

UR1987\_43

1987/43. Examination of Pleasant Hills Subdivision Phase II.

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Abstract

An investigation of the proposed phase II subdivision for Vos Nominees at Pleasant Hills has been undertaken. Geomorphological features in the area suggest that part of the area is an old landslide. Slope stability analyses have been undertaken to determine the suitability of the site for development.

Test pits have confirmed that the site is underlain by highly plastic (CH) clays, some of which show signs of disturbance (slickensides). The clay mineral montmorillonite has been identified by X-ray diffraction techniques. This mineral has a high potential for volume instability (i.e. shrinks when allowed to dry out and swells when allowed access to water).

Stability analysis of a selected slope profile indicates that unacceptable risks of slope failure can occur if the pore pressure ratio exceeds 0.37. This corresponds to a water table closer than about 3.5 m from the ground surface. Such conditions are considered unlikely to arise over the majority of the proposed subdivision. An area where water ponded on the surface causes concern as it occurs near the toe of the slope profile analyzed for stability. Provision of a deep sub-soil drain in this area is recommended.

INTRODUCTION

Slope classification at the proposed Pleasant Hills subdivision for Vos Nominees (Weldon, 1986) identified areas which are at risk with respect to slope stability. Phase II of the subdivision has been planned, and as some of the at risk area is included in the proposal, a more detailed examination was requested by Campbell Smith, Phelps, and Pedley Pty Ltd, who are acting on behalf of the developer.

GEOLOGICAL SETTING

Grindelwald is located on a Tertiary-age basalt plateau. The area to be subdivided by this proposal lies on the steep to moderately sloping south eastern flanks of this plateau, and is mapped as Quaternary-age talus deposits. These deposits consist of Tertiary-age basalt derived by slope processes mixed with Tertiary-age Launceston Beds sediments. The geomorphological features of the area indicate that landslides have occurred in the geological past.

INVESTIGATION

Eleven test pits were excavated and logged on 27 May 1987. The pits were dug by a Domino DIG tracked mini-excavator. The location of the test pits is shown on Figure 1. The engineering logs prepared from the exposures are attached as Appendix 1.

The test pits reveal that the near-surface geology is dominated by highly plastic clays, sometimes with slightly to highly weathered sub-angular to sub-rounded basalt boulders to 300+ mm in diameter, and occasionally with fine to medium size basalt gravel or lateritic gravel. Slickensides were observed in test pits 4,5, and 8.

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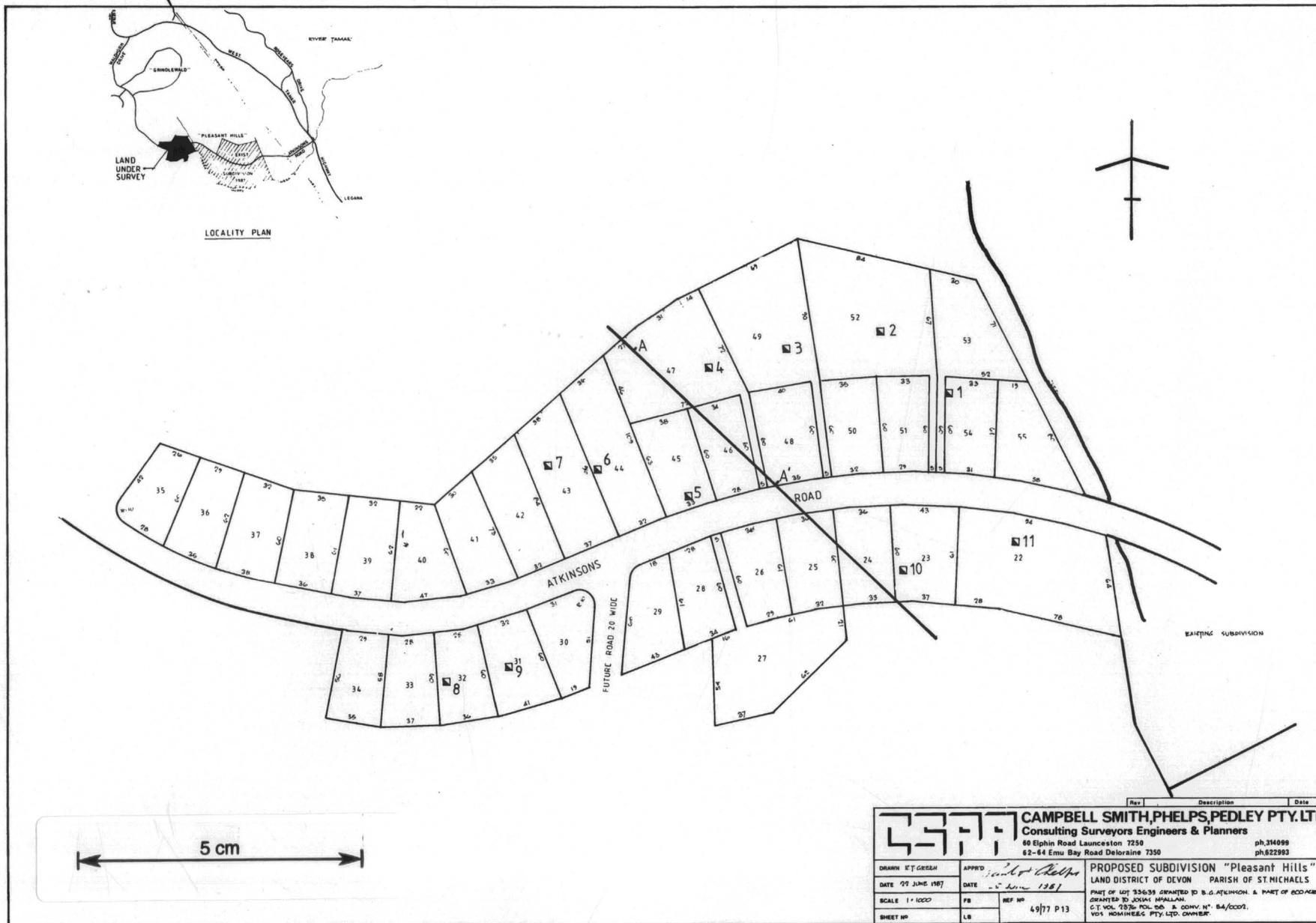


Figure 1. Proposed subdivision with positions of test pits marked

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The slickensides confirm the geomorphological observations that the area has been subject to land movements in the past.

#### LABORATORY TESTING

A typical sample of the slickensided clay from 1.4 to 1.6 m depth in test pit 5 was submitted for laboratory tests by R. N. Woolley of the Department of Mines. The results are detailed below:

|                    |                                      |                      |
|--------------------|--------------------------------------|----------------------|
| Atterberg Limits:  | Liquid Limit (%)                     | 107                  |
|                    | Plastic Limit (%)                    | 25                   |
|                    | Linear Shrinkage (%)                 | 28                   |
| Soil Strength:     | Angle of internal friction (degrees) | 19                   |
|                    | Residual cohesive strength (kPa)     | 4                    |
| X-ray Diffraction: | Clay content                         | 100% montmorillonite |

The angle of friction and the residual cohesive strength were determined by cyclical shearing in a shear box. As the sample was already disturbed (i.e. slickensided), it is appropriate to use these values in stability analysis.

Montmorillonite has high shrink-swell characteristics and weak interlayer bonding in its structure. The presence of this clay mineral is usually conducive to slope failure.

#### STABILITY ANALYSIS

Several cross-sections were initially selected for stability analysis using Bishop's method of slices (Bishop, 1955). Of these, the cross-section which gave the minimum factor of safety was selected for more detailed analysis. This cross-section is shown on Figure 2 and its location indicated by AA' on Figure 1.

The initial detailed analysis of the selected cross-section was made for a dry slope with the residual cohesive strength and angle of internal friction as determined in the laboratory tests. A density of 18 kN/m<sup>3</sup> was selected for the soil and the effect of varying the radius of the slip circle was determined. The radius which gave the minimum factor of safety was 160 m and this was used for subsequent analysis of the sensitivity of the factor of safety to density, cohesion and angle of internal friction for progressive saturation of the selected slope.

It was found that the stability analysis was relatively insensitive to variations in density but sensitive to changes in the angle of internal friction and cohesion. As the slope becomes progressively saturated the factor of safety diminishes as expected.

#### INTERPRETATION

In stability analysis, a factor of safety equal to unity indicates a slope in delicate equilibrium, for failure is deemed to have occurred when the factor of safety falls below one. Stability analyses can, at best, only approximate actual ground conditions and require that certain assumptions be made. It is thus possible to obtain a factor of safety less than unity for slopes which have not yet failed. Conversely it is possible to obtain a factor of safety in excess of unity for slopes which have actually failed.



In these cases adjustments to the model or consideration of other factors (such as intense rainfall periods or the binding effect of tree roots etc.) must be taken into account.

It is generally accepted that slopes which yield a factor of safety between 1.0 and 1.3 during stability analysis have a high risk of slope failure. Moderate risks are associated with slopes where the factor of safety is determined between 1.3 and 1.5. Where the factor of safety exceeds 1.5, the slope has a low risk of slope failure.

For phase II of the Pleasant Hills subdivision, the factor of safety for the cross-section analyzed falls below 1.3 where the pore pressure ratio (ru) exceeds 0.37 (i.e. where the water table comes within about 3.5 m of the surface).

DISCUSSION

It is noted that during construction of the roadway a spring was allegedly drained between proposed lots 54 and 22. Small seepages of water were also encountered in test pit 11 on proposed lot 22. This indicates that there is a potential for the water table to locally rise to near the surface, and places a restriction on the proposed development in this area.

There is some instability risk involved whereby pore water pressures may rise to a point where an ru of 0.37 is exceeded. This is considered unlikely to occur over the majority of the proposal. If the proposed subdivision is fully sewered and stormwater drains adequately maintained, the groundwater conditions should not be appreciably changed. The activities of future residents in watering gardens and planting trees which take up water is, however, difficult to assess.

The instability risk is greatest in the vicinity of the spring (which allegedly was drained during road construction). The details of the drainage works are unknown. Lot 22 had much surface and near-surface water at the time of the investigation. As this water indicates potentially high pore pressures at or near the toe of the slip circle analyzed, it would not be prudent to permit development without some attention to drainage in this area.

CONCLUSIONS AND RECOMMENDATIONS

The geomorphology of the proposed subdivision suggests that landslides have occurred in the past. Slickensided clays are further evidence of past land movement. Stability investigations have therefore been conducted in order to determine the suitability of the site for subdivision and subsequent building development.

Test pits have revealed that the proposed subdivision is underlain by high plasticity (CH) clays. A sample of slickensided clay submitted for laboratory testing confirmed that the clay was highly plastic. This clay was determined by X-ray diffraction to be montmorillonite, which has high linear shrinkage (i.e. volume instability).

Stability analysis of a selected cross section indicates that the lowest acceptable risk (i.e. where the factor of safety exceeds 1.3) occurs at a pore pressure ratio of 0.37. This ratio requires that the water table be no closer than about 3.5 m to the surface at the maximum thickness of the slip.

In the vicinity of lot 22 (which is downslope of and beyond the cross section analyzed), water was ponded on the surface at the time of the investigation and seepages occurred in test pit 11 on this lot at about 1.1 and 1.75 m below ground level. This high groundwater level near the toe of the potential slip is undesirable, and it is recommended that the area be drained. A deep sub-soil drain located in the road reservation, extending from the boundary between lots 24 and 25, running parallel to the road and extending to the creek should suffice. The drain should be at least two metres deep with perforated drainage pipe laid on a bed of filter materials. The drainage trench should be back-filled with filter materials. This measure should assist in draining lot 22 which could then be further subdivided into two smaller lots.

The proposed subdivision should be fully sewered and adequate storm water drainage provided and routinely maintained.

The proposed subdivision is located in an area where past landslide movements have occurred. The only significant impediment to subdivision is an area of poor drainage on lot 22. Provided this area is drained, there are no objections to the proposal.

#### REFERENCES

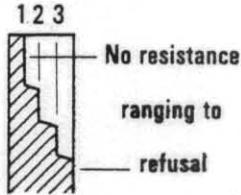
- BISHOP, A. W. 1955. The use of the slip circle in the stability analysis of slopes. *Geotechnique* 5(1):7-117.
- WELDON, B. D. 1986. Slope stability at a proposed subdivision at Rosevears. *Unpubl. Rep. Dep. Mines Tasm.* 1986/76.

[24 September 1987]

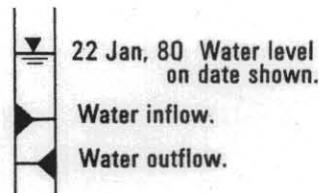
# EXPLANATION SHEET FOR ENGINEERING LOGS

## Borehole and excavation log

### Penetration



### Water



### Notes - samples and tests

- U50 Undisturbed sample 50mm diameter.
- D Disturbed sample.
- N Standard penetrometer blow count for 300mm.
- N\* SPT + sample.

### Material classification

Based on Unified Soil Classification System.  
In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

### Moisture content

- D Dry, looks and feel dry.
  - M Moist, no free water on hand when remoulding.
  - W Wet, free water on hand when remoulding.
  - LL Liquid limit.
  - PL Plastic limit.
  - PI Plasticity Index.
- eg. M > PL - Moist, moisture content greater than the plastic limit.

### Consistency

- |     |             |                         |
|-----|-------------|-------------------------|
|     |             | hand penetrometer (kPa) |
| VS  | Very soft.  | < 25                    |
| S   | Soft.       | 25 - 50                 |
| F   | Firm.       | 50 - 100                |
| St  | Stiff.      | 100 - 200               |
| VSt | Very stiff. | 200 - 400               |
| H   | Hard.       | > 400                   |
| Fb  | Friable.    |                         |

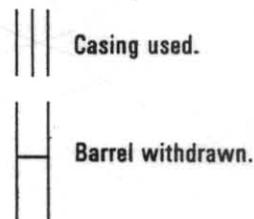
Notes: X on log is test result  
— is range of results.

### Density index

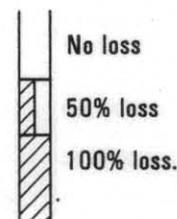
- |    |               |          |
|----|---------------|----------|
|    |               | %        |
| VL | Very loose.   | 0 - 15   |
| L  | Loose.        | 15 - 35  |
| MD | Medium dense. | 35 - 65  |
| D  | Dense.        | 65 - 85  |
| VD | Very Dense    | 85 - 100 |

## Cored borehole log

### Case - lift



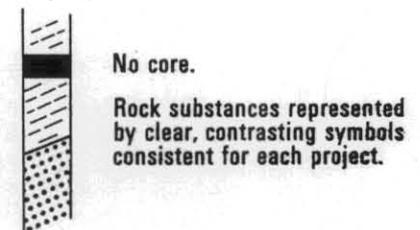
### Fluid loss



### Lugeons

Lugeon units ( $\mu\text{L}$ ) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of  $1 \times 10^{-4}$  mm/sec.

### Graphic log



### Weathering

- Fr Fresh.
- SW Slightly weathered.
- HW Highly weathered.
- EW Extremely weathered.

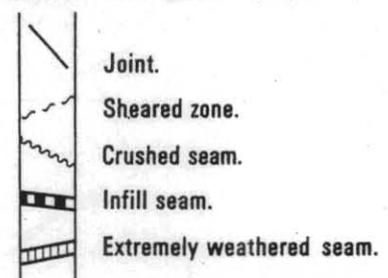
### Strength

- |    |                 |   |
|----|-----------------|---|
|    |                 | point load strength index $I_5(50)$ (MPa) |
| EL | Extremely low.  | < 0.03                                    |
| VL | Very low.       | 0.03 - 0.1                                |
| L  | Low.            | 0.1 - 0.3                                 |
| M  | Medium.         | 0.3 - 1                                   |
| H  | High            | 1 - 3                                     |
| VH | Very high.      | 3 - 10                                    |
| EH | Extremely high. | > 10                                      |

Note: X on log is test result.

### Significant defects

Significant defects shown graphically.





**ENGINEERING LOG – EXCAVATION**

excavation no. **2**  
sheet **1** of **1**

|   |   |
|---|---|
| project <b>VOS NOMINEES SUBDIVISION</b> | location <b>PLEASANT HILLS PHASE II</b> |
| co-ordinates                            | exposure type <b>test pit</b>           |
| R.L.                                    | equipment <b>Domino DIG</b>             |
| excavation dimensions                   | operator                                |
|   | pit commenced <b>27-5-87</b>            |
|   | pit completed <b>27-5-87</b>            |
|   | logged by <b>S. WELDON</b>              |
|   | checked by                              |

| penetration | support | water | notes samples, tests | metres R.L. depth | graphic log | classification symbol | material<br>soil type: plasticity or particle characteristics, colour secondary and minor components          | moisture condition | consistency density index | hand penetrometer kPa         | structure, geology |
|-------------|---------|-------|----------------------|-------------------|-------------|-----------------------|---|--------------------|---------------------------|-------------------------------|--------------------|
| 1 2 3       |         |       |                      |                   |             |                       |   |                    |                           | 25<br>50<br>100<br>200<br>400 |                    |
|             |         |       |                      | 0.20              |             | CH                    | CLAYEY TOPSOIL: high plasticity, dark brown MC > PL. rootlets highly weathered basalt boulders                | M                  | Fb                        |                               |                    |
|             |         |       |                      | 0.5               |             | CH                    | CLAY: high plasticity, MC & PL., roots some highly weathered basalt boulders to 250 mm                        | M                  | VSt                       |                               | H                  |
|             |         |       |                      | 0.85              |             | CH                    | CLAY: high plasticity, MC > PL. some roots and gravel (basalt) to 100 mm diameter red-yellow-brown            | M                  | VSt                       |                               | H                  |
|             |         |       |                      | 1.0               |             | CH                    | CLAY: high plasticity, MC > PL., yellow-brown, slightly to highly weathered basalt boulders to 400mm diameter | M                  | VSt                       |                               | H                  |
|             |         |       |                      | 1.40              |             |                       |   |                    |                           |                               |                    |

sketch

5 cm

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# ENGINEERING LOG - EXCAVATION

excavation no. **3**  
sheet **1** of **1**

|   |   |
|---|---|
| project <b>VDS NOMINEES SUBDIVISION</b> | location <b>PLEASANT HILLS PHASE II</b> |
| co-ordinates                            | exposure type <b>test pit</b>           |
| R.L.                                    | equipment <b>Domino DIG</b>             |
| excavation dimensions                   | operator                                |
|   | pit commenced <b>27-5-87</b>            |
|   | pit completed <b>27-5-87</b>            |
|   | logged by <b>B. WELDON</b>              |
|   | checked by                              |

| penetration | support | water | notes samples, tests | metres R.L. depth | graphic log | classification symbol | material<br>soil type: plasticity or particle characteristics, colour secondary and minor components                          | moisture condition | consistency density index | hand penetrometer kPa         | structure, geology |
|-------------|---------|-------|----------------------|-------------------|-------------|-----------------------|---|--------------------|---------------------------|-------------------------------|--------------------|
| 1 2 3       |         |       |                      |                   |             |                       |   |                    |                           | 25<br>50<br>100<br>200<br>400 |                    |
|             |         |       |                      | 0.20              |             | CH                    | TOPSOIL: high plasticity brown CLAY (M.C. > P.L.) with basalt boulders to 250mm   | M                  | Fb                        |                               |                    |
|             |         |       |                      | 0.5               |             | CH                    | CLAY: high plasticity, Moisture Content greater than plastic limit, rootlets, some slightly to highly weathered basalt gravel | M                  | VSt                       |                               |                    |
|             |         |       |                      | 0.80              |             | CH                    | CLAY: high plasticity, M.C. > P.L., brown-green, some basalt gravel   | M                  | VSt-M                     |                               |                    |
|             |         |       |                      | 1.0               |             | CH                    | CLAY: high plasticity, M.C. > P.L., brown-green, some basalt gravel   | M                  | VSt-M                     |                               |                    |
|             |         |       |                      | 1.25              |             |                       | BASALT: rock basement??   |                    | H                         |                               |                    |
|             |         |       |                      |                   |             |                       | END OF EXCAVATION   |                    |                           |                               |                    |

sketch

5 cm







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**ENGINEERING LOG – EXCAVATION**

excavation no. **7**  
sheet **1** of **1**

|   |   |
|---|---|
| project <b>VOS NOMINEES SUBDIVISION</b> | location <b>PLEASANT HILLS PHASE II</b> |
| co-ordinates                            | exposure type <b>test pit</b>           |
| R.L.                                    | equipment <b>Domino DIG</b>             |
| excavation dimensions                   | operator                                |
|   | pit commenced <b>27-5-87</b>            |
|   | pit completed <b>27-5-87</b>            |
|   | logged by <b>B. Weldon</b>              |
|   | checked by                              |

| penetration<br>1 2 3 | support<br>water | notes<br>samples,<br>tests | metres |       | graphic log | classification<br>symbol | material<br>soil type: plasticity or particle characteristics,<br>colour secondary and minor components | moisture<br>condition | consistency<br>density index | hand<br>penetr-<br>ometer<br>kPa | structure, geology                    |
|----------------------|------------------|----------------------------|--------|-------|-------------|--------------------------|---|-----------------------|------------------------------|----------------------------------|---------------------------------------|
|                      |                  |                            | R.L.   | depth |             |                          |   |                       |                              |                                  |                                       |
|                      |                  |                            |        | 0.20  |             | CH                       | TOPSOIL: highly plastic dark brown<br>CLAY with some basalt boulders to 300mm                           | M                     | St                           |                                  | R.P. 60-220 kPa<br><br>P.P. = 200 kPa |
|                      |                  |                            |        | 0.45  |             | CH                       | CLAY: highly plastic, brown, rootlets<br>Moisture Content > Plastic Limit                               | M                     | St-<br>Vst                   |                                  |                                       |
|                      |                  |                            |        | 0.5   |             | CH                       | CLAY: highly plastic, yellow-brown,<br>Moisture Content > Plastic Limit                                 | M                     | Vst                          |                                  |                                       |
|                      |                  |                            |        | 0.90  |             | GC                       | CLAYEY GRAVEL WITH BOULDERS,<br>medium to coarse size sub-angular<br>SW-NW basalt gravel with boulders  | M                     |                              |                                  |                                       |
|                      |                  |                            |        | 1.0   |             |                          |   |                       |                              |                                  |                                       |
|                      |                  |                            |        | 1.20  |             |                          |   |                       |                              |                                  |                                       |
|                      |                  |                            |        |       |             |                          | END OF EXCAVATION   |                       |                              |                                  |                                       |
|                      |                  |                            |        | 1.5   |             |                          |   |                       |                              |                                  |                                       |

sketch

5 cm







**ENGINEERING LOG - EXCAVATION**

excavation no. **11**  
sheet **1** of **1**

project **VOS NOMINEES SUBDIVISION** location **PLEASANT HILLS PHASE II**

co-ordinates exposure type **test pit** pit commenced **27-5-87**  
equipment **Domino DIG** pit completed **27-5-87**  
R.L. logged by **B. WELDON**  
excavation dimensions operator

| penetration<br>1 2 3 | support<br>water | notes<br>samples,<br>tests | metres |       | graphic log | classification<br>symbol | material<br>soil type: plasticity or particle characteristics,<br>colour secondary and minor components                            | moisture<br>condition | consistency<br>density index | hand<br>penetr-<br>ometer<br>kPa<br>25<br>50<br>100<br>200<br>400 | structure, geology |
|----------------------|------------------|----------------------------|--------|-------|-------------|--------------------------|--|-----------------------|------------------------------|---|--------------------|
|                      |                  |                            | R.L.   | depth |             |                          |  |                       |                              |   |                    |
|                      |                  |                            |        | 0.20  |             | CH                       | TOPSOIL: highly plastic, dark brown-red<br>CLAY M.C. > P.L.  | M                     | st                           |   |                    |
|                      |                  |                            |        | 0.50  |             | CH                       | CLAY: yellow brown highly plastic<br>M.C. > P.L. some fine lateritic gravel  | M                     | st                           |   |                    |
|                      |                  |                            |        | 0.60  |             | CH                       | CLAY: grey - highly plastic  | M                     | st                           |   |                    |
|                      |                  |                            |        | 0.70  |             | CH                       | CLAY: yellow-brown, highly plastic,<br>Moisture Content > Plastic Limit<br>some fine lateritic gravel and MW-SW<br>basalt boulders | M                     | st-<br>Vst                   |   |                    |
|                      |                  |                            |        | 1.0   |             |                          |  |                       |                              |   |                    |
|                      |                  |                            |        | 1.5   |             |                          |  |                       |                              |   |                    |
|                      |                  |                            |        | 2.0   |             |                          |  |                       |                              |   |                    |
|                      |                  |                            |        | 2.20  |             |                          |  |                       |                              |   |                    |
|                      |                  |                            |        | 2.5   |             |                          | END OF EXCAVATION  |                       |                              |   |                    |

sketch

5 cm