A landslip investigation on the toe area of an old landslip at McEwans Road, West Tamar.

C.J. Knights

Abstract

McEwans Road is situated on a valley slope which extends from the basalt plateau at 160 m to the shoreline of the River Tamar. The valley is eroded in Tertiary lacustrine sediments, which are capped by a layer of basalt. Talus overlies much of the slope.

Large landslips have been active throughout the valley slope, but they are very old and appear to be stable under present-day conditions. Smaller parasitic landslips, shallow slumps and cutting failures occur today on sections of the old landslips where there are oversteepened slopes and on previously weakened zones of slippage.

The area investigated by drilling is on the toe of a large, very old, slip. The sediments dip downslope and there is a subsurface layer of soft to semi-liquid material which indicates a previous slip plane.

In these soft materials saline water under a high piezometric head reduces the effective frictional strength of the clay. Stability analysis indicates that stability of the site is very tenuous.

1977/47. A landslip investigation on the toe area of an old landslip at McEwans Road, West Tamar.

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McEwans Road is situated on a valley slope which extends from the basalt plateau at 160 m to the shoreline of the River Tamar. It probably extends 30-60 m below the present water level, although in recent times this has backfilled with silt. The valley is eroded in Tertiary lacustrine sediments which are capped by a layer of basalt. Talus overlies much of the slope, and there may be small intrusions of basalt in the sediments. Large landslips have been active throughout this valley slope, but they are very old, and appear to be stable in the present environmental conditions. Smaller landslips, shallow slumps and cutting failures occur to-day on sections of the old landslips, where there are oversteepened slopes, and on the previously weakened zones of slippage. The old structures form steep scarps and hollows (fig. 1). The area investigated by drilling, and which is on the toe of a sequence of large old landslips, is outlined in Figure 1.

There are a number of minor scarps which are particularly evident in aerial photographs (fig. 2). At the time of drilling (1974) there was no evidence of recent instability, but subsequently the road along the Tamar foreshore (Rosevears Drive) has failed extensively.

DRILLING RESULTS

Materials

The results of the drilling are summarised in Figure 3 and detailed bore logs are given in Appendix 1. In general there is a variable sequence of oxidised clay, with a minor grey clay, overlying grey plastic clay. Black carbonaceous clay and lignite underlie this sequence.

There is a tendency for the red and brown oxidised clay to be crumbly, less plastic and more sandy than the grey clay, which is stiff and very plastic. Atterberg limits for these materials are high (LL 75-120, PI 53-97). Further work on the composition and properties of these clays is in preparation by W.L. Matthews.

The sediments dip downslope: there is a particularly rapid drop between Holes 4 and 9, which may be due to dip, or to a failure or fault scarp. Hole 8 has a totally different sequence of materials. From the surface to 5.5 m very wet red clay and gravel were encountered yet only 2 m away these are absent. Below this depth oxidised clay, overlying grey plastic clay was found. The wet gravelly material is interpreted as being the infilling of a fissure, the fissure probably being formed during landslip movement.

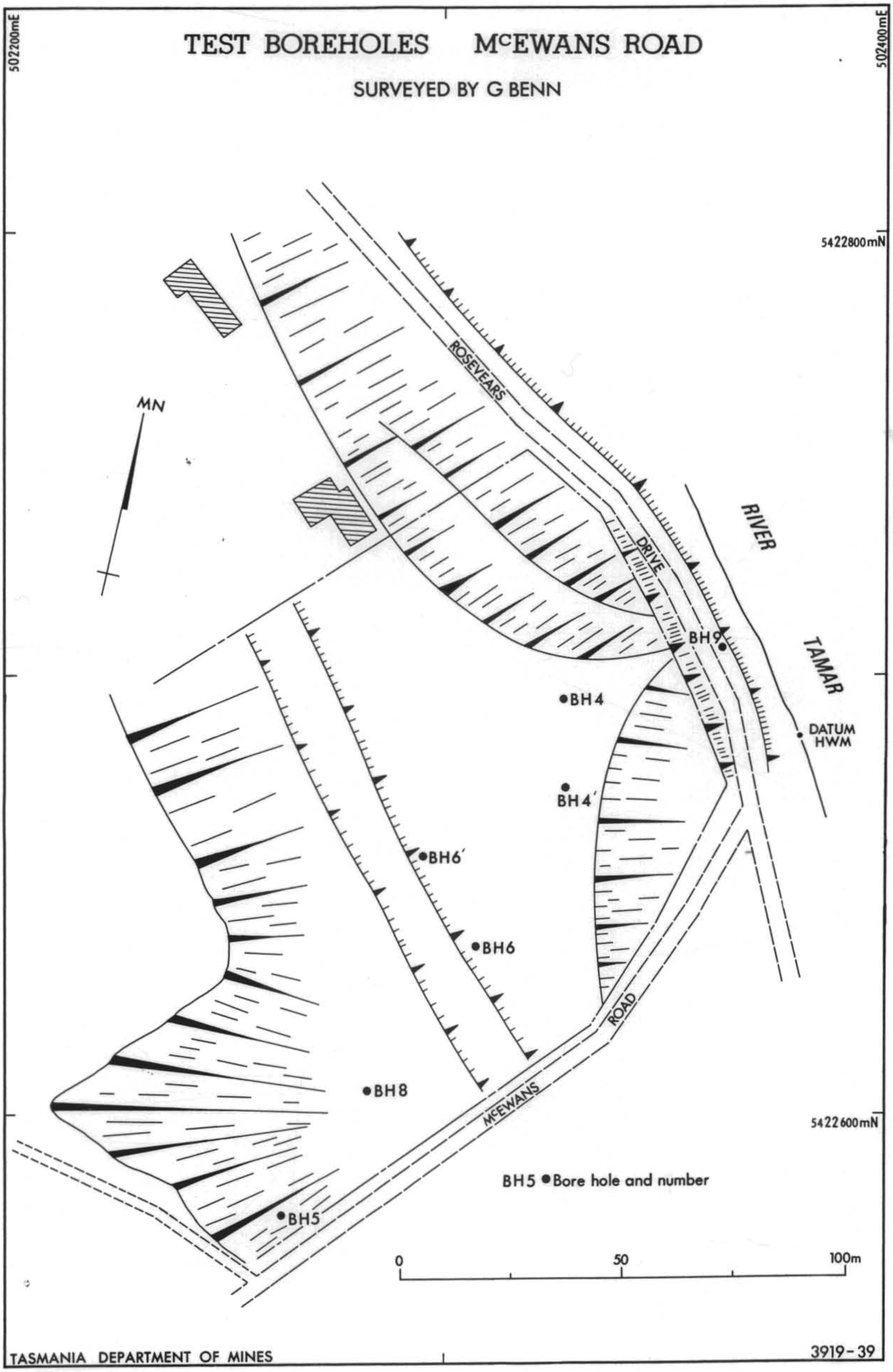
About 100 m up-slope of Hole 5, Hole 7 was drilled through predominately strong, oxided, sandy clay terminating at 8.2 m in dry gravelly clay. Although softish clay was found at 4.5-5.4 m there was no free water.

Free water was encountered in all holes except 7 and 9. In Hole 5 water came into the hole towards the base of the oxidised clay, in fairly firm materials, and with a piezometric head of about 2 m. As discussed above, Hole 8 appears to have been drilled into a localised, backfilled and very wet fissure. Hole 6 was drilled through rather soft, oxidised clay to a depth of 8.2 m. Water entered the hole near this depth, with a head of 5.2 m.

LANDFORM MAP SHOWING OLD LANDSLIP STRUCTURES ON THE HILL SLOPE NEAR McEWANS ROAD
GEOLOGIST: C.J. KNIGHTS
RIVER
TAMAR
N
ROSEVEARS DRIVE
McEWANS ROAD
WEST TAMAR HIGHWAY
10
20
30
40
50
60
70
80
7
House
7 Borehole and number
Scarp
Old slip
Area investigated by drilling
0
100
200
300m
TASMANIA DEPARTMENT OF MINES
4157-39

Figure 1

5 cm



502200mE
502400mE
TEST BOREHOLES McEWANS ROAD
SURVEYED BY G BENN
5422800mN
5422600mN
MN
ROSEVEARS
DRIVE
RIVER
TAMAR
DATUM HWM
BH9
BH4
BH4'
BH6'
BH6
BH8
BH5
ROAD
McEWANS
BH5 • Bore hole and number
0
50
100m
TASMANIA DEPARTMENT OF MINES
3919-39

Figure 2

5 cm

In Holes 4 and 4′ water first entered the hole through fine sand seams (observed in an undisturbed sample) at the base of the oxidised clay at 5.7 m. Below this the clay becames very soft, and the hole ended in almost liquified (well above liquid limit) carbonaceous clay and lignite. The head of water is 6.4 m above the base of the hole.

There was no free flowing water in Hole 9, but the top 3.5 m of clay was soft, and there was slight seepage.

Seasonal fluctuation of piezometric head are minimal near the base of the slope in Hole 4, but become larger up-slope and reach 0.9 m in Hole 5. Piezometric pressures are discussed in more detail by Knights (1977).

Salinity of the deep groundwater is high, indicating that the water has travelled through and leached the Tertiary sediments for a considerable distance. Chemical analyses of the groundwater are given in Appendix 2.

LANDSLIP POTENTIAL

Drilling has revealed a sub-surface zone of very weak to weak materials upon which the upper materials may slip. These weak materials possess low inherent cohesive strength, especially the materials found in Holes 4 and 4′ which are wetter than the liquid limit. Also, the groundwater in this soft zone is under a high piezometric head, so that the effective frictional resistance of the clay is severely reduced.

The near-liquid carbonaceous clay and lignite found in Holes 4 and 4′ strongly suggest that there has been slip movement, and that this is the disrupted material near the basal slip planes. Such very soft sub-surface material may also indicate that dispersion processess are active. Deep, localised wet gravels in Hole 8, which have been interpreted as a fissure infilling, also suggests past landslip movement. The form of this landslip is shown in Figure 3.

STABILITY ANALYSIS

Analysis of the stability of the feature was undertaken by the method of Bishop (1955), using the dimensional parameters described above and measured piezometric pressures. For a factor of safety of 1, the parameters $c' = 0$ and $\phi' = 16^{\circ}$ are required.

In view of the wetness of the clay, and probable previous movement it is reasonable to assume that cohesion equals zero. There are no laboratory test results for the angle of friction of the clay at this site. In practice a reasonable frictional value could only be obtained from several tests, to include the various materials intercepted by the failure surface.

Assessment of the stability of this land by analysis depends on the residual angle of friction of the clays. $\phi'_r = 16^{\circ}$ is actually a rather higher value than is found in other Tamar clays, therefore it appears that the stability of this site is very tenuous.

CONCLUSIONS

The area investigated by drilling is located on the toe of a large, very old slip.

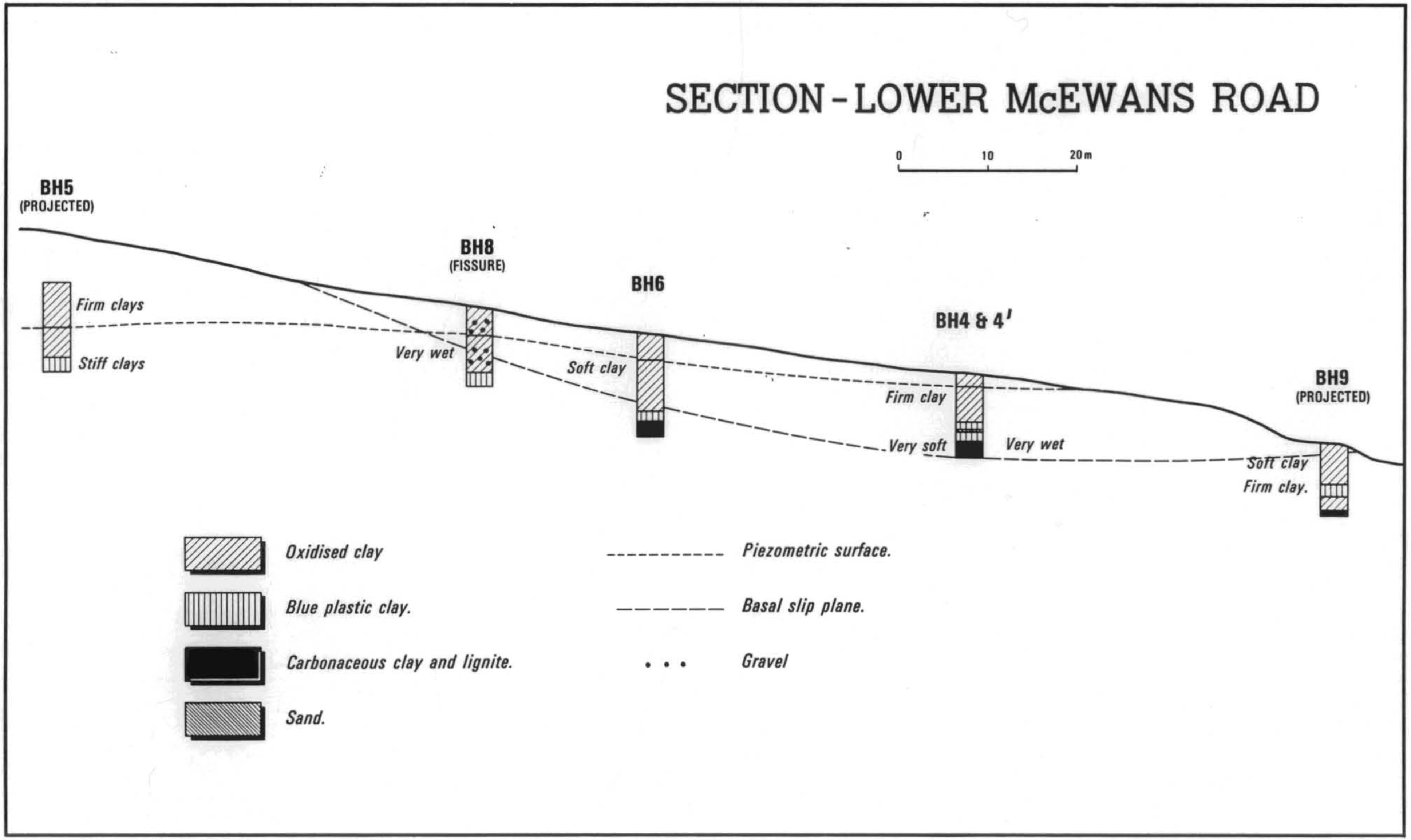


Figure 3 *Section, Lower McEwans Road.*

5 cm

47-5

6/10

The sediments dip downslope. There is a sub-surface zone of soft to very soft material which indicates previous disturbances and slip movement (fig. 3). In the soft material saline water under a high piezometric head reduces the effective frictional strength of the clay. Stability analysis indicates that stability of the site is tenuous.

[28 November 1977]

APPENDIX 1

Bore logs

Hole	*Depth (m)*	*Description*
4, 4′		Collar elevation: 11.30 m
	0-0.9	Plastic fawn and red clay.
	0.3-1.8	Grey and orange clay with ironstone fragments.
	1.8-2.7	Firm, rather fragmental grey and orange clay.
	2.7-3.6	As above, some red crumbly clay and some soft damp red-brown clay.
	3.6-4.5	Stiff grey clay mixed with softer brown clay.
	4.5-5.5	Stiff blue clay.
	5.7-6.4	Clay with sandy laminae (with water). Water rose overnight to 1.3 m below surface.
	6.4-7.3	Soft clay, orange and grey (mainly the former).
	7.3-8.2	Very soft black carbonaceous clay, with gritty lignite fragments.
5		Collar elevation 22.25 m
	0-1.8	Mottled orange and grey, silty, fissured clay.
	1.8-4.5	Friable clay, dry, grey and yellow, some very plastic.
	4.5-5.4	Less friable red clay.
	6.3-7.2	Fragmental silty clay. Some firm grey, some softer red-brown.
	6.3-7.2	Fawn crumbly clay, water.
	7.2-8.2	As above.
	8.2-9.8	Very plastic grey clay with some harder orange oxidised clay. Much ironstone in gravel sized fragments.
6		Collar elevation 14.02 m
	0-0.9	Fairly stiff red-brown plastic clay with ironstone fragments.
	0.9-1.8	Fragmented, soft, red, grey and orange mottled clay.
	1.8-2.7	Soft orange silty clay, with grey flecks.
	2.7-3.6	As above but paler.
	3.6-4.5	Soft, fawn silty clay, with a consistency of soft plasticine.
	4.5-5.5	Moderately stiff orange silty clay with ironstone fragments 13 mm in diameter.
	5.5-6.4	Silty orange crumbly clay with nodules of stiff grey plastic clay.
	6.4-7.3	Orange and grey fragmental clay. A soft patch felt when drilling.
	7.3-8.2	Soft red clay with nodules of stiff grey clay.
	8.2-9.2	Water. Stiff grey clay with gritty ironstone fragments.
6′	9.2-11	Clay becomes dark and carbonaceous.
7		Position: north side of restaurant property, *c.* 100 m upslope from BH5.
	0-0.9	Mottled red and brown clay.
	0.9-1.8	Very hard, comes up as coarse orange rock dust; dry. Probably ironstone.
	1.8-2.7	Plastic on wetting.
	2.7-3.6	Firm, red and brown silty clay with grey laminations.
	3.6-4.5	As above.
	4.5-5.4	Soft orange clay and sand particles.

Hole	Depth (m)	Description
7	6.4-7.3	As above.
	2.3-8.2	Fine clayey gravel with larger quartz pebbles.
		Hole remained dry after 24 hours.
8		Collar elevation: 17
	0-0.9	Soft, brown, gritty clay.
	0.9-1.8	Very soft, wet, gravel and mud.
	1.8-2.7	As above, then clayey material, orange and grey, soft.
	2.7-3.4	Firm, fawn and grey clay.
	3.4-3.6	Red clay and quartz gravel fragments.
	3.6-4.5	Red, sandy clay with grey clay flecks and black grit fragments.
	4.5-5.4	Fairly soft, adheres to auger very soft, wet, red gravelly clay.
	5.4-6.4	Firm red and grey, sandy laminated clay with some very soft patches.
	6.4-7.3	As above.
	7.3-8.2	Very stiff grey clay with brown patches, polished surfaces.
		Water level 3.05 m after drilling. Sample 5.
9		Collar elevation: ∿ 2.4 m
	0-0.45	Fill.
	0.45-1.3	Crumbly dark red sandy clay with ironstone gravel.
	1.3 -1.8	Damp gravelly red clay.
	1.8 -2.7	As above, some grey clay seams.
	2.7 -3.6	Soft, fawn gravelly clay with grey seams.
	3.6 -4.6	Laminated fawn and grey clay with quartz gravels passing into grey very plastic clay.
	4.6 -5.5	Plastic stiff, blue clay with shiny surfaces.
	5.5 -6.4	Fragmental grey and fawn clay with hematite band.
	6.4 -7.3	Mixed grey plastic and red crumbly clay with yellow quartz pebbles and ironstone.
	7.3 -8.2	As above, passing into dark, plastic, carbonaceous clay.
		Water seepage into hole.

APPENDIX 2

Chemical analyses of groundwater.

Item analysed	*Borehole 4´*	*Borehole 6´*
pH	8.1	7.5
	ppm	*ppm*
CO_3	nil	nil
HCO_3	300	790
Cl	4250	4600
SO_4	55	14
SiO_2	14	6.3
Ca	280	370
Mg	700	870
Fe	<0.1	<0.1
Al	<0.2	<0.2
K	6.3	10
Na	1560	1560
T.D.S.	7670	8530
Calculated		
E.S.P.	13.4	12.1