


**Division of Mines and Mineral Resources — Report 1990/20**
**Investigation of a landslide,  
Hone Road – Officer Street, Rosetta**
*by B. D. Weldon*
**Abstract**

Land in the Hone Road – Officer Street area of Rosetta is subject to landslide movement. Boulders of Jurassic age dolerite, Triassic age sandstone, siltstone, mudstone and carbonaceous shale, and Permian age siltstone/mudstone are present in a matrix of clay, sandy clay or silt. From the surface, the sequence of the boulders is reversed with respect to geological age. The materials are considered to be derived from an uplifted fault block to the southwest where brecciated Permian age siltstone/mudstone occurs.

Groundwater occurs near the boundary between materials derived mostly from Permian age rocks and materials derived mostly from Triassic age rocks. The groundwater is under pressure, with a hydrostatic head of at least 5.5 metres. A reduction of this pressure should decrease the rate of movement of the landslide.

Restraint of the landslide by driven piles is considered impracticable. Bored piles or a concrete buttress are possible alternatives. Feasibility studies of the economics of potential remedial measures are necessary. Additional subsurface investigations may be required.

**INTRODUCTION**

Previous investigations in the Hone Road – Officer Street area at Rosetta have established that damage to homes is due to landslide movement. Initial studies concluded that

movement is occurring at a depth beyond that which was initially investigated. Further investigations to greater depths were recommended and are the subject of this report.

**INVESTIGATION PROGRAMME**

Five boreholes were drilled at the locations shown on Figure 1. A summary of the borings is provided in Table 1. Engineering logs are provided in Appendix A. Standard Penetration Tests (SPT's) were performed at 1.5 m intervals as the holes were advanced.

**GEOLOGY**

With the exception of borehole 4, the sequence of materials encountered from the surface is in reverse order of geological age. This reverse order, and the nature of the materials recovered by the diamond drilling, suggests that the materials are either ancient landslide deposits or materials which have accumulated in a depression adjacent to an uplifted fault block. The latter is considered more likely.

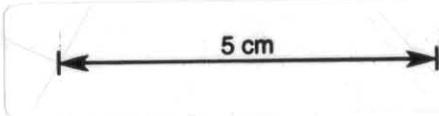
Vertical movement on faults is generally considered to be in the order of 1–5 metres during any one event, but a multiple number of events may result in tens to hundreds of metres of movement over geological time. The width of faults varies and may be narrow or occupy a wide zone. The author is not aware of any reports of earthquake

**Table 1. Summary of bore holes, Hone Road–Officer Street area, Rosetta**

BORE	LOCATION	DRILLING METHOD	AGE OF ROCKS FROM WHICH MATERIALS ARE DERIVED		
			PERMIAN	TRIASSIC	JURASSIC
1	12 Hone Rd	auger & roller tricone	0–17 m	17–21.45 m	
2	8 Hone Rd	roller tricone	0–14 m	14–40 m	
3	7 Officer St	roller tricone	0–9 m	9–13.83 m	
4	15 Hone Rd	diamond	0–8.4 m		
5	12 Hone Rd	roller tricone & diamond	0–17.5 m	18.0–21.5 m	17.5–18 m & 21.5–22.0 m



Figure 1. Location of boreholes, Hone Road area, Rosetta.



activity (which is associated with faulting) in the Rosetta area since European settlement of Tasmania.

The inferred fault line is approximately parallel to the line of Hone Road and occurs between Hone Road and the rear boundary of the homes on the upslope side of the road. Material exposed in the paddock behind these homes appears to be moderately to steeply dipping, brecciated Permian age siltstone/mudstone which is considered to be *in situ*.

It would appear that ground to the southwest of Hone Road has been uplifted, with bedding drag resistance along the fault line. This accounts for the moderate to steep dip of the Permian age siltstone/ mudstone which occurs on the ridge line behind the homes. As uplifting occurred, erosion and weathering processes would have operated on the uplifted materials resulting in spalled debris from the fault block accumulating on the lower ground. A wedge-shape deposit of boulders, some possibly larger than a medium size car, would have therefore accumulated along the fault line. A matrix of clay, silt, sand and gravel-size materials would have accumulated between the boulders. It has not been established whether these materials accumulated in a sub-aerial or sub-aqueous environment.

In Borehole 5 there are slickensided defects within boulders. These are clay-lined surfaces between fractures in the rock. The slickensides show distinct lineations and have a polished, shiny appearance due to alignment of the clay particles. This alignment is caused by friction (pressure) generated during movement of the rock mass. The slickensides may be related either to the faulting of the original rock mass or to subsequent landslide activity.

### HYDROLOGY

Some moisture was present on the Standard Penetration Test (SPT) sample at 18.45 m depth in Borehole 1. The materials at this depth are derived from Triassic age rocks. A sandy material was encountered in the SPT sample at 19.5 m depth and this was wet. The water is under pressure, and rose in the borehole to 12.5 m below ground level. There is a hydrostatic head of at least 7 metres in this borehole. Borehole 2 was dry to 40.0 m depth. The borehole was generally a "duster", with dust from the borehole settling over everything within a 10 m radius of the drill site. Periodically, the dust would diminish during the drilling, perhaps indicating zones which were moist.

Borehole 3 encountered moisture at 8.0 m depth in materials derived from Permian age rocks. Again, the water was under pressure and quickly rose to 2.5 m below surface level. There is a hydrostatic head of 5.5 metres in this borehole. Borehole 4 was drilled with mud as a drilling fluid. The borehole remained full for several days after completion, but this is no measure of the tightness of the rock. The drilling mud tends to seal the hole and this sealing effect gradually deteriorates with time.

Borehole 5 was completed by diamond drilling, using mud as a drilling fluid. Measurements of the volume of fluid at the commencement of drilling and on completion indicate a loss of 300 litres. This includes the fluid remaining in the borehole on completion of the drilling.

Reference to Table 2 shows that water was encountered in Boreholes 1 and 3 at a similar level, and that the standing water level shortly after drilling was also at a similar level. Significantly, the materials in which the water was encountered are derived from Triassic age rocks in Borehole 1 and from Permian age rocks in Borehole 3. There is thus unlikely to be any stratigraphic correlation between the water-bearing ground in these boreholes. However, the intersections of groundwater are close to the boundary between materials derived predominantly from Permian age rocks and those derived predominantly from Triassic age rocks. This is considered to indicate a change in the hydraulic characteristics between the materials derived from the two distinct rock ages. For this reason, the groundwater intersections are likely to be interconnected and therefore probably indicate a continuous groundwater table.

Table 2. Water level measurements, Boreholes 1 and 3

Bore	Elevation (m RL)	Depth water struck (m RL)	Standing water level (m RL)
1	97.17	78.72	84.67
3	86.91	78.91	84.41
Difference	10.26	-0.19	0.26

### FAILURE MECHANISM

In Borehole 5, a slickensided defect occurs in a clayey matrix containing fine to medium-size sandstone and carbonaceous shale gravel at about 18 metres below ground level. The defect is sloping at about 50° from the horizontal (about 40° from the vertical). The core was not orientated so that there is no control over the direction in which the defect dips. It is tempting to assume that the dip direction is towards the River Derwent. This defect is considered to be unrelated to faulting, and is the most shallow defect on which movement through the matrix materials can be demonstrated in this hole.

The defect mentioned above is unlikely to be the only failure surface. The defect dips steeply and if it is a planar feature (and there is no guarantee that this is so), the plane will not intersect the ground surface. Should the dipping defect intersect a much flatter defect at depth beneath the slope, landslide movement is much easier to explain.

There is insufficient evidence to conclusively demonstrate the failure mechanism. Steeply-sloping defects on which past movement has occurred are present. The orientation of these is uncontrolled. Groundwater is present under the slope and the groundwater is under pressure with a hydrostatic head of at least 5.5 metres.

### RESISTIVITY SURVEY

A resistivity sounding survey has been conducted in the paddock behind the homes in Hone Road. Computer modelling of the field results indicates a surface layer with apparent high resistivity (200 ohm-metres) which gradually falls to a lower apparent resistivity of 20 Ωm at three metres depth. The gradual change indicates a deterioration in the condition of the rock, as confirmed by an examination of materials recovered from Borehole 4.

Constant, short electrode spacing resistivity traverses have also been conducted along the side property boundaries of 11-19 Hone Road. These traverses generally show a decrease in apparent resistivity from the rear boundary of the properties in a NNW direction towards the street frontage. This is interpreted as indicating an increasing clay content in the sub-surface materials in a NNW direction. Alternatively, the rock content (or quality) deteriorates away from the rear boundaries of these properties. This is consistent with other observations in the area.

**MONITORING PROGRAMME**

A survey line has been established along Hone Road. The line consists of a series of nails driven into the pavement at regular intervals. The line extends beyond the area where movement is considered to be occurring and will serve to provide long-term measurements of the gross movement of the area. Variations greater than 2 mm from the previous measurements are likely to be real, but smaller variations are within the error range of the technique used and no significance should be placed on these. It is stressed that the purpose of the survey line is to monitor movement in the long term.

A prototype data logger installation has been operational at 15 Hone Road for some time now. The prototype installation has shown deficiencies in the method of installing the linear position sensors. This has now been modified and the sensors appear to be operating effectively. The monitoring programme has been expanded to include linear position sensors at 13 and 17 Hone Road and a rain gauge. The purpose of the installations is to monitor movement of individual cracks with the intent of detecting any acceleration in the rate of movement. Such changes may be related to rainfall events, possibly with a time lag, and need to be critically evaluated.

The data collected to date is presented in Appendix B and graphically shows that movement is continuing to occur. The network of monitors will be completed in the near future to include a water depth sensor in Borehole 3. This will increase our ability to relate rainfall events, groundwater levels and rates of movement.

**REMEDIAL MEASURES**

Borehole 4 was sited in order to examine the quality of the rock behind 13-17 Hone Road. The borehole encountered Permian age materials which are brecciated (i.e. fragmental rock whose components are angular). Although the borehole was terminated at a relatively shallow depth of 8.40 m below ground level, the material is considered to have formed in a fault zone, rather than having been deposited by weathering or mass wasting processes. The interim report suggestions on remedial measures considered that rock bolts could be installed and the portion of the foundations of these homes which have failed could be supported on a platform secured to the rock bolts. The quality of the rock encountered suggests that the ground would need to be reinforced by grouting (under pressure) prior to installing rock bolts.

Borehole 3 was sited towards the presumed toe area of the landslide. The failure plane was expected to occur closer

to the surface in this area than further upslope. The drilling method used in this borehole only provided cuttings or chips of rock fragments. Therefore it has not been possible to determine where the failure plane occurs in this borehole.

A common method of stabilising landslides is to provide some form of restraint in the toe area. Piles, driven below the failure plane, are commonly used. Because of the rocky nature of the materials present, it is unlikely that piles could be driven into the ground. Ground vibrations would also be generated. There is a possibility that liquefaction on the failure plane or zone may occur. Bored piles are probably significantly more expensive to install but would eliminate these difficulties.

An alternative to piling the toe area is to provide a mass concrete buttress founded below the failure plane. There is insufficient information to evaluate the founding depth of such a structure and additional drilling investigations would be necessary.

Toe restraints will not be immediately effective in preventing ground movement. Movement will be diminished but not totally cease until the moving mass compresses against the restraint and re-consolidates.

The release of the hydrostatic head may provide the most effective means of decreasing the rate of movement. This could be attempted by boring sub-horizontal holes beneath the slope, possibly radiating out from the vacant lots at 26 and 32 Crosby Road. Sub-horizontal drainage has been attempted elsewhere in Tasmania with mixed success. Deviation of the drilling bit from the intended line of drilling often occurs, particularly where boulders are present (as in this case). Unconsolidated materials will often collapse in the hole once the drilling stem has been withdrawn prior to installation of the drainage pipe. It is stressed that drainage may not be a complete solution in itself, but if achieved effectively it is likely to reduce the rate of landslide movement.

**PROCLAMATION UNDER SECTION 431A OF THE LOCAL GOVERNMENT ACT**

The Governor may, by Order-in-Council made on the recommendation of the Director of Mines, declare any area of a municipality which is subject to the danger of earth movement as a landslip area. One of the purposes of such a proclamation is to control the erection of or additions to a building or structure. The effect of the proclamation is: *where buildings and structures are erected in an area after it has been properly registered as a proclaimed area, the Crown will give no compensation or other relief for any damage caused by earth movement to such buildings or structures.* After an area has been properly registered following an Order-in-Council, the titles or deeds of the property within the proclaimed area are endorsed with the Order-in-Council. This serves as a warning to future prospective purchasers that the land is in an area subject to landslide. This is the other main purpose of the proclamation.

As part of the proclamation process, excepting emergency proclamations, the Director of Mines must notify the corporation (in this case the Glenorchy City Council)

before he makes a recommendation to the Governor-in-Council. The corporation is required to give notice to the owners of all land in the proposed area of the proclamation. An owner or occupier of land in the proposed area may, within 30 days after the corporation has given notice in respect of his land, object to the proposed recommendation in writing to the Director of Mines who shall not proceed with his recommendation until he has considered such objections and any report or evidence sent therewith.

The above has been provided because of enquiries from local residents. The Director of Mines has not yet given consideration to a recommendation but may do so at some future date.

**CONCLUSIONS**

The inferred failure plane occurs 18 m below ground level at Borehole 5 and is probably deeper than 8 m below ground level at Borehole 3.

Groundwater is present under pressure. A reduction in hydrostatic head by drainage should result in a decrease in the rate of landslide movement.

The quality of rock behind 13-17 Hone Road is such that grouting would appear to be necessary to reinforce the rock mass prior to the installation of rock bolts. A feasibility study of the economics of grouting and installing the rock bolts is required.

The lack of detailed subsurface data in the toe area of the landslide precludes firm recommendations on possible toe restraint remedial measures. Driven piles are considered impracticable as they are unlikely to penetrate the rock which is expected to overlie the failure plane in this area.

A feasibility study into the economics of alternative toe restraint remedial measures is required. Such a study may be hampered by the lack of detailed subsurface data regarding the foundation depth for bored piles or a mass concrete buttress. Additional subsurface investigations may be required.

[10 August 1990]

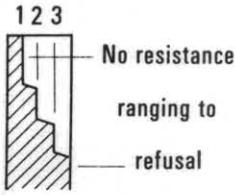
## APPENDIX A

## Engineering logs of drill holes

Bore	Easting	Northing	Reduced level (m)
1	520477.8	5258764.3	97.17
2	520428.7	5258756.6	102.38
3	520461.2	5258838.7	86.91
4	520440.0	5258693.9	107.13
5	520472.6	5258755.3	98.6

# EXPLANATION SHEET FOR ENGINEERING LOGS

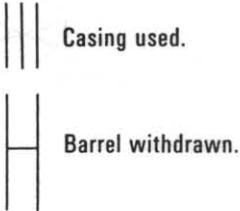
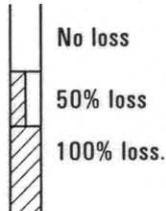
## Borehole and excavation log

<b>Penetration</b> 	<b>Water</b> 	<b>Notes - samples and tests</b> U50 Undisturbed sample 50mm diameter. D Disturbed sample. N Standard penetrometer blow count for 300mm. N* SPT + sample.	<b>Material classification</b> Based on Unified Soil Classification System. In Graphic Log materials are represented by clear contrasting symbols consistent for each project.
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<b>Moisture content</b> 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.	<b>Consistency</b> VS Very soft. S Soft. F Firm. St Stiff. VSt Very stiff. H Hard. Fb Friable.	hand penetrometer (kPa) < 25 25 - 50 50 - 100 100 - 200 200 - 400 > 400	<b>Density index</b> VL Very loose. 0 - 15 L Loose. 15 - 35 MD Medium dense. 35 - 65 D Dense. 65 - 85 VD Very Dense 85 - 100
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Notes: X on log is test result  
 — is range of results.

## Cored borehole log

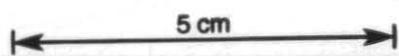
<b>Case - lift</b> 	<b>Fluid loss</b> 	<b>Lugeons</b> Lugeon units (µL) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of $1 \times 10^{-4}$ mm/sec.	<b>Graphic log</b>  No core. Rock substances represented by clear, contrasting symbols consistent for each project.
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<b>Weathering</b> Fr Fresh. SW Slightly weathered. HW Highly weathered. EW Extremely weathered.	<b>Strength</b> EL Extremely low. VL Very low. L Low. M Medium. H High. VH Very high. EH Extremely high.	point load strength index $I_{5(50)}$ (MPa) < 0.03 0.03 - 0.1 0.1 - 0.3 0.3 - 1 1 - 3 3 - 10 > 10	<b>Significant defects</b> Significant defects shown graphically. 
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# ENGINEERING LOG - BOREHOLE

project <b>HONE RD ROSETTA</b>		location <b>12 HONE RD</b>	
co-ordinates	drill type <b>GEMCO</b>	hole commenced	
R.L.	drill method <b>auger + roller kri-cone</b>	hole completed	
inclination <b>vertical</b>	drill fluid <b>air</b>	drilled by <b>G. BAKER</b>	
bearing		logged by <b>B. WELDON</b>	
		checked by	

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
			0		GC	GRAVELLY CLAY: dark grey medium plasticity clay with medium gravel size fragments of Permian mudstone siltstone, some sandy fines	D			Rock fragments derived from Permian qtz rocks. SPT samples often show high primary porosity (which may be due to disturbance by gravel fragments).
		SPT 17 26 24	1.50 1.92		GC	as above	M	D- VD		
			2							
		SPT 12 29 21	3.00 3.36		GC	as above but lighter grey colour	M	D- VD		
			4							
		SPT 9 25 20	4.50 4.95		GC	as above but with yellow-brown and grey clay	M	D		
			5							
		SPT 23 28 22	6.00 6.45		GC	as above but light grey-brown clay and fawn/buff coloured mudstone/siltstone rock fragments with dark grey medium to high plasticity clay between some rock fragments	M	D- VD		
			7							
		SPT 23 25 25	7.50 7.89		GC		M	D- VD		
			8							
		SPT 12 26 24	9.00 9.43		GC	as above	D	D- VD		
			10							



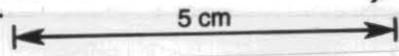
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# ENGINEERING LOG - BOREHOLE

project <b>HONE RD ROSETTA</b>	location <b>12 HONE RD</b>
co-ordinates	drill type <b>GEMCO</b>
R.L.	drill method <b>auger + roller tri-cone</b>
inclination <b>vertical</b>	drill fluid <b>air</b>
bearing	hole commenced
	hole completed
	drilled by <b>G. BAKER</b>
	logged by <b>B. WELDON</b>
	checked by

penetration 1 2 3	support water	notes samples, tests	metres		graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
			R.L.	depth							
				10							
		SPT 20 25 25		10.50		GC	GRAVELLY CLAY: yellow-brown medium plasticity clay with medium gravel size fragments of Permian age siltstone/mudstone with dark gray high-medium plasticity clay between some rock fragments	D	D-VD		
				10.95							
				11							
		SPT 13 18 25		12.00		GC	fawn-brown moist, medium-high plasticity clay at 13.30 m depth	D	D		
				12.45							
				13							
		SPT 11 13 27		13.50		GC	GRAVELLY CLAY: as above but light grey clay in colour	D	D		Rock fragments mostly derived from Permian age rocks
				13.95							
				14							
		SPT 15 24 26		15.00		GC	as above	D	D-VD		
				15.42							
				16							
		SPT 10 11 15		16.50		GC	as above but with some medium to light brown clay and sandstone, siltstone + carbonaceous shale rock fragments derived from Triassic age rocks	D	MD		
				16.45							
				17							
		SPT 8 9 12		18.00		GC	CLAYEY SAND: fine grained fawn to light yellow sand with some clay fines	M	MD		some iron staining on rock fragments
				18.45							
				19							
		SPT 21 34 16		19.50		SC	Rock fragments derived from Triassic age rocks	M	D-VD		
				19.60							

NIL - ROLLER TRI-CONE

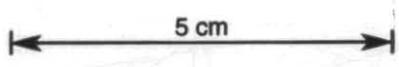


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ENGINEERING LOG - BOREHOLE

project <b>HONE RD ROSETTA</b>	location <b>12 HONE RD</b>
co-ordinates	drill type <b>GEMCO</b>
R.L.	drill method <b>auger + roller tri-cone</b>
inclination <b>vertical</b>	drill fluid <b>air</b>
bearing	hole commenced
	hole completed
	drilled by <b>G. BAKER</b>
	logged by <b>B. WELDON</b>
	checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material 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 50 100 200 400	
				20		GC	GRAVELLY CLAY: grey-orange / dark brown clay with fine-medium size sub-rounded gravel of sandstone, carbonaceous shale in a sandy clay matrix. Rock fragments derived from Triassic age rocks.				One carbonaceous shale rock fragment has lineations and shiny surfaces.
			SPT 14 21 29	21.00 21.45		GC		M	DVD		
							END OF BOREHOLE				



ENGINEERING LOG - BOREHOLE

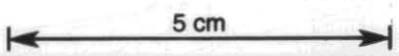
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project **HONE RD ROSETTA** location **8 HONE RD**

co-ordinates \_\_\_\_\_ drill type **GEMCO** hole commenced \_\_\_\_\_  
 drill method **roller tri-cone** hole completed \_\_\_\_\_

R.L. \_\_\_\_\_ drill fluid **air** drilled by **G. BAKER**  
 inclination **vertical** logged by **B. WELDON**  
 bearing \_\_\_\_\_ checked by \_\_\_\_\_

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
				0		GC	GRAVELLY CLAY: gray-brown medium plasticity clay with sub angular - sub rounded medium gravel size fragments of rock derived from Permian age rocks; some silt and sand fines.				Rock fragments derived from Permian age rocks
			SPT 6 10 18	1.50		GC	as above: medium grey colour mudstone/siltstone rock fragment	M	MD		
				2							
			SPT 5 7 9	3.00		GC	as above: medium grey-brown colour.	M	MD		
				3.45							
				4							
			SPT 6 9 11	4.50		GC	as above: light grey - light brown colour.	D	MD		
				4.95							
				6.00							
			SPT 10 21 29	6.42		GC	as above: grey colour	D	D- VD		
				7							
			35 SPT 30 -	7.50		GC	as above: light grey - light brown	D	D- VD		
				7.75							
				8							
				9.00			medium grey clay				
			SPT 13 24 26	9.44		GC	SILTY GRAVELLY CLAY: medium grey, light grey some yellow-orange colour	D	D- VD		
				10							



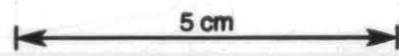
ENGINEERING LOG - BOREHOLE

12/26

project HONE RD ROSETTA location 8 HONE RD

co-ordinates drill type GEMCO hole commenced  
 drill method roller kr.-cone hole completed  
 R.L. drill fluid air drilled by G. BAKER  
 inclination vertical logged by B. WELDON  
 bearing checked by

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material 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 50 100 200 400	
				10		GC	SILTY GRAVELLY CLAY: light grey, some orange-brown, medium to low plasticity clay, medium size gravel derived from Permian age rocks (mudstone - siltstone)	D	D-VD		Permian age rock fragments
			SPT 18 37 10	10.50 10.86							
				11							
			SPT 35 15 -	12.00 12.21		GC	as above: cream-brown-grey colour	D	VD		
				13							
			SPT 12 23 25	13.50 13.95		GC	as above: orange-brown to brown colour, mottled white in places (? feldspar).	D	D-VD		
				14							
			SPT 12 26 24	15.00 15.44		GC	GRAVELLY CLAY: orange-brown to cream colour, layered structure, some white mottles. Possibly extremely weathered Triassic siltstone-mudstone	D	D-VD		
			SPT's dis-continued	16							
				17		SC	SANDY CLAY: brown - orange brown colour, medium plasticity, medium size quartz sand, some feldspar (derived from Triassic age sandstone).				Triassic age rock fragments
				18							
				19		SC	as above but light brown in colour				
				20							



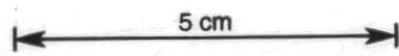
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borehole no. 2  
sheet 3 of 4

# ENGINEERING LOG - BOREHOLE

project	HONE RD - ROSETTA	location	8 HONE RD
co-ordinates		drill type	GEMCO
R.L.		drill method	roller tricone
inclination	vertical	drill fluid	air
bearing		hole commenced	
		hole completed	
		drilled by	G. BAKER
		logged by	B. WELDON
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
				20		SC	SANDY CLAY: orange-brown, medium plasticity, some light grey clay, sand size grains ~ 30%	D			Triassic age rock fragments
				21							
				22			as above, dark grey, some light grey + brown colours. (Dark grey material is a carbonaceous shale)	D			
				23							
				24							
				25		SC	SANDY CLAY: medium plasticity, colour of chips varies considerably from light grey - dark grey - green/grey - mauve	D			
				26							
				27							
				28			green-brown + light grey colour	D			
				29			mauvish colour, some green clay + orange-brown to dark brown clay.	D			
				30							



# ENGINEERING LOG - BOREHOLE

4/26

project	HONE RD ROSETTA	location	8 HONE ROAD
co-ordinates		drill type	GEMCO
R.L.		drill method	roller tricone
inclination	vertical	drill fluid	air
bearing		hole commenced	
		hole completed	
		drilled by	G. BAKER
		logged by	B. WELDON
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
				30	#	Dark grey carbonaceous shale with some mauve & green coloured siltstone / mudstone	D			Triassic age rocks - possibly in situ
				31	#					
				32	#					
				33	#	SILTSTONE-MUDSTONE - light green-grey with some brown medium plasticity clay	D			
				34	#	SILTSTONE-MUDSTONE - light grey to grey-green colour	D			
				35	#					
				36	#	SILTSTONE-MUDSTONE: medium grey to brown colour.	D			
				37	#	CARBONACEOUS SHALE: dark grey-black colour, thinly bedded shale with some lighter grey mudstone / claystone.	D			
				38	#					
				39	#					
				40	#	as above.				

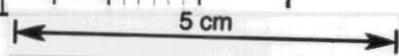
END OF BOREHOLE 5 cm

ENGINEERING LOG - BOREHOLE

15/26

project	HONE RD ROSETTA	location	7 OFFICER ST
co-ordinates		drill type	GEMCO
R.L.		drill method	Roller tri-cone
inclination	vertical	drill fluid	Air
bearing		hole commenced	
		hole completed	
		drilled by	G. BAKER
		logged by	R. WELDON
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
				0			GRAVELLY CLAY: brown, light grey dark grey mudstone siltstone fine- medium gravel size rock in a medium plasticity clay matrix. Sand fines. fawn colour				Permian age rock fragments.
			SPT 19 36 14	1.50		GC	as above: light grey - brown colour	D	D- VD		
				2							
			SPT 26 40 10	3.00		GC	as above:	D	D- VD		
				4							
			SPT 4.50 6.60	4.50		GC	as above:	D	VD		
				5			grey with brown iron staining on chips of siltstone + mudstone				
			SPT No penetration	6.00					VD		
			SPT 40 35 15	7.00		GC	as above	D	D- VD		
			SPT 35 26 24	7.37		GC	as above grey + brown siltstone	M- W	D- VD		
				8.00							
			SPT >50	8.45		GC	as above medium grey siltstone with some brown mudstone/sandstone derived from TRIASSIC age rock	W	D- VD		
				9							
			SPT 9.50 9.71	9.50		GC					
				9.71							
				10							



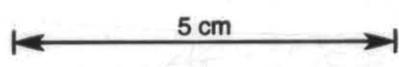
ENGINEERING LOG - BOREHOLE

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project **HONE RD ROSETTA** location **7 OFFICER ST**

co-ordinates \_\_\_\_\_ drill type **GEMCO** hole commenced \_\_\_\_\_  
 drill method **Roller tri-cone** hole completed \_\_\_\_\_  
 R.L. \_\_\_\_\_ drill fluid **Air** drilled by **G. BAKER**  
 inclination **vertical** logged by **B. WELDON**  
 bearing \_\_\_\_\_ checked by \_\_\_\_\_

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa	structure, geology
				10							
			SPT 21 35 15	10.50 10.85		GC	GRAVELLY CLAY: light grey medium - high plasticity clay with brown sandstone - siltstone (Triassic age) gravel (medium size).	W	VD		shiny surfaces on some rock fragments ? slickensides
			SPT 20 26 24	12.00 12.44		GC	as above: light grey - brown colour with quartz pebble	W	VD		Triassic age rock fragments
			SPT 20 30 15	13.50 13.83		GC	as above: yellow-brown, sand fines	W	VD		slickensides



# ENGINEERING LOG - CORED BOREHOLE

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borehole no.

4

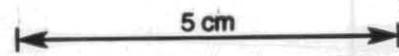
sheet 1 of 1

17/26

project	HONE RD ROSETTA	location	15 HONE RD
co-ordinates		drill type	GEMCO
R.L.		drill method	NQ DT
inclination	vertical	drill fluid	mud
bearing		hole commenced	
		hole completed	
		drilled by	G. BAKER
		logged by	B. WELDON
		checked by	

drilling information				rock substance			rock mass defects		
case-lift	fluid loss	water	notes	lugesons	metres	substance description	strength	defect spacing	defect description
				0.3 1 3 10 30 100	R.L. depth	rock type: grain characteristics, colour, structure, minor components.	weathering	30 100 300 1000 3000	thickness, type, inclination, planarity, roughness, coating.
							EL VL L M H VH EH		significant general
					0	CORE LOSS			
					0.35	GRAVELLY SILTY CLAY: topsoil, grey, medium size gravel in silty matrix			
					0.80	CORE LOSS			
					0.90	GRAVELLY SILTY CLAY: as above			
					1	SILTSTONE - MUDSTONE: sub-angular brecciated fragments of grey to brown siltstone-mudstone. Bedding plane partings or lineations commonly dip at about 30° from the horizontal. Where brecciation is intense, materials are soil like.			joint at 30° to vertical
					1.67				
					2				
					2.60				
					3				
					3.67				
					4.10				joint at 30° to vert
					5				
					5.50	CORE LOSS			
					6.00	SILTSTONE - MUDSTONE: as above			
					6.50				
					7.00	CORE LOSS			
					7.10				
					8.07	SILTSTONE - MUDSTONE: - as above			joint at 40° to vert Subvertical joint
					8.40				
						END OF BOREHOLE			

Defects are commonly joints at between 30-50° from the vertical within brecciated rock fragments & commonly 30-40° through entire diameter of core. The defects are commonly lined with a dark grey clay. Subvertical & subhorizontal joints are less common.



**ENGINEERING LOG - CORED BOREHOLE**

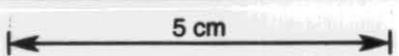
18/26

project **HONE RD ROSETTA** location **12 HONE RD**

co-ordinates drill type **GEMCO** hole commenced  
 R.L. drill method **NQDT** hole completed  
 inclination **vertical** drill fluid **mud** drilled by **G. BAKER**  
 bearing logged by **B. WELDON**  
checked by

drilling information				rock substance				rock mass defects				
case lift	fluid loss	water	notes	lugesons	metres	graphic log	substance description rock type: grain characteristics, colour, structure, minor components.	weathering	strength	defect spacing	defect description	
				0.3 1 3 10 30 100	R.L. depth				EL V L M H VH	30 100 300 1000 3000	significant	general
					0		<p>Previous auger drilling in this area encountered gravelly materials (derived from Permian age rocks) in a silty clay matrix</p>					
					1							
					2							
					3							
					4							
					5							
					6							
					7							
					8							
					9							
					9.50							
					9.94		<p><b>CORE LOSS</b></p> <p><b>SLOPE DEBRIS: sub angular rock fragments in silty matrix</b></p>					

Roller tricone no sampling



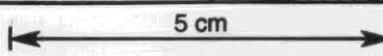
ENGINEERING LOG - CORED BOREHOLE

19/20

drilling information				rock substance				rock mass defects				
case-lift	fluid loss	water	notes	lugesons	metres	graphic log	substance description	weathering	strength	defect spacing mm.	defect description	
				0.3 1 3 10 30 100	R.L. depth		rock type: grain characteristics, colour, structure, minor components.	EL VL L H VH EH	30 100 300 1000 3000		thickness, type, inclination, planarity, roughness, coating. significant general	
project HONE RD ROSETTA location 12 HONE RD co-ordinates R.L. inclination vertical bearing drill type GEMCO drill method NQDT drill fluid mud hole commenced hole completed drilled by G. BAKER logged by B. WELDON checked by												
			Rock fragments derived from Permian age siltstone-mudstone		10		CORE LOSS					
					10.74							
					10.95		SLOPE DEBRIS - see below					
					11.32		CORE LOSS					
					11.44		SLOPE DEBRIS - see below					
					11.63		CORE LOSS					
					12.00		SLOPE DEBRIS: sub-angular to subrounded fine to coarse size gravel fragments of Permian age rock in a silty clay matrix					
					12.50							
					12.60		CORE LOSS					
					13.00		SLOPE DEBRIS: as above					
				13.58		CORE LOSS						
				14		SLOPE DEBRIS: see above						
				14.50								
				14.70		CORE LOSS						
				15		SLOPE DEBRIS: sub-angular to subrounded fine to coarse size gravel fragments of Permian age rocks in a silty clay matrix.						
				16.00								
				17.10		CORE LOSS						
				17.50		SLOPE DEBRIS: as above						
				17.65		CORE LOSS						
			Rock fragments derived from Triassic age sediments		18		SLOPE DEBRIS: sub-angular boulders of Jurassic age dolerite and Triassic age sandstone (fine-medium grain size) in a clayey matrix with silt and sand fines and medium to coarse gravel size rock fragments derived from Triassic age rocks (siltstone, carbonaceous slate).	MW			dolerite boulder slickensided defect through matrix dolerite boulder	
					19.00				MW			
									MW			sandstone boulder
					20				MW			sandstone boulder

Many rock fragments are coated with a dark grey high plasticity clay. A brown clay is also present but does not occur on joints within the rock fragments.

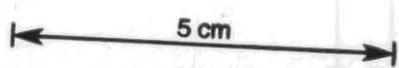
Rock fragments are often jointed & the joints lined with slickensided clay (30-40° from vertical)



# ENGINEERING LOG – CORED BOREHOLE

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drilling information				rock substance				rock mass defects				
case-lift	fluid loss	water	notes	lugesons	metres	graphic log	substance description	weathering	strength	defect spacing mm.	defect description	
				0.3 1 3 10 30 100	R.L. depth		rock type; grain characteristics, colour, structure, minor components.		E V L M H VH EH	30 100 300 1000 3000	thickness, type, inclination, planarity, roughness, coating.	
											significant	general
			Rock fragments derived from Triassic age sediments & Jurassic age dolerite		20 20.50 21 22.00		<p>SLOPE DEBRIS: red-brown consolidated clay containing silt and sand size grains possibly of weathered rock (? dolerite).</p> <p>dolerite boulder, green-grey with slickensides at various angles</p>	<p>HW MW SW</p>			dolerite boulder	<p>Slickensided joints common through rock fragments. Lineations suggest multiple directions of movement.</p>
							END OF BOREHOLE					



## APPENDIX B

### Data logger monitoring programme

A prototype data logger installation was established at 15 Hone Road, initially with four linear position sensors. These were monitored for performance (events A to B). The initial set up of the linear position sensors was defective in that insufficient surface area was provided for the probes to rest against. This resulted in erratic data plots (see 15 Hone Road — pillar). This has now been corrected. Two linear position sensors were attached to 17 Hone Road and connected to the logger at event C. A rain gauge was also connected to the installation at event C. Two linear position sensors are installed at 13 Hone Road as a separate installation.

The probes were set at mid-range of their travel so as to detect widening or closure of the gap in cracks. When the probe reaches the end of its travel it is necessary to install

a spacer and reset the probe. This has already happened at 15 Hone Road — slab and wall X (event D). The probe on wall X at 13 Hone Road also needs to be reset.

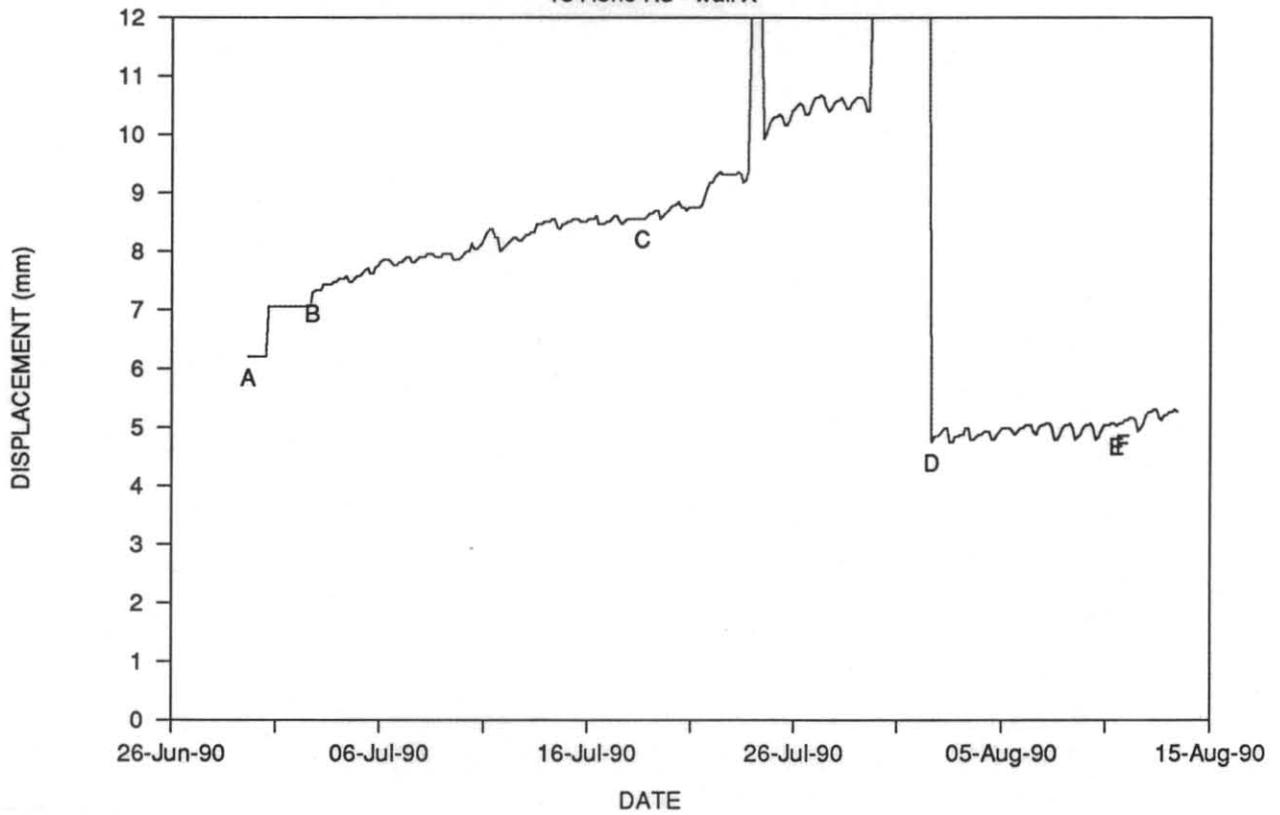
The logger at 15 Hone Road was loaded with a program which gave it incorrect instructions for recording rainfall (events C to E). This has now been corrected (event F).

The network of detectors will be completed in the near future to include a water level probe in Borehole 3.

The results collected to date are presented here graphically. Daily variations due to thermal expansion and contraction of the walls or the materials comprising the installations can be detected in the overall trend of the widening gaps.

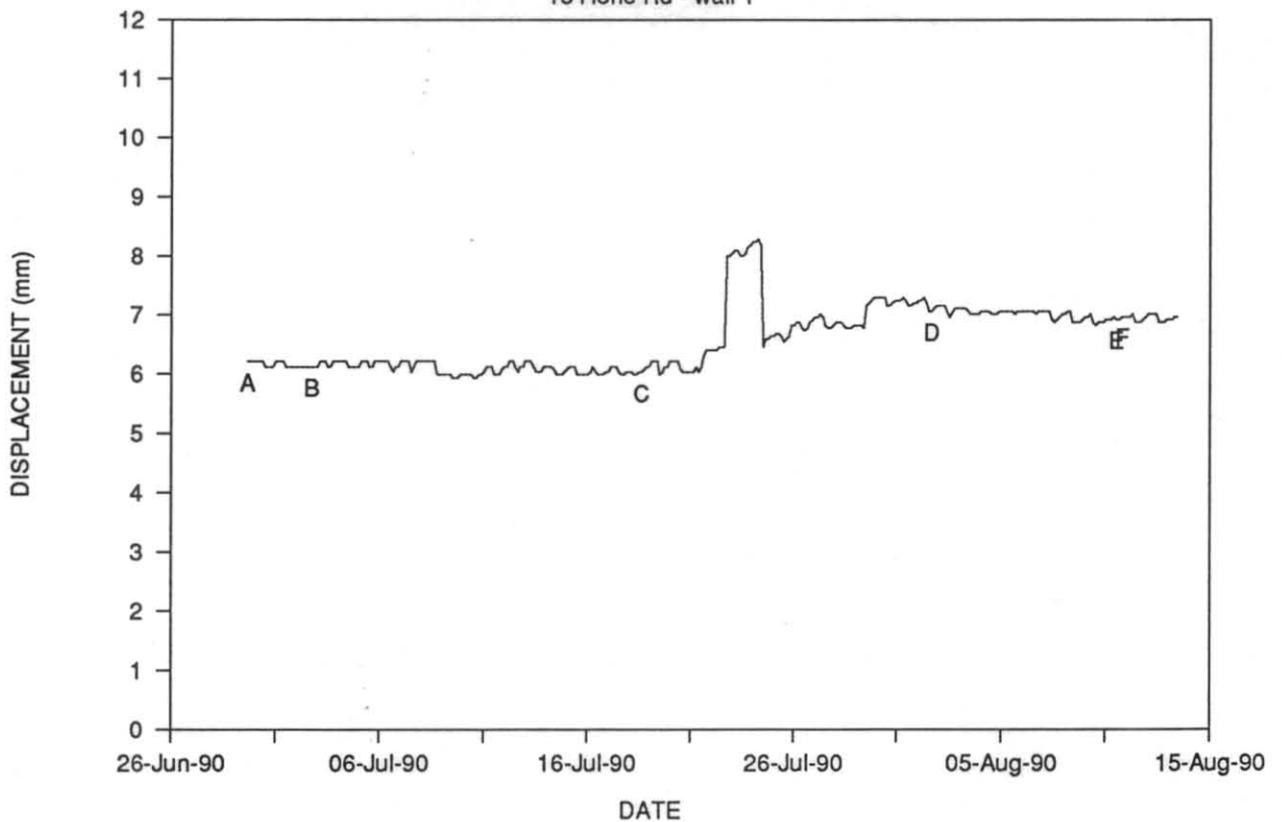
### Landslide Monitoring Station

15 Hone Rd - wall X



### Landslide Monitoring Station

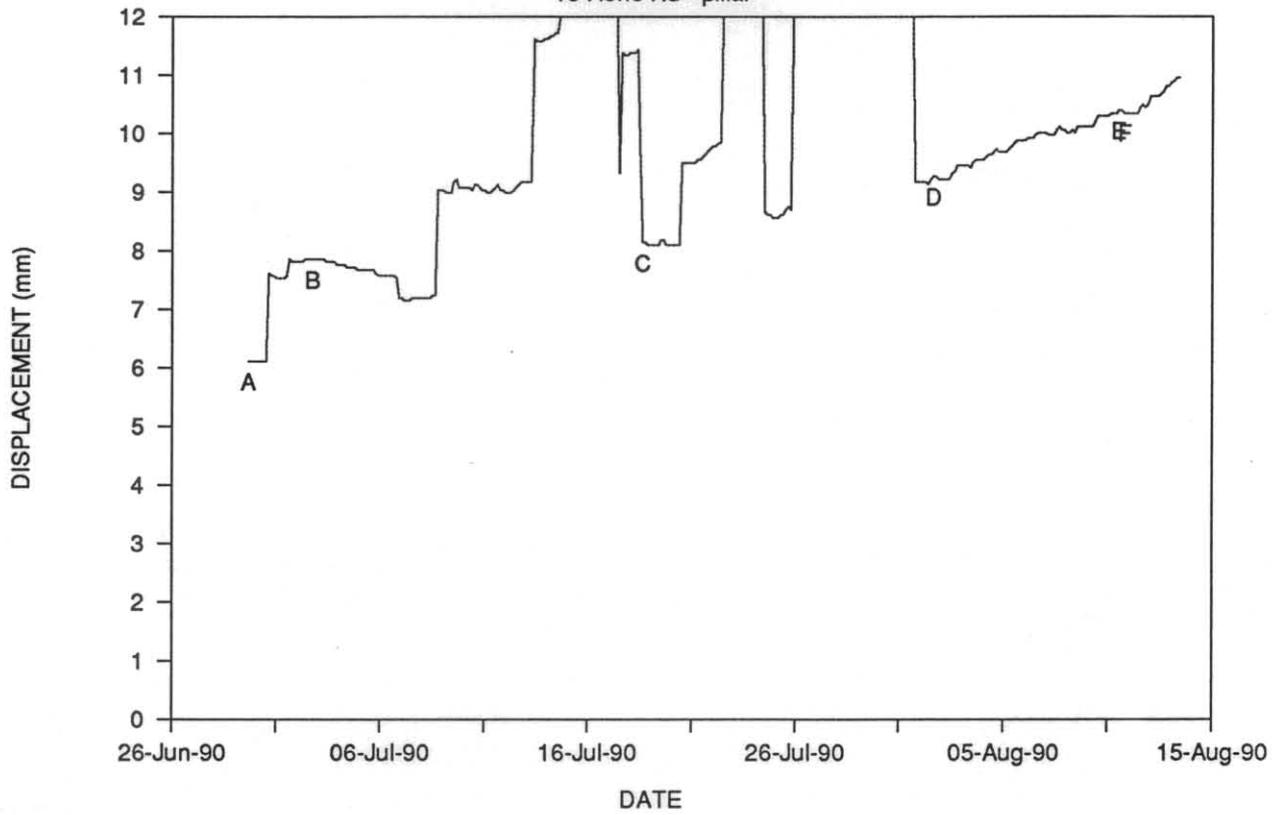
15 Hone Rd - wall Y



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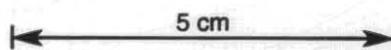
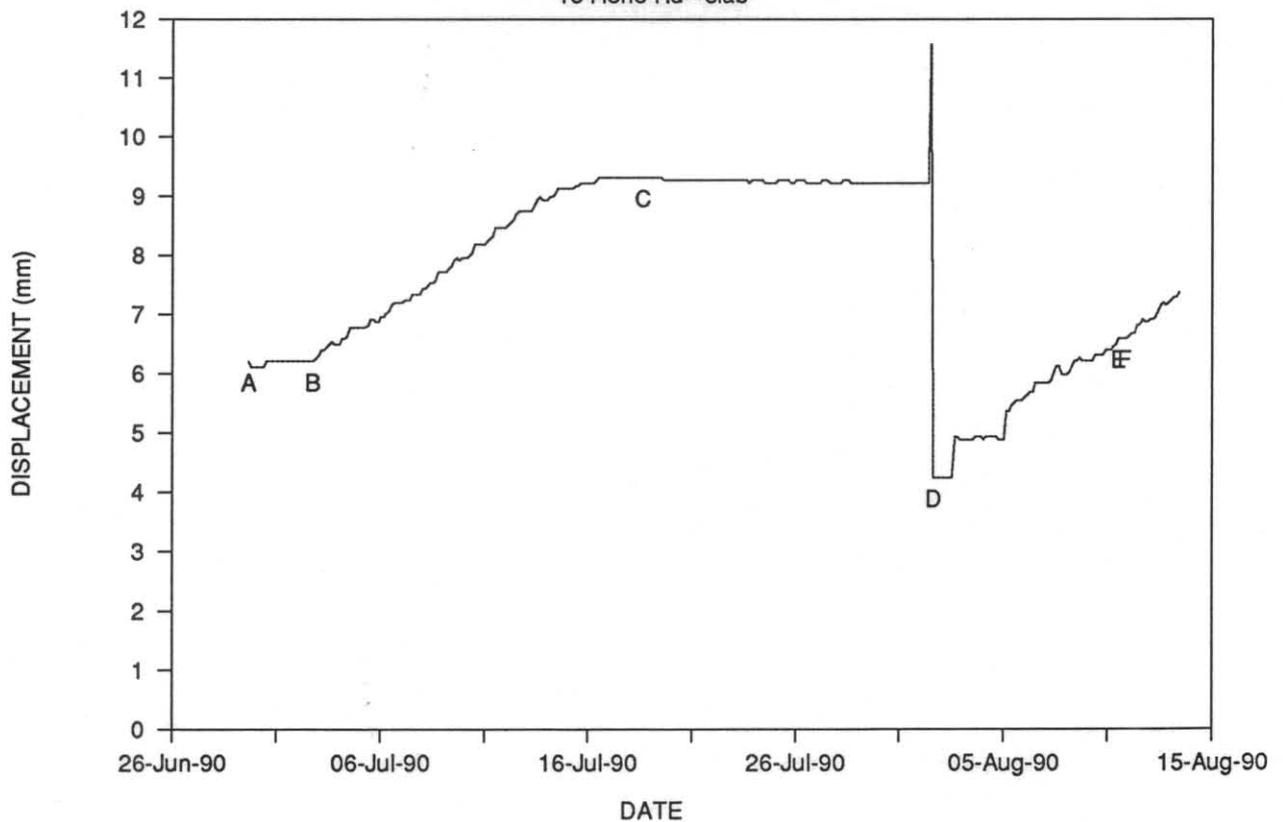
### Landslide Monitoring Station

15 Hone Rd - pillar



### Landslide Monitoring Station

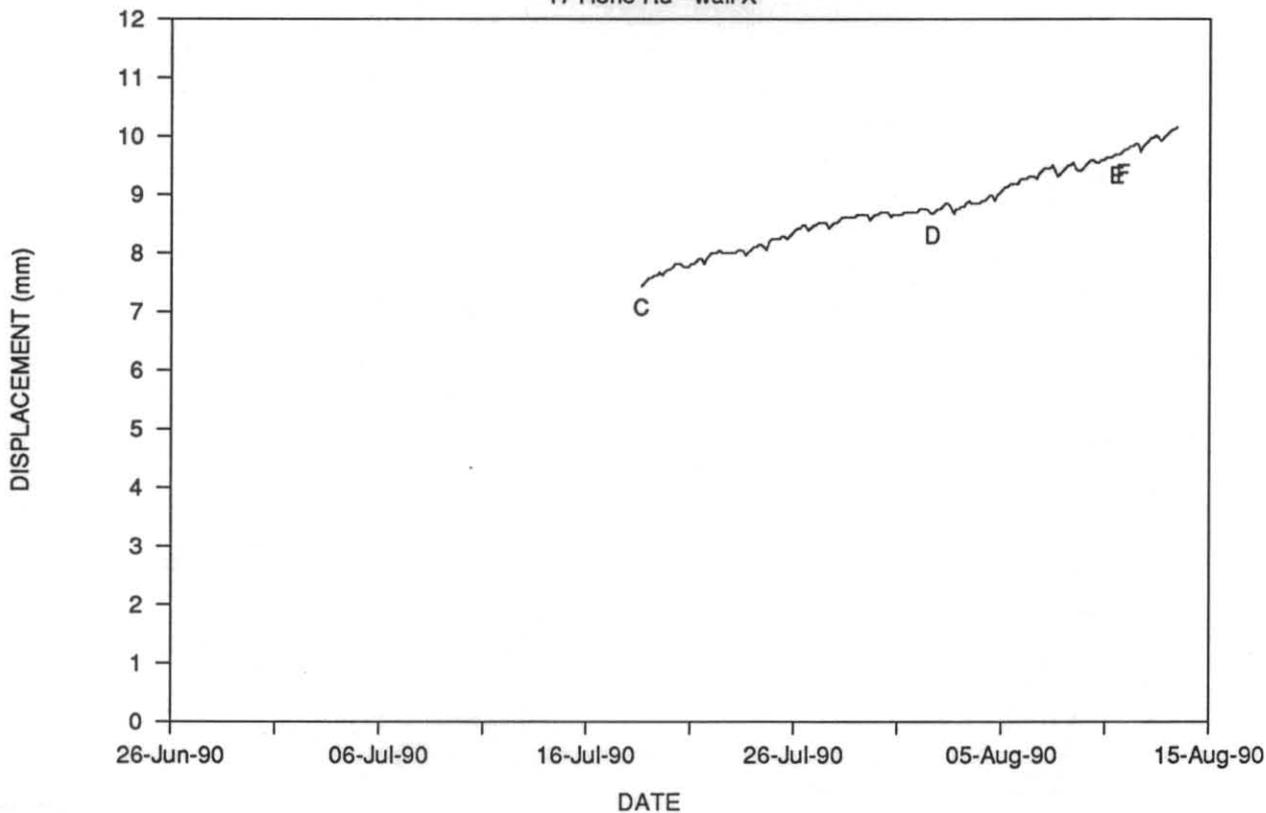
15 Hone Rd - slab



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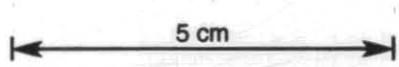
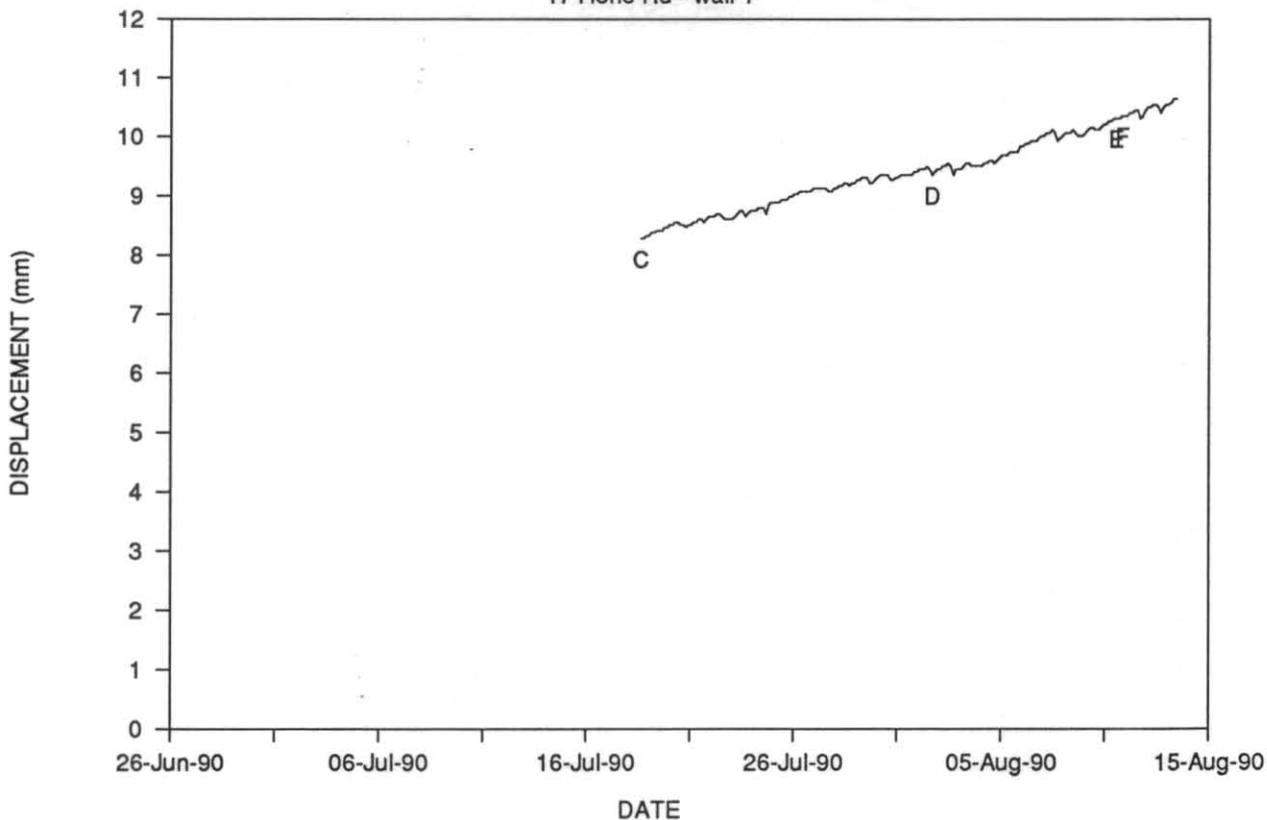
### Landslide Monitoring Station

17 Hone Rd - wall X



### Landslide Monitoring Station

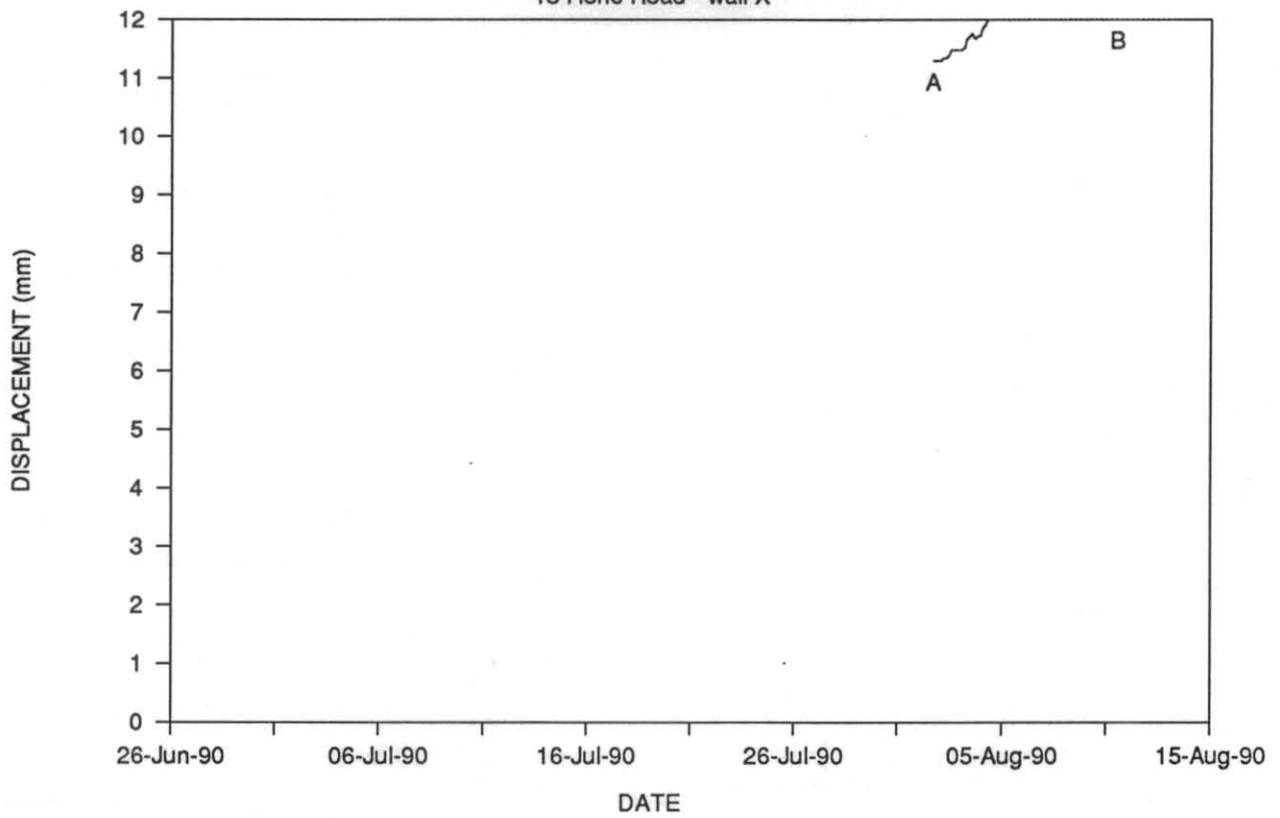
17 Hone Rd - wall Y



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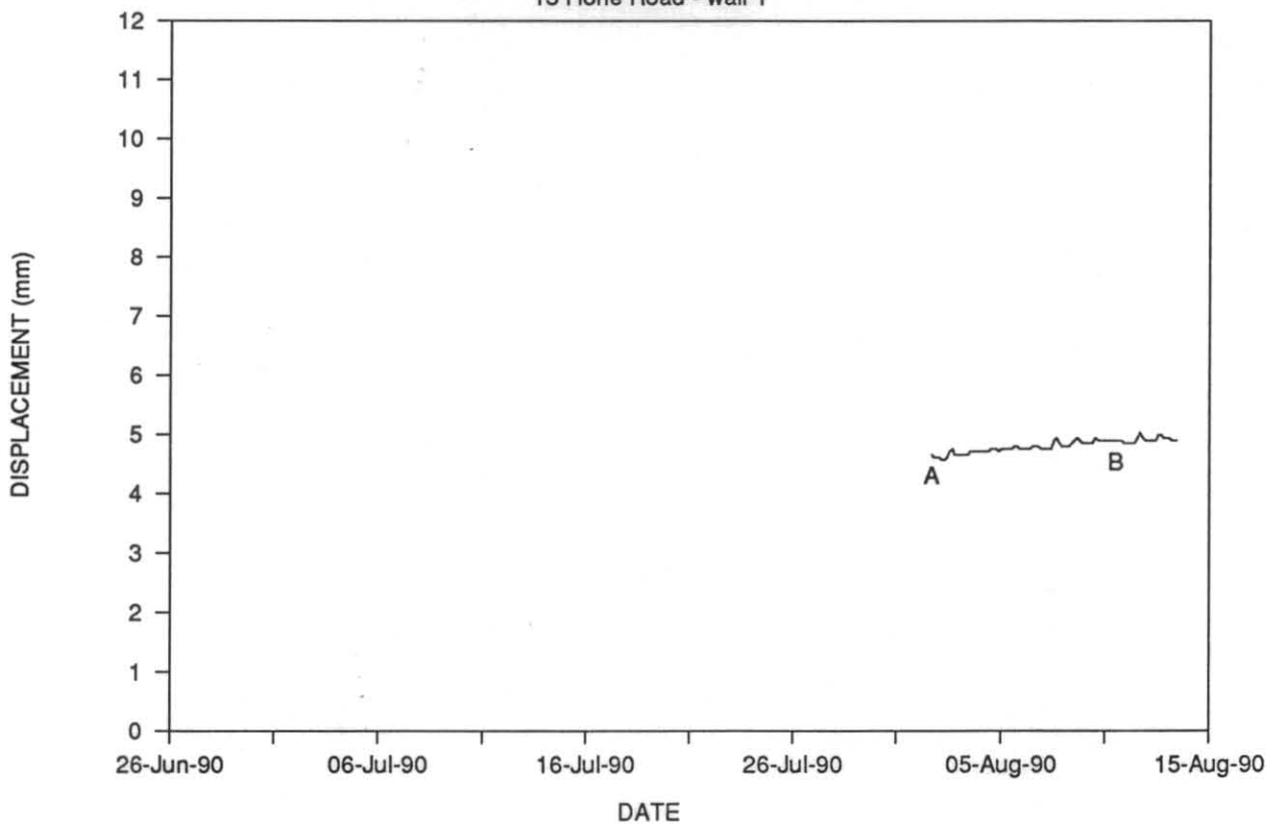
# Landslide Monitoring Station

13 Hone Road - wall X



# Landslide Monitoring Station

13 Hone Road - wall Y



# Landslide Monitoring Station

Hone Road - rainfall guage

