                    |              |
|-------------------------|--------------|
| Location: See Site Plan |              |
| RL: From Surface        |              |
| mm Driven               | No. of Blows |
| 50                      | 1            |
| 100                     | 2            |
| 150                     | 7            |
| 200                     | 3            |
| 250                     | 3            |
| 300                     | 3            |
| 350                     | 10           |
| 400                     | Refusal      |
| 450                     |              |
| 500                     |              |
| 550                     |              |
| 600                     |              |
| 650                     |              |
| 700                     |              |
| 750                     |              |
| 800                     |              |
| 850                     |              |
| 900                     |              |
| 950                     |              |
| 1000                    |              |



## SCALA PENETROMETER LOG

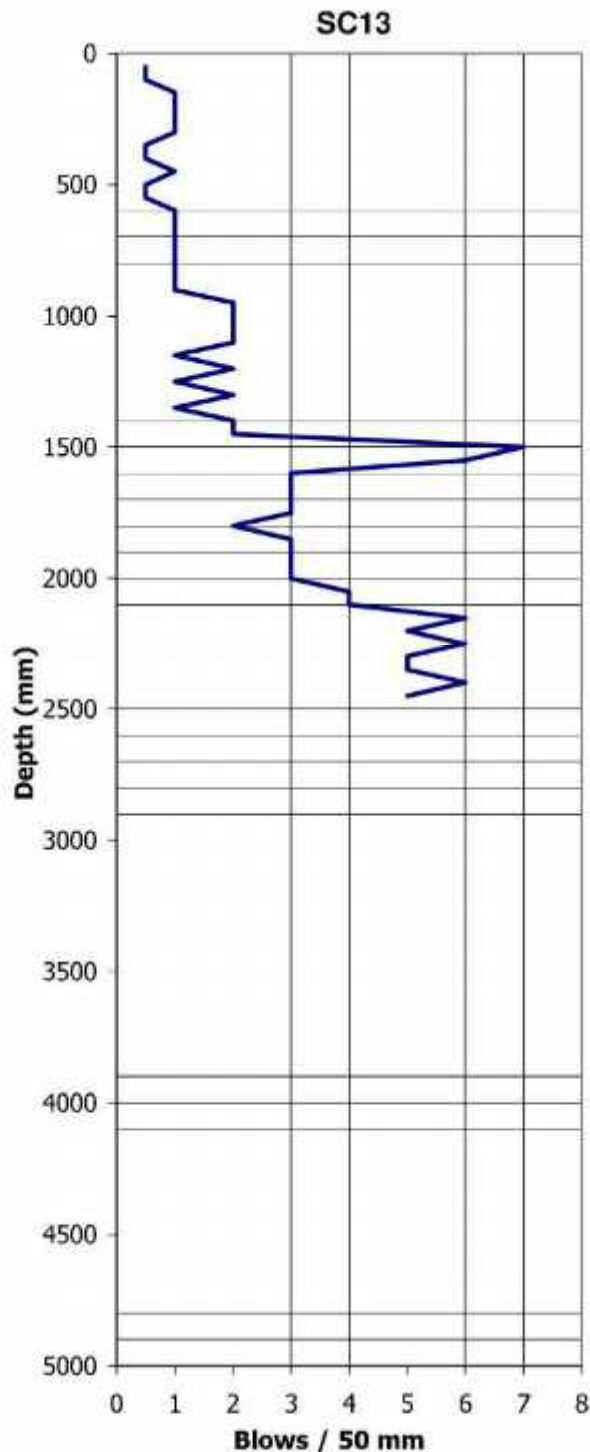
Job No: 160677  
Project: Mt Cardrona Station  
Location: Beside TP13  
RL: From Surface

Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC  
Checked by: FAW

Test No. SC13  
Sheet of 1

| SC13      |              |
|-----------|--------------|
| mm Driven | No. of Blows |
| 50        | 0.5          |
| 100       | 0.5          |
| 150       | 1            |
| 200       | 1            |
| 250       | 1            |
| 300       | 1            |
| 350       | 0.5          |
| 400       | 0.5          |
| 450       | 1            |
| 500       | 0.5          |
| 550       | 0.5          |
| 600       | 1            |
| 650       | 1            |
| 700       | 1            |
| 750       | 1            |
| 800       | 1            |
| 850       | 1            |
| 900       | 1            |
| 950       | 2            |
| 1000      | 2            |
| 1050      | 2            |
| 1100      | 2            |
| 1150      | 1            |
| 1200      | 2            |
| 1250      | 1            |
| 1300      | 2            |
| 1350      | 1            |
| 1400      | 2            |
| 1450      | 2            |
| 1500      | 7            |
| 1550      | 6            |
| 1600      | 3            |
| 1650      | 3            |
| 1700      | 3            |
| 1750      | 3            |
| 1800      | 2            |
| 1850      | 3            |
| 1900      | 3            |
| 1950      | 3            |
| 2000      | 3            |
| 2050      | 4            |
| 2100      | 4            |
| 2150      | 6            |
| 2200      | 5            |
| 2250      | 6            |
| 2300      | 5            |
| 2350      | 5            |
| 2400      | 6            |
| 2450      | 5            |
| 2500      |              |

| SC13 cont... |              |
|--------------|--------------|
| mm Driven    | No. of Blows |
| 2550         |              |
| 2600         |              |
| 2650         |              |
| 2700         |              |
| 2750         |              |
| 2800         |              |
| 2850         |              |
| 2900         |              |
| 2950         |              |
| 3000         |              |
| 3050         |              |
| 3100         |              |
| 3150         |              |
| 3200         |              |
| 3250         |              |
| 3300         |              |
| 3350         |              |
| 3400         |              |
| 3450         |              |
| 3500         |              |
| 3550         |              |
| 3600         |              |
| 3650         |              |
| 3700         |              |
| 3750         |              |
| 3800         |              |
| 3850         |              |
| 3900         |              |
| 3950         |              |
| 4000         |              |
| 4050         |              |
| 4100         |              |
| 4150         |              |
| 4200         |              |
| 4250         |              |
| 4300         |              |
| 4350         |              |
| 4400         |              |
| 4450         |              |
| 4500         |              |
| 4550         |              |
| 4600         |              |
| 4650         |              |
| 4700         |              |
| 4750         |              |
| 4800         |              |
| 4850         |              |
| 4900         |              |
| 4950         |              |
| 5000         |              |



Test Method Used: NZS 4402:1988 Test 6.5.2 Dynamic Cone Penetrometer



# SCALA PENETROMETER LOG

Job No: 160677  
Project: Mt Cardrona Station

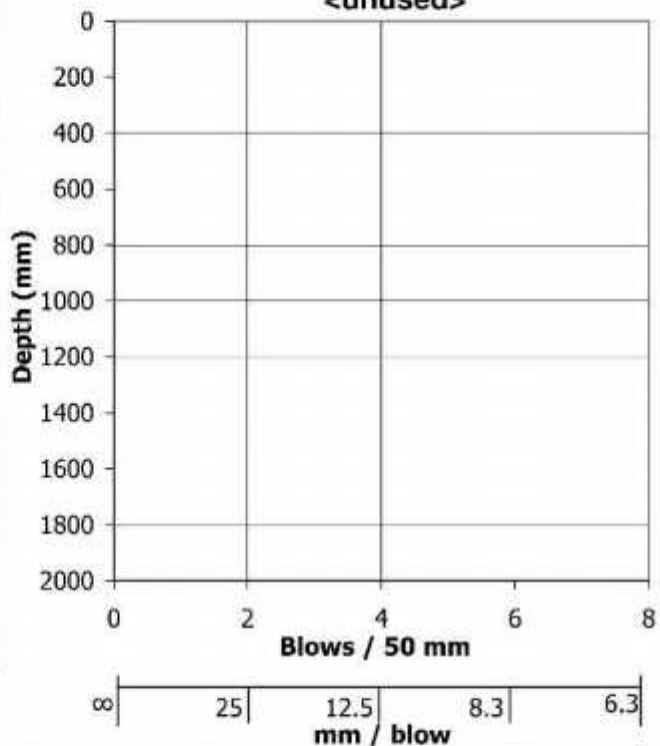
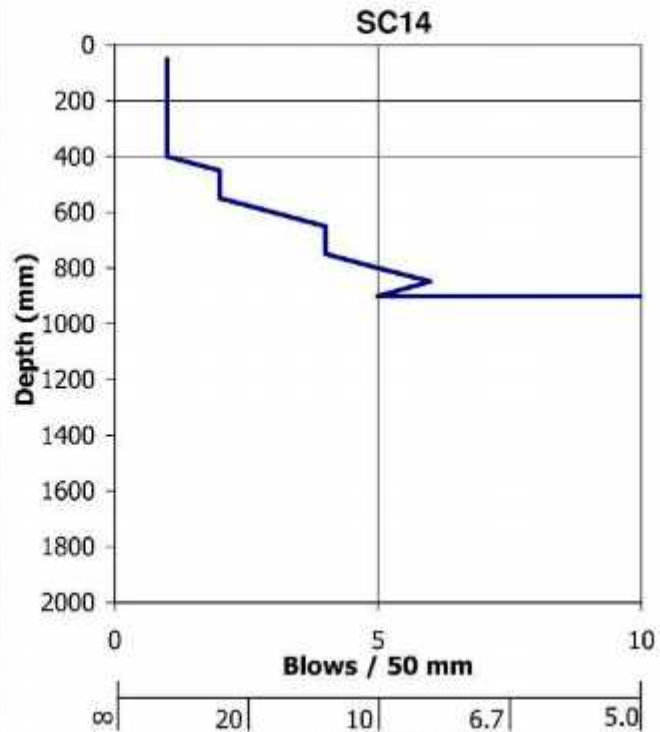
Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC14**

Sheet of 1  
of 1

| SC14                  |              |
|-----------------------|--------------|
| Location: Beside TP13 |              |
| RL: From Surface      |              |
| mm Driven             | No. of Blows |
| 50                    | 1            |
| 100                   | 1            |
| 150                   | 1            |
| 200                   | 1            |
| 250                   | 1            |
| 300                   | 1            |
| 350                   | 1            |
| 400                   | 1            |
| 450                   | 2            |
| 500                   | 2            |
| 550                   | 2            |
| 600                   | 3            |
| 650                   | 4            |
| 700                   | 4            |
| 750                   | 4            |
| 800                   | 5            |
| 850                   | 6            |
| 900                   | 5            |
| 950                   | Refusal      |
| 1000                  |              |
| 1050                  |              |
| 1100                  |              |
| 1150                  |              |
| 1200                  |              |
| 1250                  |              |
| 1300                  |              |
| 1350                  |              |
| 1400                  |              |
| 1450                  |              |
| 1500                  |              |
| 1550                  |              |
| 1600                  |              |
| 1650                  |              |
| 1700                  |              |
| 1750                  |              |
| 1800                  |              |
| 1850                  |              |
| 1900                  |              |
| 1950                  |              |
| 2000                  |              |

| Location: |              |
|-----------|--------------|
| RL:       |              |
| mm Driven | No. of Blows |
| 50        |              |
| 100       |              |
| 150       |              |
| 200       |              |
| 250       |              |
| 300       |              |
| 350       |              |
| 400       |              |
| 450       |              |
| 500       |              |
| 550       |              |
| 600       |              |
| 650       |              |
| 700       |              |
| 750       |              |
| 800       |              |
| 850       |              |
| 900       |              |
| 950       |              |
| 1000      |              |
| 1050      |              |
| 1100      |              |
| 1150      |              |
| 1200      |              |
| 1250      |              |
| 1300      |              |
| 1350      |              |
| 1400      |              |
| 1450      |              |
| 1500      |              |
| 1550      |              |
| 1600      |              |
| 1650      |              |
| 1700      |              |
| 1750      |              |
| 1800      |              |
| 1850      |              |
| 1900      |              |
| 1950      |              |
| 2000      |              |



## SCALA PENETROMETER LOG

Job No: 160677  
Project: Mt Cardrona Station

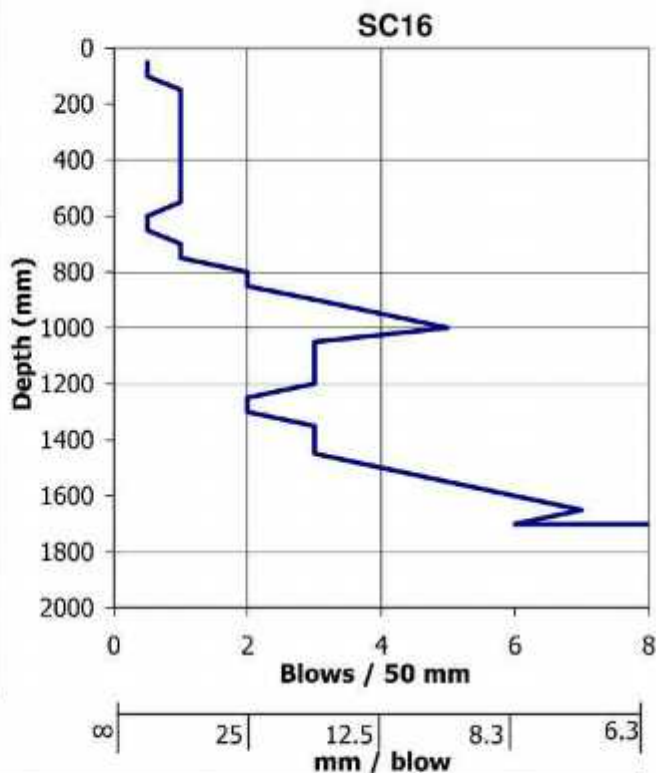
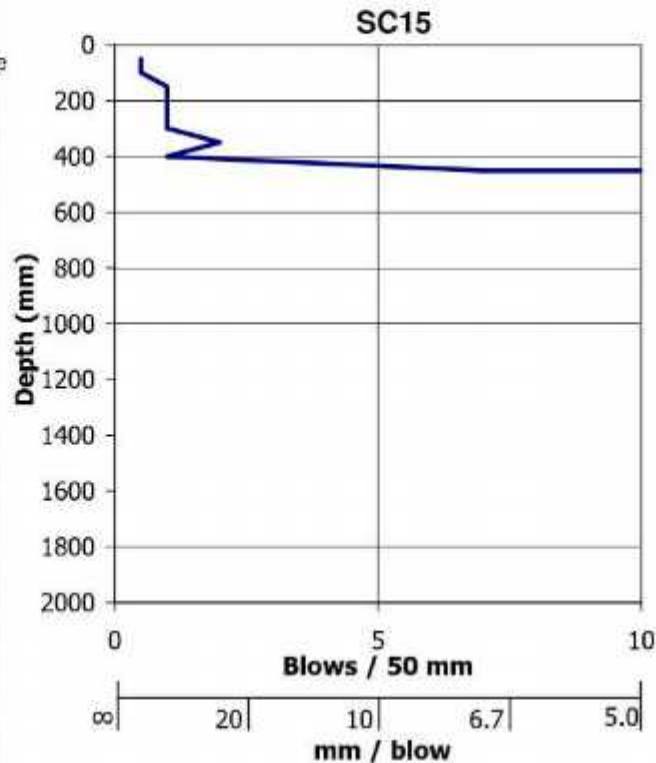
Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC15 & SC16**

Sheet of 1  
of 1

| SC15                  |              |
|-----------------------|--------------|
| Location: Beside TP14 |              |
| RL: From Surface      |              |
| mm Driven             | No. of Blows |
| 50                    | 0.5          |
| 100                   | 0.5          |
| 150                   | 1            |
| 200                   | 1            |
| 250                   | 1            |
| 300                   | 1            |
| 350                   | 2            |
| 400                   | 1            |
| 450                   | 7            |
| 500                   | Refusal      |
| 550                   |              |
| 600                   |              |
| 650                   |              |
| 700                   |              |
| 750                   |              |
| 800                   |              |
| 850                   |              |
| 900                   |              |
| 950                   |              |
| 1000                  |              |
| 1050                  |              |
| 1100                  |              |
| 1150                  |              |
| 1200                  |              |
| 1250                  |              |
| 1300                  |              |
| 1350                  |              |
| 1400                  |              |
| 1450                  |              |
| 1500                  |              |
| 1550                  |              |
| 1600                  |              |
| 1650                  |              |
| 1700                  |              |
| 1750                  |              |
| 1800                  |              |
| 1850                  |              |
| 1900                  |              |
| 1950                  |              |
| 2000                  |              |

| SC16                  |              |
|-----------------------|--------------|
| Location: Beside TP16 |              |
| RL: From Surface      |              |
| mm Driven             | No. of Blows |
| 50                    | 0.5          |
| 100                   | 0.5          |
| 150                   | 1            |
| 200                   | 1            |
| 250                   | 1            |
| 300                   | 1            |
| 350                   | 1            |
| 400                   | 1            |
| 450                   | 1            |
| 500                   | 1            |
| 550                   | 1            |
| 600                   | 0.5          |
| 650                   | 0.5          |
| 700                   | 1            |
| 750                   | 1            |
| 800                   | 2            |
| 850                   | 2            |
| 900                   | 3            |
| 950                   | 4            |
| 1000                  | 5            |
| 1050                  | 3            |
| 1100                  | 3            |
| 1150                  | 3            |
| 1200                  | 3            |
| 1250                  | 2            |
| 1300                  | 2            |
| 1350                  | 3            |
| 1400                  | 3            |
| 1450                  | 3            |
| 1500                  | 4            |
| 1550                  | 5            |
| 1600                  | 6            |
| 1650                  | 7            |
| 1700                  | 6            |
| 1750                  | Refusal      |
| 1800                  |              |
| 1850                  |              |
| 1900                  |              |
| 1950                  |              |
| 2000                  |              |



**SCALA PENETROMETER LOG**

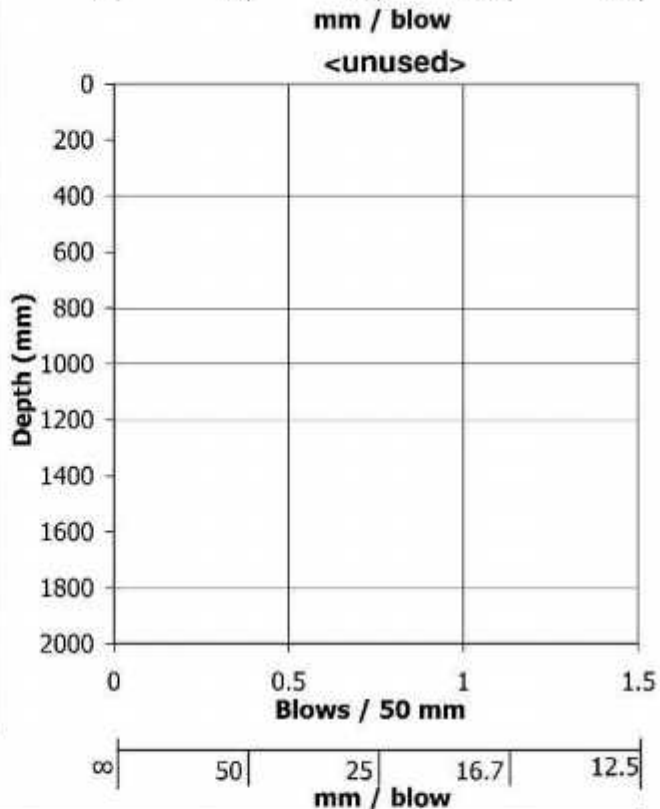
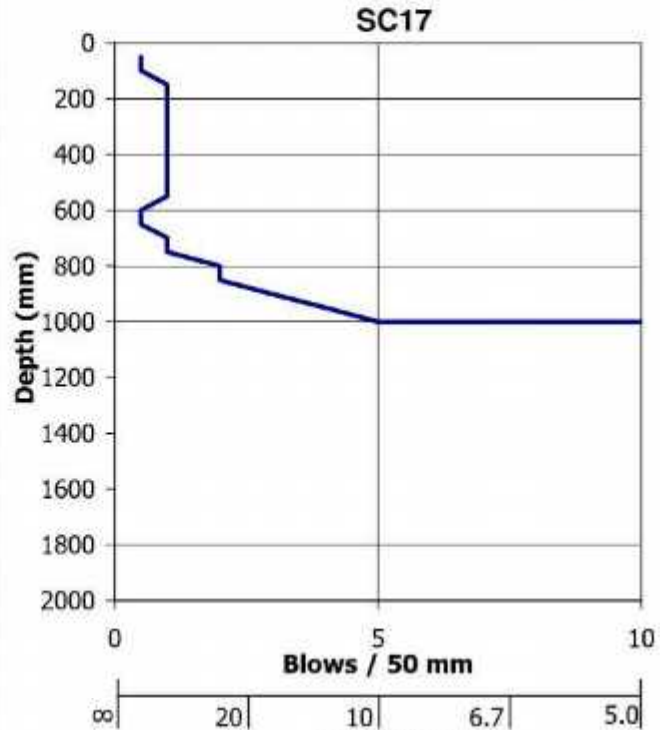
Job No: 160677  
Project: Mt Cardrona Station

Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number **SC17**  
Sheet of 1

| SC17                  |              |
|-----------------------|--------------|
| Location: Beside TP18 |              |
| RL: From Surface      |              |
| mm Driven             | No. of Blows |
| 50                    | 0.5          |
| 100                   | 0.5          |
| 150                   | 1            |
| 200                   | 1            |
| 250                   | 1            |
| 300                   | 1            |
| 350                   | 1            |
| 400                   | 1            |
| 450                   | 1            |
| 500                   | 1            |
| 550                   | 1            |
| 600                   | 0.5          |
| 650                   | 0.5          |
| 700                   | 1            |
| 750                   | 1            |
| 800                   | 2            |
| 850                   | 2            |
| 900                   | 3            |
| 950                   | 4            |
| 1000                  | 5            |
| 1050                  | Refusal      |
| 1100                  |              |
| 1150                  |              |
| 1200                  |              |
| 1250                  |              |
| 1300                  |              |
| 1350                  |              |
| 1400                  |              |
| 1450                  |              |
| 1500                  |              |
| 1550                  |              |
| 1600                  |              |
| 1650                  |              |
| 1700                  |              |
| 1750                  |              |
| 1800                  |              |
| 1850                  |              |
| 1900                  |              |
| 1950                  |              |
| 2000                  |              |

| Location: |              |
|-----------|--------------|
| RL:       |              |
| mm Driven | No. of Blows |
| 50        |              |
| 100       |              |
| 150       |              |
| 200       |              |
| 250       |              |
| 300       |              |
| 350       |              |
| 400       |              |
| 450       |              |
| 500       |              |
| 550       |              |
| 600       |              |
| 650       |              |
| 700       |              |
| 750       |              |
| 800       |              |
| 850       |              |
| 900       |              |
| 950       |              |
| 1000      |              |
| 1050      |              |
| 1100      |              |
| 1150      |              |
| 1200      |              |
| 1250      |              |
| 1300      |              |
| 1350      |              |
| 1400      |              |
| 1450      |              |
| 1500      |              |
| 1550      |              |
| 1600      |              |
| 1650      |              |
| 1700      |              |
| 1750      |              |
| 1800      |              |
| 1850      |              |
| 1900      |              |
| 1950      |              |
| 2000      |              |





# SCALA PENETROMETER LOG

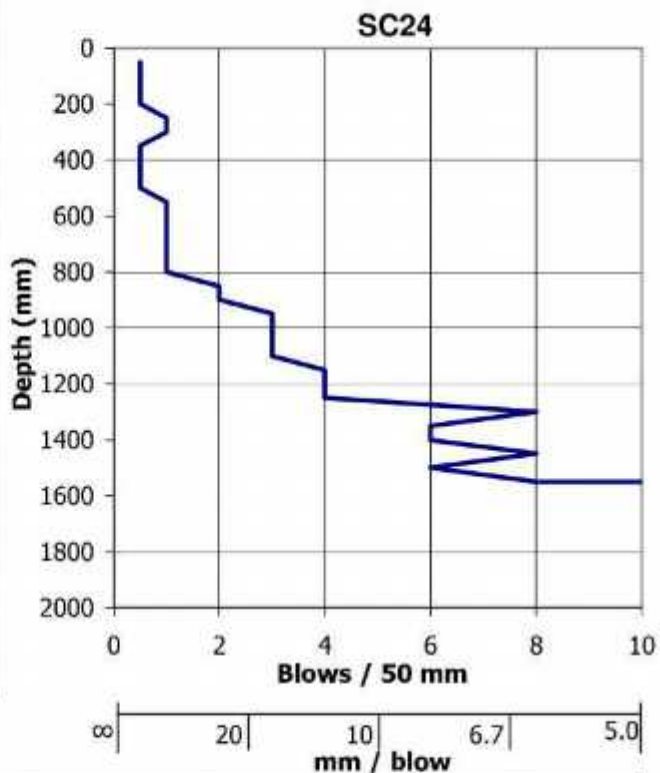
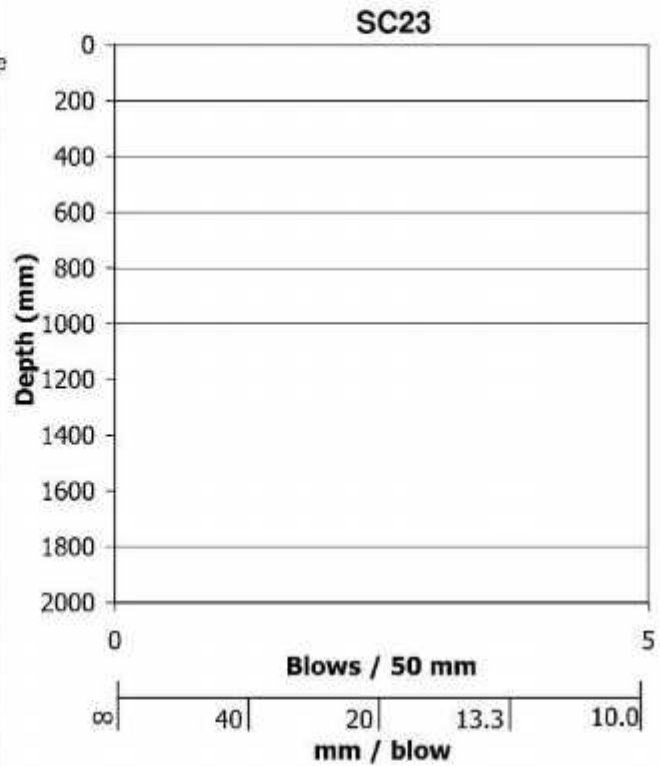
Job No: 160677  
Project: Mt Cardrona Station

Date: 16/09/2005  
Operated by: FAW  
Logged by: ASC

Test Number SC23 & SC24

Sheet 1  
of 1

| Location:<br>RL: |                 | SC24<br>Location: Beside TP7<br>RL: From Surface |                 |
|------------------|-----------------|--|-----------------|
| mm<br>Driven     | No. of<br>Blows | mm<br>Driven                                     | No. of<br>Blows |
| 50               |                 | 50   | 0.5             |
| 100              |                 | 100  | 0.5             |
| 150              |                 | 150  | 0.5             |
| 200              |                 | 200  | 0.5             |
| 250              |                 | 250  | 1               |
| 300              |                 | 300  | 1               |
| 350              |                 | 350  | 0.5             |
| 400              |                 | 400  | 0.5             |
| 450              |                 | 450  | 0.5             |
| 500              |                 | 500  | 0.5             |
| 550              |                 | 550  | 1               |
| 600              |                 | 600  | 1               |
| 650              |                 | 650  | 1               |
| 700              |                 | 700  | 1               |
| 750              |                 | 750  | 1               |
| 800              |                 | 800  | 1               |
| 850              |                 | 850  | 2               |
| 900              |                 | 900  | 2               |
| 950              |                 | 950  | 3               |
| 1000             |                 | 1000   | 3               |
| 1050             |                 | 1050   | 3               |
| 1100             |                 | 1100   | 3               |
| 1150             |                 | 1150   | 4               |
| 1200             |                 | 1200   | 4               |
| 1250             |                 | 1250   | 4               |
| 1300             |                 | 1300   | 8               |
| 1350             |                 | 1350   | 6               |
| 1400             |                 | 1400   | 6               |
| 1450             |                 | 1450   | 8               |
| 1500             |                 | 1500   | 6               |
| 1550             |                 | 1550   | 8               |
| 1600             |                 | 1600   | Refusal         |
| 1650             |                 | 1650   |                 |
| 1700             |                 | 1700   |                 |
| 1750             |                 | 1750   |                 |
| 1800             |                 | 1800   |                 |
| 1850             |                 | 1850   |                 |
| 1900             |                 | 1900   |                 |
| 1950             |                 | 1950   |                 |
| 2000             |                 | 2000   |                 |



## Appendix C: Royden Thomson's Geological Hazard Report



ROYDEN THOMSON, GEOLOGIST

11 Leitch Street  
Cromwell  
Phone 03 445 0025  
Fax 03 445 0029

20 June '06

Jenny Parker  
Arrow Resource Management  
11 Argyle place  
ARROWTOWN

Dear Jenny

### **MT. CARDRONA STATION: FAULT LINE AND HYDROLOGICAL REPORT**

Please find below a discussion on the six items you listed as being pertinent to the proposed development on Mt. Cardrona Station. Each item related to one or more natural hazards that have been identified by the Otago Regional Council near the site and which require to be assessed and clarified in order to progress the resource consent process.

#### **Geological Setting**

Pringles Creek drains east from the ridge crest immediately south of Mt. Cardrona (Fig.1). The upper half of the catchment comprises a moderate to steep sided basin that spans a vertical relief of more than 1000m. Beyond the basin, Pringles Creek is variably incised into a set of alluvial fans, of different ages, that effectively extend down to the Cardrona Valley floor. A prominent fan, at lower levels, is the dominant area for the proposed development on Mt Cardrona Station.

From both a field inspection and a photogeological study I have come to the conclusion that the physiography in the area is dominated by glacial processes. All tributaries draining east and south off Mt. Cardrona have upper morphologies indicative of past glacial occupation; valley glaciers to in excess of 3km in length during the Late Quaternary (probably larger for some older events), and snowfields/cirque glaciers for events associated with very recent cold periods. The alluvial fans are also considered to be fluvioglacial sedimentary deposits that formed by aggradation, in sympathy with the infilling of the main valleys during the same glaciations. In the interglacial periods rivers and streams degrade, there is progressive erosion of exposed surfaces by both aerial weathering and landslide processes, and tectonism impacts irregularly. More or less typical of many areas in Central Otago.

Faulting is a known hazard within the Cardrona Valley and its projections, and the approximate trace of the fault (zone) that trends along the north-west margin of the valley should be marked on the QLDC hazard maps. Apart from a single, defined trace on Mt. Cardrona Station there is little local evidence on which to define past and future tectonic deformation, however. Please note that for this exercise no attempt was made to investigate the distribution of tectonism or to research previous work on seismicity and likely return periods.

#### **Item 1: Ages of Alluvial Terraces and Fans**

Profiling of both field determined and photogeologically defined Cardrona River terrace surfaces and proximal fan margins was undertaken for this study. To establish best-fit ages the profiles



were extended to the main Clutha Valley, for which there is an approximate to relatively precise geometric relationship and chronology. On this basis a set of 'local' values was determined for the mid Cardrona area.

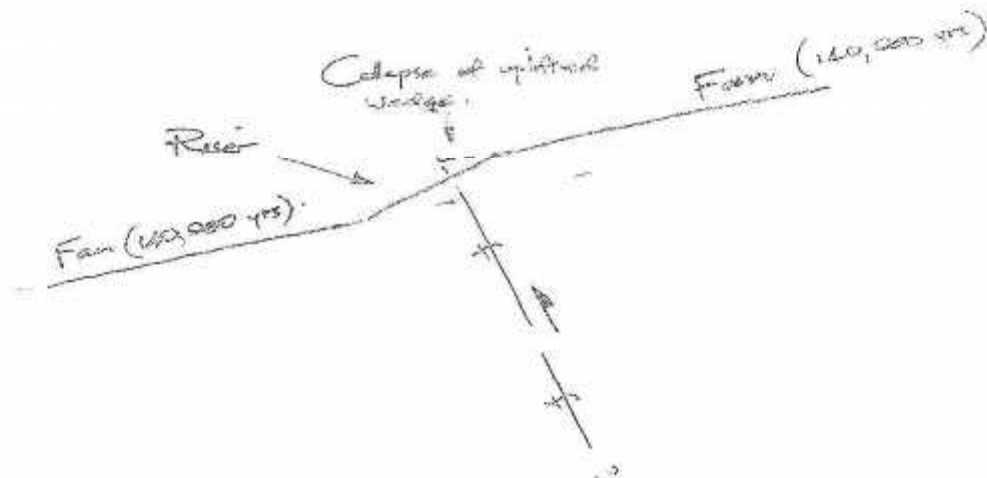
Table 1 lists the assessed ages of the principal features of interest.

### Item 2: Fault Trace Position

Figures 3a and 4 indicate the approximate position of the fault trace in plan while Figure 3b shows a likely attitude at depth, assuming a compressional regime for local tectonism. Several photos also illustrate the position and morphology of the fault scarp.

Features of note:

- The fault only dislocates the upper, prominent fan surface with an assessed 140,000 year age. A west-side-up displacement suggests reverse movement on a west-dipping plane.
- There is a prominent but eroded scarp on the Skifield Road at RL670 approximately (Photo 6).
- Across a gully, to the south of the road, a prominent, arcuate scarp is present which is also highlighted by springs. I suspect the arcuate nature is a function of stream incision and that the trace is on a line trending from the foreground in Photo 6.  
From contour profiling it is estimated the fault throw is about 10 – 15m. As indicated in the sketch below,



it is probable that the trace lies about at the centre of the fault riser; the initially uplifted margin of the western block would collapse then erode, to produce a debris apron on the downfaulted side.

- A 10 – 15m throw appears to be excessive for a single event. Multiple, same-sense movements are assumed to have occurred along this fault strand.
- The riser near the apex of the "Village Terrace" fan does not reflect the tectonic displacement in total as the adjoining fans have different ages. Significant landslide deposits mantle the riser and mask any prospective fault trace (Photo 1).

- f) No fault trace is visible on the floor or margins of Pringles Creek. There is no apparent deformation of the "Village Terrace" fan but the trace probably lies to the west of the fan apex (Fig. 3a). As a consequence, it is not possible to estimate whether the latter fan has been disrupted or not when it still existed upstream from The Bend.
- g) To the south of Pringles Creek the fault scarp is again evident as an irregular step in the 140,000 year old fan, the downthrown side of which is only slightly higher than the "Village Terrace" fan apex. The surface trace is highlighted by springs. It is also apparent that:
- the older fan has been significantly degraded south of Pringles Creek.
  - fault scarp heights are small to negligible.

Perhaps only the most recent deformation phase has been preserved here.

- h) South of a point 300m south of Pringles Creek there has been extensive landsliding which has obliterated any pre-existing fault traces (Photo 1).

In summary, the fault scarp is evident on both sides of Pringles Creek but it does not disrupt the channel perimeter. As well as can be projected, the trace will cross the channel just upslope from the apex of the "Village Terrace" fan i.e. approximately in the centre of the large radius bend. The time of last movement has not been assessed.

### **Item 3: Sources, Movement and Aggradation of Stream Sediment**

#### **a) Sediment Sources**

Although there is some potential for erosion of stream channel margins below RL800, most potential sources of sediment in Pringles Creek lie within the steep, upper basin. In the latter area I have both visually and photogeologically defined (Fig. 2):

- i/ an apparently creeping slide mass in the central gully area; toe at RL920, crest at RL1220 (Photos 2, 3, 5).  
From a photo in an ORC memo, supplied by Lamorna Cooper, I understand this feature is called the Arcadia Slip. No maps have been supplied so I cannot compare absolute boundaries.
- ii/ an extensive slide area on the lower to mid section of the north flank of the Pringles Creek basin. Various lobes and degrees of activity. Some potential for relatively small debris flows – my assessment.
- iii/ multiple slides feeding into the upper reach of the Arcadia Slide. Not particularly active.
- iv/ an incipient failure in schist, incorporating a spur in the central basin, with the upper limit of distress at RL1700, approximately. No perceived debris flow potential.
- v/ irregular, small failures in the road switchback area of the south flank of the basin. Minimal debris flow potential.

From comment in the April 2006 "Snow Making Pond" report (supplied), plus notes provided by Lamorna Cooper, I interpret the contentious pond is sited in a pre-existing depression, near the south fringe of the basin, at RL1550–1560. The inference from the ORC

publications is that the dam itself would be sited on a landslide, with a large areal extent, and that there is potential for mass movement on the slope above which puts the pond at even greater risk of failure. (I also note there is a geotechnical report by Jeff Bryant, which I haven't seen.) Information supplied suggests the pond site is on the Scum Valley Landslide, but I may be in error, here, especially as I have not visited the area.

My interpretation of the geology at and near the ponds site is that there are several glacial cirques on the upper slopes, one of which will be effectively occupied by the pond. While indeed there is an apron of debris on the downslope side of the depression, and there may be local erosion on the outer edge of the apron, the mass will be clastic, glacial till, which should not be debris flow prone.

In summary, I assess:

- the proposed pond is within a cirque glacier moraine loop. No debris flow potential.
- a landslide on the valley axis in the lower basin appears to be creeping and have some debris flow potential. (But not as a result of dam leakage.)
- landslides on the north flank of the basin also have limited debris flow potential during storm events.

b) Sediment Movement and Aggradation

Recent storm events, such as that in November 1999, have had no significant influence on the active channel and no impact at all on the broad floodplain downstream from the Skifield Road crossing. It can be assumed, therefore, that:

- i/ no debris flows were generated.
- ii/ existing landslides are not particularly susceptible to debris flows, either in part or as a whole.

And the question can be asked as to whether any debris flows of significance have actually passed down the central and lower reaches of Pringles Creek since it has been in its degradational phase; also whether similar conditions have occurred even within the present inner gorge, which is clearly the youngest morphological feature. My view is that debris flows have probably occurred but they would have been small at mid reaches of the lower half of the catchment, which actually has a low channel gradient (Fig. 3b). The scattered boulders along and near the channel cannot be used as a guide, as they may be merely a lag from the erosion of the last fluvio-glacial fan, and there is no unequivocal evidence of aggradation in the channel segment that I saw.

The ORC report (April 2006) has assessed debris flow impacts assuming a range of scenarios, including a rapid failure of the pond during a rainstorm event. Assuming a debris flow can actually be generated on the Arcadia Slip area, the analysis defines a worst case situation as having a 150,000m<sup>3</sup> volume, travelling at 3.5m/sec. and passing debris at 91m<sup>3</sup>/sec. While the Skifield Road would be destroyed at the crossing, the diminished gradient and widening floodplain further downstream will cause debris deposition and a termination of the debris flow before reaching the floor of the main valley. Levels of peak flow at different segments in the catchment have been plotted and it is informative that all are within the inner gorge and only to about 2m above the channel thalweg downstream from the road crossing. No incursion onto the flood plain is depicted.



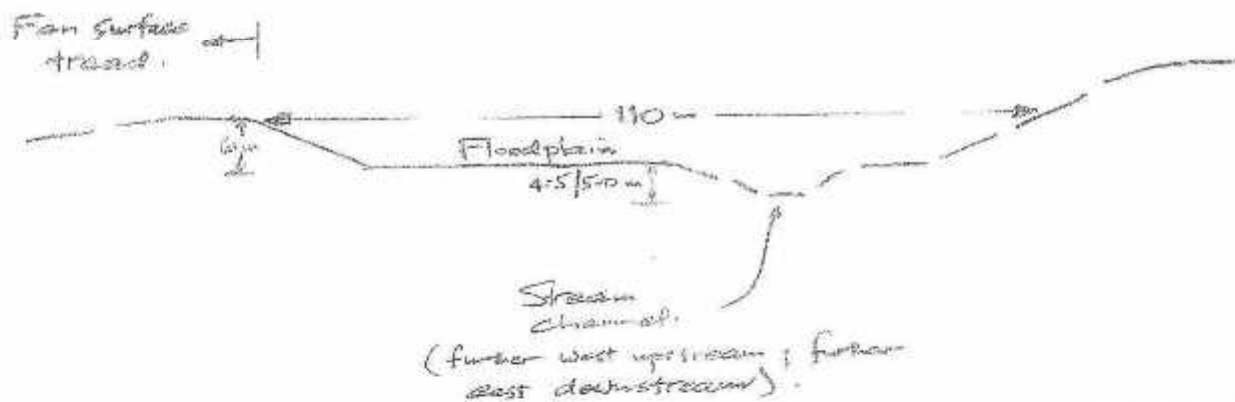
One assumes a certain amount of aggradation will occur as a consequence of the debris flow event but most detritus should be rapidly removed from the inner channel during normal stream functions. Boulders may cause some aggradation of a more permanent nature. In summary, I conclude the modelling undertaken as part of the ORC dambreak report is sensible, with end results fitting observations in the existing Pringles Creek channel/floodplain complex. A worst case scenario would generate a maximum flood/debris flow level 2m above the channel thalweg downstream from the bridge crossing and a limited amount of aggradation will occur in the inner channel as a consequence.

#### Item 4: Risk of Aggradation and Overflow at the Pringles Creek Bend

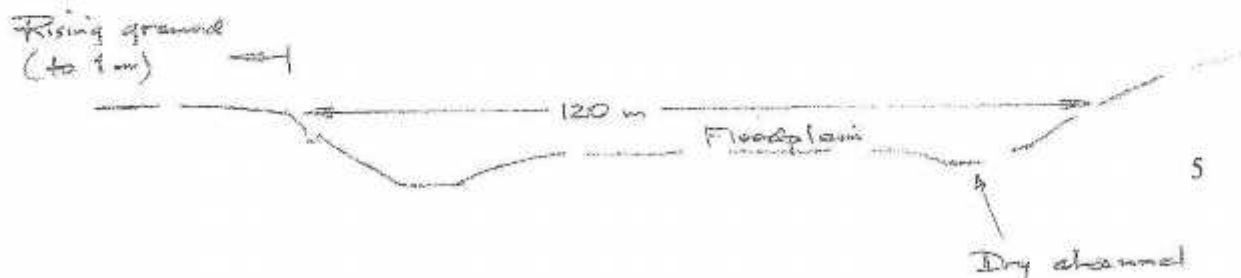
Pringles Creek, on the left bank, is flanked by an assessed fluvioglacial deposit that has a surface tread variously grading to the east and south-east (Fig. 3a). At the apex of the ("Village Terrace") fan there appears to be a remnant of the primary aggradational surface which is slightly higher, and less channelled, than the clearly degraded equivalent that forms most of the fan surface and the area marginal to Pringles Ck. (Photo 2).

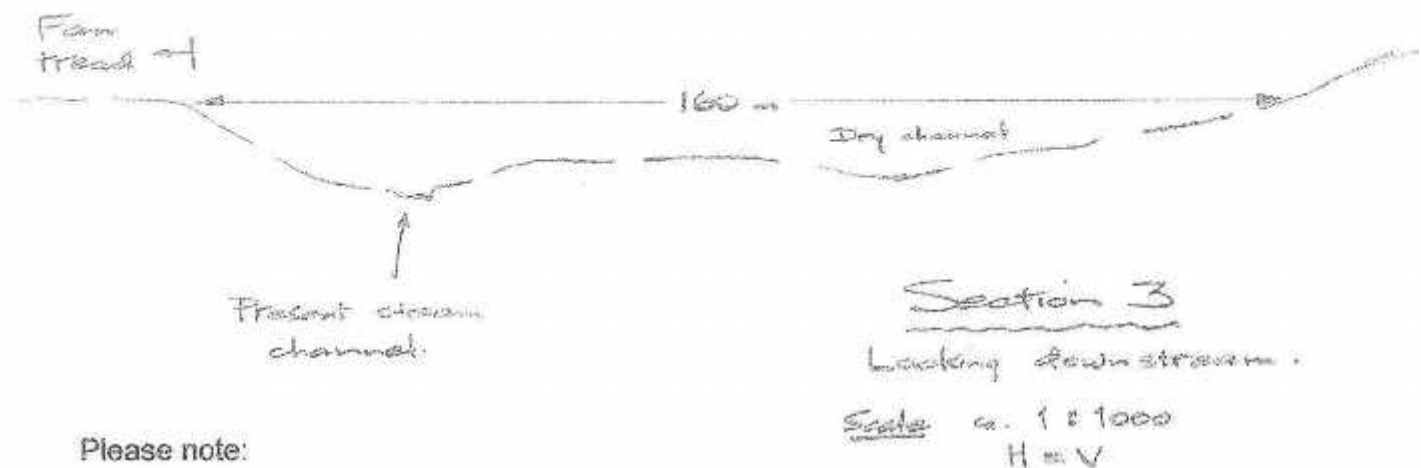
The right margin, and marginal strip, of the fan is obviously a key feature in the overflow hazard scenario and I measured some sections, in a simple way, to illustrate channel geometries. An identified most susceptible left bank position was located just downstream from the fan apex (Section 1 on Fig. 3a) and a couple of other sections (Sections 2 and 3) were measured as well. It should be noted that the ORC Report Section 1130 corresponds closely with Section 1 while ORC 1020 and Section 3 are near each other.

Section 1 Looking downstream  
Scale ca. 1:1000  
H = V.



Section 2 Looking downstream  
Scale ca. 1:1000  
H = V.





Please note:

- The deeply incised floodplain (6m below fan margin) and active stream channel (almost 5m below floodplain) on Section 1.
- Even more deeply incised profiles on Sections 2 and 3, relative to the fan margin.
- The large cross sectional area for each section below the level of the fan margin.
- On ORC Section 1130, a modelled 2m rise in fluid level in the stream channel during the peak flow for a worst case scenario involving a simultaneous rainstorm and dam break. When the overall channel dimensions are considered this is a negligible impact.

Further Comment:

- A catastrophic slope failure in the catchment leading to a major debris flow in Pringles Creek cannot be precluded in the future. However, one hasn't occurred to a level of intruding onto the "Village Terrace" fan in the last 23,000 years so the risk of it occurring in the life of the proposed development is assessed as extremely low.
- The risk of a moderate sized debris flow even exiting the inner channel of Pringles Creek at "The Bend" in the next 50 years or so is also assessed as low when considering:
  - the ORC modelling.
  - the rather low channel gradient downslope from the road crossing.
  - the broad floodplain upstream from The Bend, which will substantially reduce velocities and allow appreciable sediment deposition.
- My intuition also indicates a flood or debris flow won't overtop the left bank along the fan margin, even allowing for surging. As illustrated by Photos 4 and 5, the overall channel is very wide and generally deep and The Bend is, in reality, a large radius curve.
- The ORC continues to have residual flood and debris flow concerns, including the risk to the "Village Terrace" fan development. I had a discussion with Lamorna Cooper, who also supplied memoranda of March and May vintage, and it transpired that her main concern regarding a left bank breach was the apparent presence of a "switching point" (new term to me) between ORC Cross Sections 850 and 1020. "At this junction the freeboard on the true left reduces to ca. 1.5m." The high level dam is considered to exacerbate the risk compared with the existing condition.

Lamorna's area of concern lies more-or-less at my Section 3, where there is a deeply incised active channel at the left of the broad valley. One point she raised was an initial valley floor aggradation phase which would diminish the superelevation on the left at the time of the flood/debris flow wave. But, the latter will be at the front of the flow and will pass down an unaffected channel, so there will be no precursory aggradation, in my opinion.

I believe continuing dialogue with the ORC, perhaps with some dedicated cross sections being constructed at key localities, may easily resolve the issue of "Village Terrace" fan inundation without resorting to remedial works such as embankment construction.

#### Item 5: Incremental Hazards for Kidson Development Model

##### a) Flooding

As previously discussed, the flood/debris flow hazard to the "Village Terrace" fan from an event traversing Pringles Creek has essentially been negated by the ORC Dambreak Report that can, in turn, be diminished in impact terms if it is accepted the dam location is within a cirque moraine rather than on a landslide. ORC staff have a residual issue with one small section of the Pringles Creek channel, however, and this needs further prudent attention. Assuming a positive outcome here, I cannot perceive any difference in flood hazard and risk from the creek to either the existing Rural Visitor Zone or the enlarged Kidson version (Attachment 1).

There are surface flows on the upper "Village Terrace" fan that need to be considered, however. These include groundwater seepages in the Upper Terrace Escarpment and limited runoff from the terrace above the scarp. These either intrude, or potentially intrude, into the north-west quadrant of the "Village Terrace" (Attachment 2) from where they will be directed to the north-east to the creek that runs down Homestead Valley. Attachment 1 contours in this area depict a shallow basin on the fan which will be a subcatchment. As the enlarged Rural Visitor Zone will be entirely to the east of this catchment no hazard and risk from surface flooding should result.

##### b) Faulting

The Upper Terrace Escarpment brackets the indicated fault scarp which:

- i/ has a slightly uncertain trace position.
- ii/ reflects probable multiple events, an individual one of which will have a likely maximum throw of 2 – 3m.
- iii/ could have a zone of deformation rather than a single plane.
- iv/ is west-side-up on a presumed west-dipping fault.
- v/ is due to a fault strand that has an uncertain relationship to the regionally persistent NW Cardrona Fault Zone. Perhaps it is the master fault.

Irrespective of these uncertainties there is no evidence that the "Village Terrace" fan has been tectonically deformed since its formation – assessed as 23,000 years BP – nor has the assessed 140,000 year old fan that caps the ridge to the north been deformed apart from the one distinctive scarp at RL660 approximately. On the basis of these interpretations the "Village Terrace" fan as a whole is assessed as having a very low to extremely low risk of tectonic deformation in the lifetime of the proposed development, apart from, perhaps, the



fan apex. As both the assumed existing Rural Visitor Zone and the Kidson enlargement are well away from the existing fault scarp they will be equally in the same risk category and be affected by the same levels of future seismic shaking.

c) Landsliding

The southern half of the Upper Terrace Escarpment is affected by landsliding, the toe zone of which locally extends to below the water race. Mobility is influenced by groundwater seepages but movement rates are clearly low.

It is assumed that there will be an increase in the size of the landslide toe zone, should rupture again occur on the fault in the life of the proposed development, but the wet margin of the enlarged Kidson zone lies 450m away from the present toe and should not be adversely affected by future slide enlargement.

Conclusions

- a) Both the existing Rural Visitor Zone, and its proposed enlargement, span a fan/gully complex just west of the Cardrona River. The various prominent surfaces are attributed to aggradation caused by both regional glacial events and the contemporaneous development of small valley glaciers on the flanks of Mt. Cardrona.
- b) The surface of the fan to the north of lower Pringles Creek ("Village Terrace"), on which development is proposed, has an assessed 23,000 year age. The remnant surface at higher levels to the north has an assessed minimum age of 140,000 years.
- c) A north-south-trending fault disrupts the older fan approximately 800m west of the present Visitor Zone and 600m west of the proposed enlargement. The fault is west-side-up, has indicated multiple phases of post 140,000 year movement, and has an uncertain relationship to the master fault in the NW Cardrona Fault Zone. Timing of the last movement event is uncertain as the projected trace will lie just to the north-west of the "Village Terrace" fan.
- d) Concerns have been expressed by the Otago Regional Council with respect to the potential for Pringles Creek to overtop its left bank in the lower reach and flow down the "Village Terrace" fan to the proposed development area during a major flood or debris flow event. The latter includes a rapid release from a proposed pond on the skifield, which would exacerbate the hazard.  
However, modelling of a worst case scenario Pringles Creek flow indicates only a minimal rise in the level of the creek in the active channel will occur at key stations. As the active channel constitutes only a small fraction of a wide, high sided valley incision that adjoins the "Village Terrace" fan, the risk of channel overtopping and stream avulsion on the left bank is considered to be effectively zero for perceived sensible events in the upper catchment.
- e) This study concludes the proposed snowmaking pond is sited within a cirque moraine, rather than a landslide mass as previously interpreted. A diminution of the risk of dam failure as a consequence will have a beneficial influence on flood or debris flow risks in the lower catchment.

- f) Expanding the proposed Rural Visitor Zone on the "Village Terrace" fan, as per the Kidson concept, should not incrementally increase the risk factors from flooding/debris flows, direct displacement by faulting, or landsliding in the development area.

I trust the various discussions on requested items are informative and pertinent. Personally I don't foresee significant geotechnical hazards in the proposed development area but items such as the more regional extent of faulting have not been addressed for this report and there are ongoing elements of the study by ORC of Pringles Creek hazards which have yet to be concluded; a timeframe for this aspect is unknown.

Regards



| Feature and Location  | Age<br>(yrs. BP)  | Glaciation | Comment   |
|---|-------------------|------------|---|
| "Village Terrace" fan surface, north of Pringles Creek (Photos 7, 8). | 23,000            | Otira      | Profile on outer edge fan; close to proto Cardrona River surface. |
| Skifield Road remnant terrace by pine trees. (Photo 1)                | $\geq 140,000$    | Waimea     | Surface faulted on road west of pine trees.                       |
| Faulted fan south of Pringles Creek Bend (Photos 1, 4)                | $\geq 140,000$    | Waimea     | Same surface as Skifield Road, above.                             |
| Nominal moraine, north side of Pringles Creek, RL830                  | 300,000           | Waimaunga  | Equivalent likely on south side of Pringles Creek.                |
| Cirques in head of Pringles Creek                                     | $\leq 1,000$ yrs? | Otira      | Probably multiple occupancy phases in 'recent' times.             |

**Table 1** Assessed ages for surfaces near the proposed development area.



Captions for photos illustrating hazard sources and fan surfaces.

| Nbr  | Description  |
|------|--|
| 1    | Looking west to the Pringles Creek catchment and some nearby geomorphic features.  |
| 2, 3 | Head basin of Pringles Creek catchment, Creeping landslide mass at centre.   |
| 4    | View up Pringles Creek. Note: <ul style="list-style-type: none"> <li>a) edge of "Village Terrace" at centre right.</li> <li>b) very wide floodplain with stream incised right of centre.</li> <li>c) fault scarp, upper left.</li> </ul>   |
| 5    | View up Pringles Creek. Note: <ul style="list-style-type: none"> <li>a) large, glaciated basin at head.</li> <li>b) wide floodplain in foreground.</li> <li>c) fault scarp, lower left.</li> <li>d) landsliding at right of centre.</li> </ul>   |
| 6    | Looking south along fault scarp from the Skifield Road terrace remnant. Note: <ul style="list-style-type: none"> <li>a) steep slope in foreground is the northernmost fault scarp.</li> <li>b) road just beyond fence.</li> <li>c) estimated 10 – 15m throw on fault.</li> <li>d) surface trace probably mid height of scarp.</li> </ul> |
| 7    | Looking south-west across much of the "Village Terrace" fan (at left of centre) and faulted higher terrace at night.   |
| 8    | Looking WSW across "Village Terrace" fan. It grades out to an indicated proto Cardrona River surface behind the pine trees at left.  |









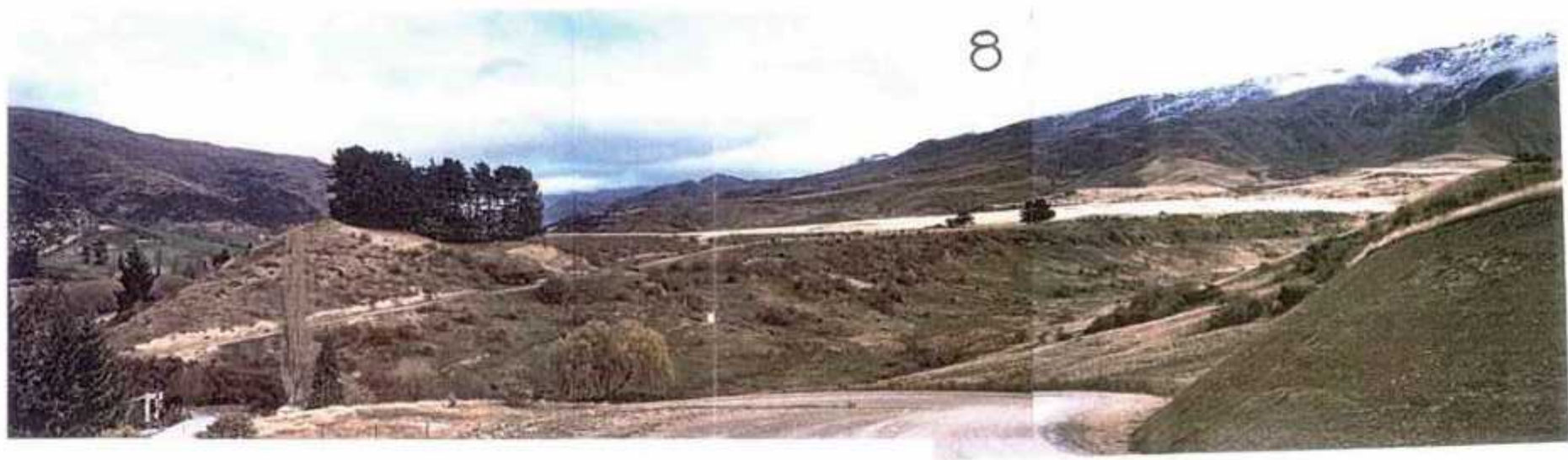


5

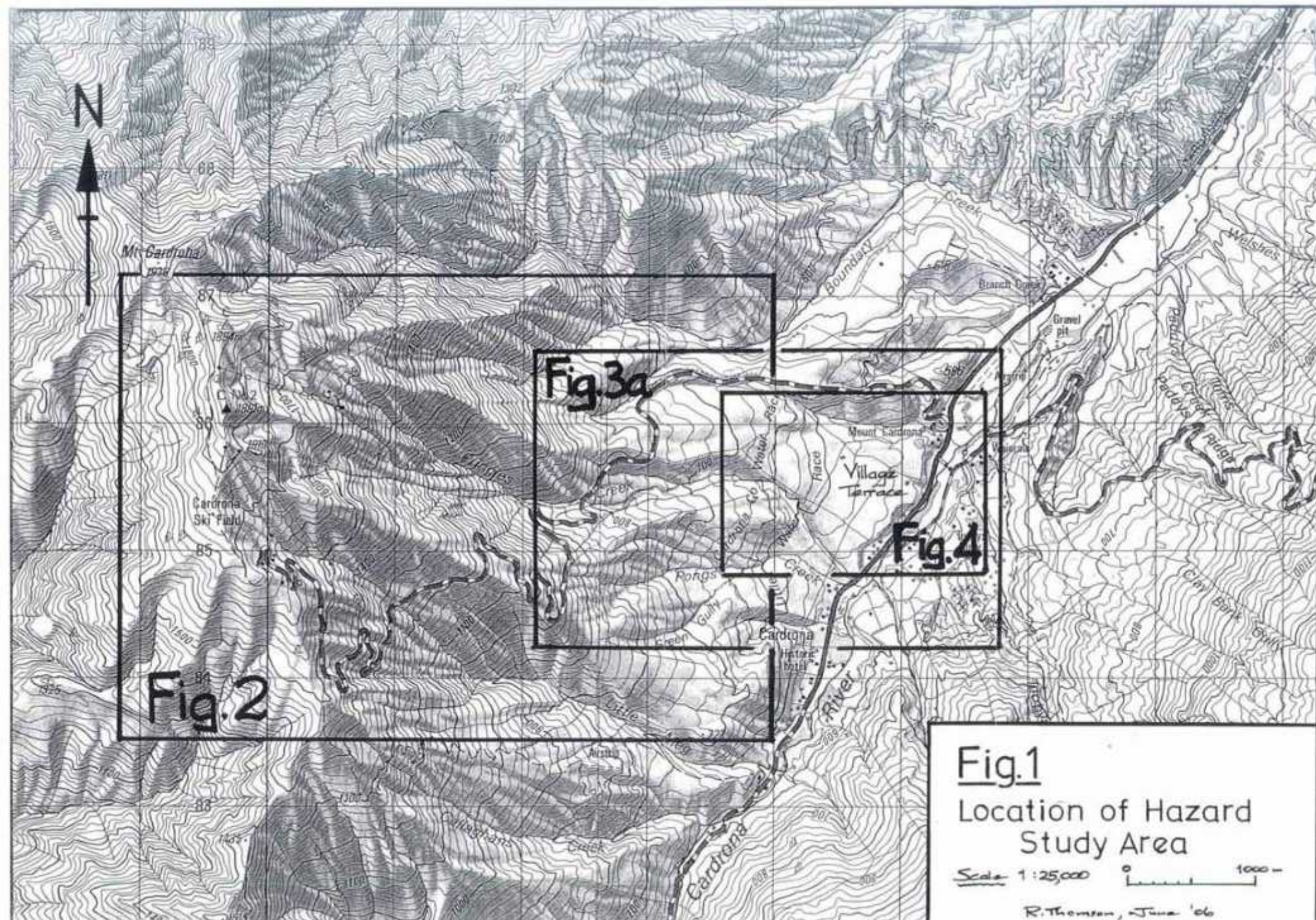












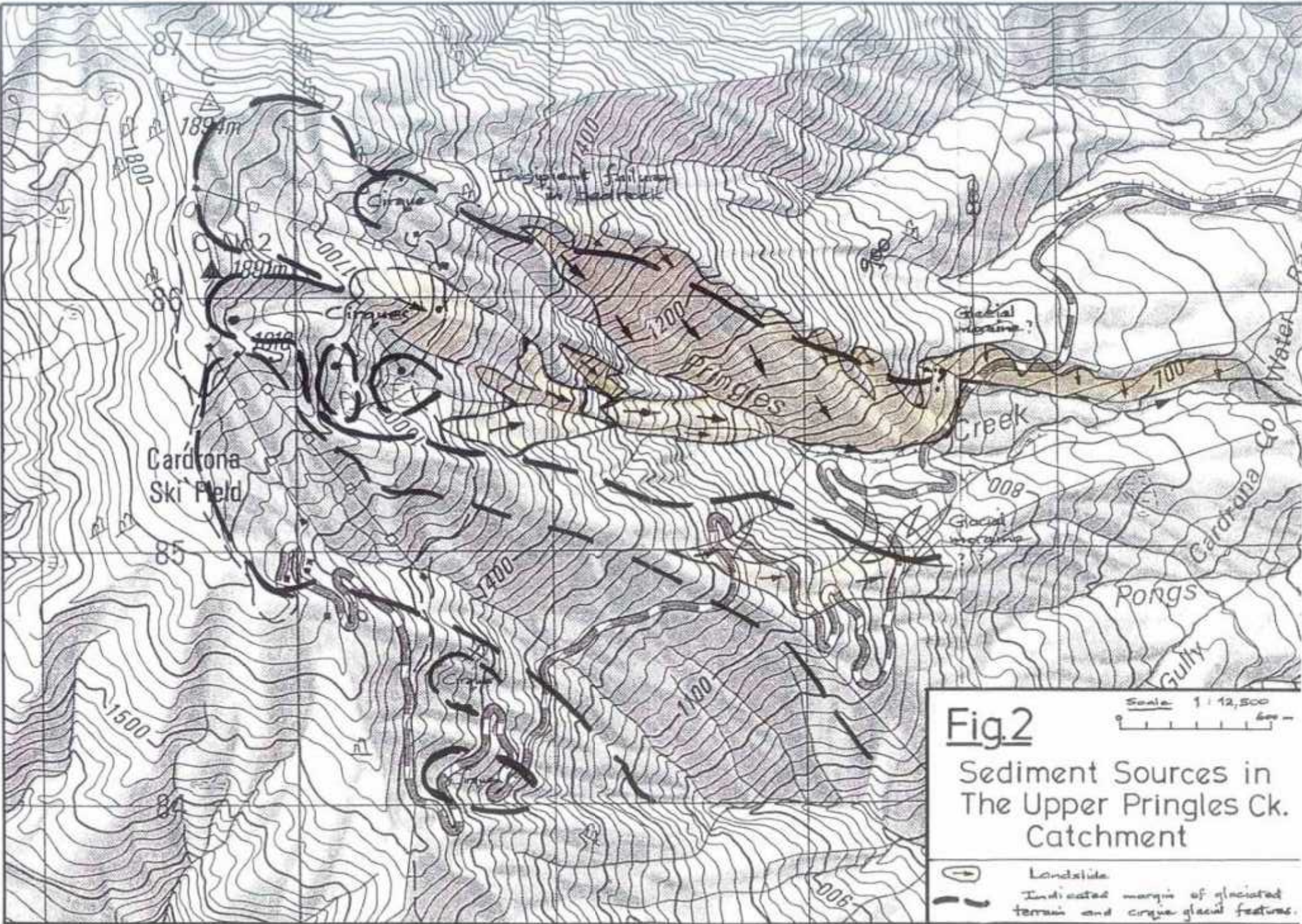
**Fig.1**

Location of Hazard  
Study Area

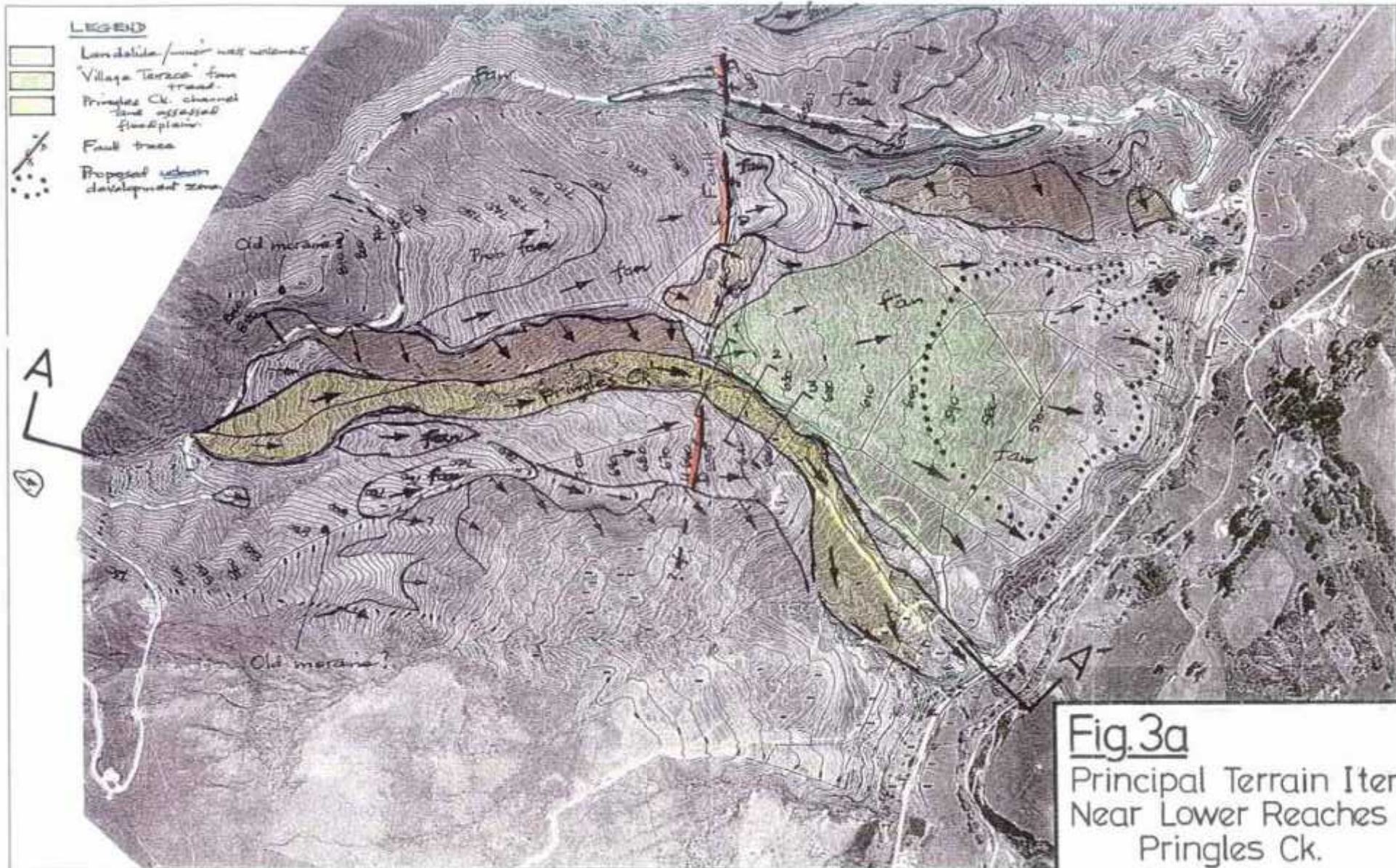
Scale 1:25,000

R. Thompson, June '06



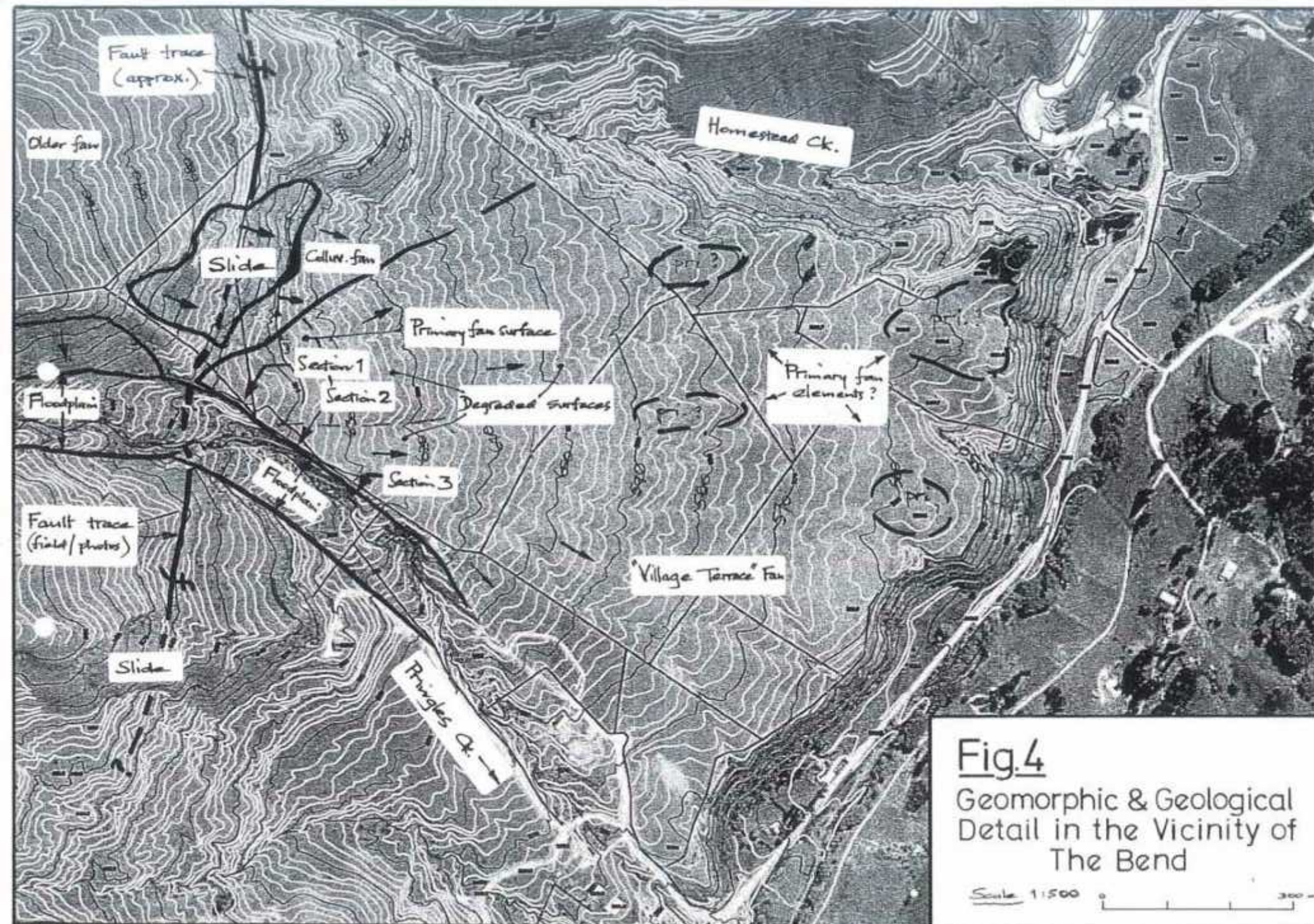






|   |  |                                     |                                   |   |  |   |  |   |   |  |  |   |
|---|--|-------------------------------------|-----------------------------------|---|--|---|--|---|---|--|--|---|
| <p><b>PROJECT</b></p> <p>Topography &amp; Orthophoto<br/>25-5201-02</p> | <p><b>CLIENT</b></p> <p>BAXTER BROWN</p> | <p><b>DATE</b></p> <p>JUNE 2005</p> | <p><b>SCALE</b></p> <p>1:1000</p> | <p><b>PROJECT NO.</b></p> <p>25-5201-02</p> | <p><b>PROJECT NAME</b></p> <p>CARDRONA<br/>TOPOGRAPHY &amp; ORTHOPHOTO</p> | <p><b>PROJECT LOCATION</b></p> <p>Cardrona, New Zealand</p> | <p><b>PROJECT DESCRIPTION</b></p> <p>Topography &amp; Orthophoto</p> | <p><b>PROJECT STATUS</b></p> <p>Completed</p> | <p><b>PROJECT CONTACT</b></p> <p>John Brown</p> | <p><b>PROJECT PHONE</b></p> <p>06 336 1111</p> | <p><b>PROJECT FAX</b></p> <p>06 336 1112</p> | <p><b>PROJECT EMAIL</b></p> <p>john.brown@baxterbrown.co.nz</p> |
|---|--|-------------------------------------|-----------------------------------|---|--|---|--|---|---|--|--|---|



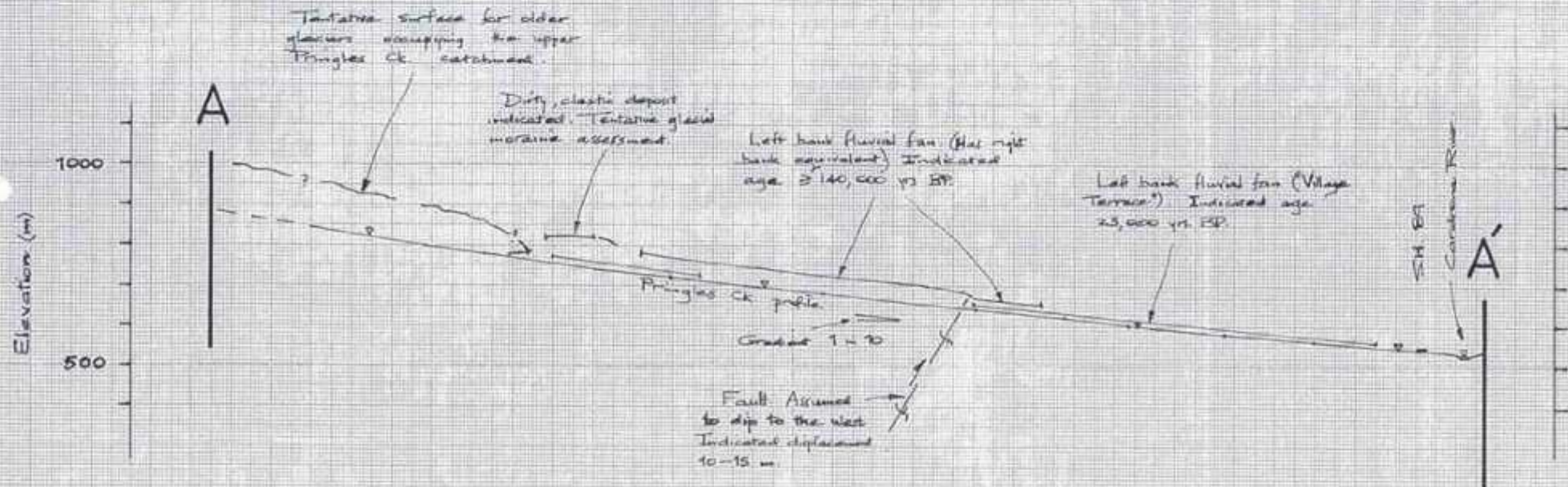


**Fig.4**

Geomorphic & Geological  
Detail in the Vicinity of  
The Bend

Scale 1:500 0 300





**Fig. 3b**

Geological Cross Section AA'

Scale 1:1000  
H = V