UR1976_42

1976/42. Drilling at Casuarina Crescent, Glenorchy.

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A detailed account of ground movements at Casuarina Crescent, Glenorchy was given by Stevenson (1976). A drilling programme was recommended to examine subsurface conditions in the slip area.

A preliminary programme involving the drilling of four holes was undertaken on 29 and 30 April 1976. It is to be appreciated that there are inherent technical difficulties in selecting suitable drilling sites in residential areas on relatively steep slopes. Thus the positioning of the bore holes was partly pre-determined by accessibility to the slip area. Bore Holes 1-3 were sited in order to examine the nature and variability of the subsurface materials, the position of movement planes, and the groundwater conditions existing within the slip area. Bore Hole 4 was sited in the probable toe region of an old slip (fig. 1). The logs of the auger holes are given in Table 1.

Table 1. LOGS OF AUGER HOLES AT CASUARINA CRESCENT, GLENORCHY.

Bore Hole number	Depth (m)	Description
1	0-0.61	Brown sandy loam.
	0.61-1.68	Grey/brown sandy clay with 30% quartz grains.
	1.68-2.74	Firm mottled grey/ochre red sandy clay similar to above.
	2.74-3.20	Firm ochre-red sandy clay; highly ferruginised.
	3.20-4.57	Firm fawn sandy clay with inclusions of grey clay (mudstone?) fragments.
	4.57-5.33	Wet soft/firm fawn sandy clay similar to above.
	5.33-5.49	Beige highly weathered quartz sandstone. Water at 4.57 m. Piezometric level 4.05 m.
2	0-0.30	Brown sandy loam.
	0.30-1.22	Brown/fawn sandy clay with 30% quartz grains.
	1.22-3.66	Firm fawn sandy clay with up to 50% rock fragment inclusions (mudstone, basalt, quartz, dolerite, sandstone) to 4 cm in diameter.
	3.66-7.32	Firm mottled fawn/grey sandy clay with inclusions of grey clay (mudstone?) fragments.
	7.32-7.47	Beige highly weathered quartz sandstone. Dry hole.
3	0-0.76	Brown sandy loam.
	0.76-1.52	Brown/fawn sandy clay with 30% quartz grains.
	1.52-5.49	Firm fawn/grey sandy clay with inclusions of grey clay (mudstone?) fragments up to 3 cm in diameter. Fragments commonly exhibit fawn oxidised exterior with a grey centre.
	5.49-6.71	Firm fawn sandy clay, noticeable absence of mudstone? inclusions.
	6.71-7.77	Firm/soft wet fawn/grey sandy clay with mudstone? inclusions. Water at 6.71 m. Piezometric level 2.90 m.
4	0-0.61	Brown sandy loam.
	0.61-1.37	Brown/fawn sandy clay with 30% quartz grains.
	1.37-3.35	Firm fawn/grey sandy clay with up to 15% rock fragments (sandstone dominant, some dolerite).

Table 1. (continued)

Bore Hole number	Depth (m)	Description
4	3.35-4.57	Firm fawn/grey sandy clay with up to 50% rock fragments (quartz, mudstone, sandstone, dolerite, basalt) to 5 cm in diameter.
	4.57-6.10	Firm/soft fawn moist sandy clay with 10% sandstone fragments.
	6.10-9.45	Soft/firm wet fawn/grey sandy clay with grey mudstone? inclusions. Water at 6.10 m. Piezometric level 3.81 m.

SUBSURFACE CONDITIONS

Geology

The drilling programme has shown that Triassic sandstone is overlain by a variable but appreciable thickness of post-Tertiary sediments. These sediments comprise a heterogeneous deposit of poorly sorted rock fragments dispersed through a firm sandy clay matrix which readily becomes plastic with the addition of water. The rock fragments are essentially sub-angular and include Permian and Triassic sediments, Jurassic dolerite and Tertiary basalt. The material has been reworked and deposited possibly during the Quaternary.

Hydrology

From bore hole water level measurements, water analysis and pump tests, a preliminary assessment of groundwater conditions within the confines of drilling is considered. The widely varying levels at which water was struck, in Bore Holes 1, 3 and 4 suggests considerable subsurface disturbance, probably the result of shear zones or slip zones within the clay sequence. It is thought that such disruption has placed the groundwater under a considerable, but highly variable hydraulic pressure as evidenced by the piezometric levels recorded in Bore Holes 1, 3 and 4.

The test pump data obtained from Bore Holes 3 and 4 is of limited use due to restricted drawdown. Prior to pumping, both bores had caved in to a level between 0.5 and 1.0 m below the static water level. Thus an estimate as to the probable yield from the entire thickness of clays can only be surmised.

Pump testing indicated a surprisingly large quantity of water in the clays. During 30 minutes of pumping at a constant discharge rate, approximately 820 *l* and 450 *l* of water had flowed from Bore Hole 4 and Bore Hole 3 respectively, when both bores were suddenly pumped dry. A good recovery rate was recorded from both bores.

Water analysis indicated that the water pumped from the clays probably originated from the underlying Triassic sandstone. The water has an unusually high concentration of sulphate and bicarbonate ions (table 2).

Water samples taken from Bore Holes 3 and 4 were subjected to a colliform bacterial count in an attempt to determine whether sewage was being discharged directly into the ground from suspected broken or fissured pipes. An additional water sample was taken from Conneware Bay, immediately in front of the slip area for comparison.

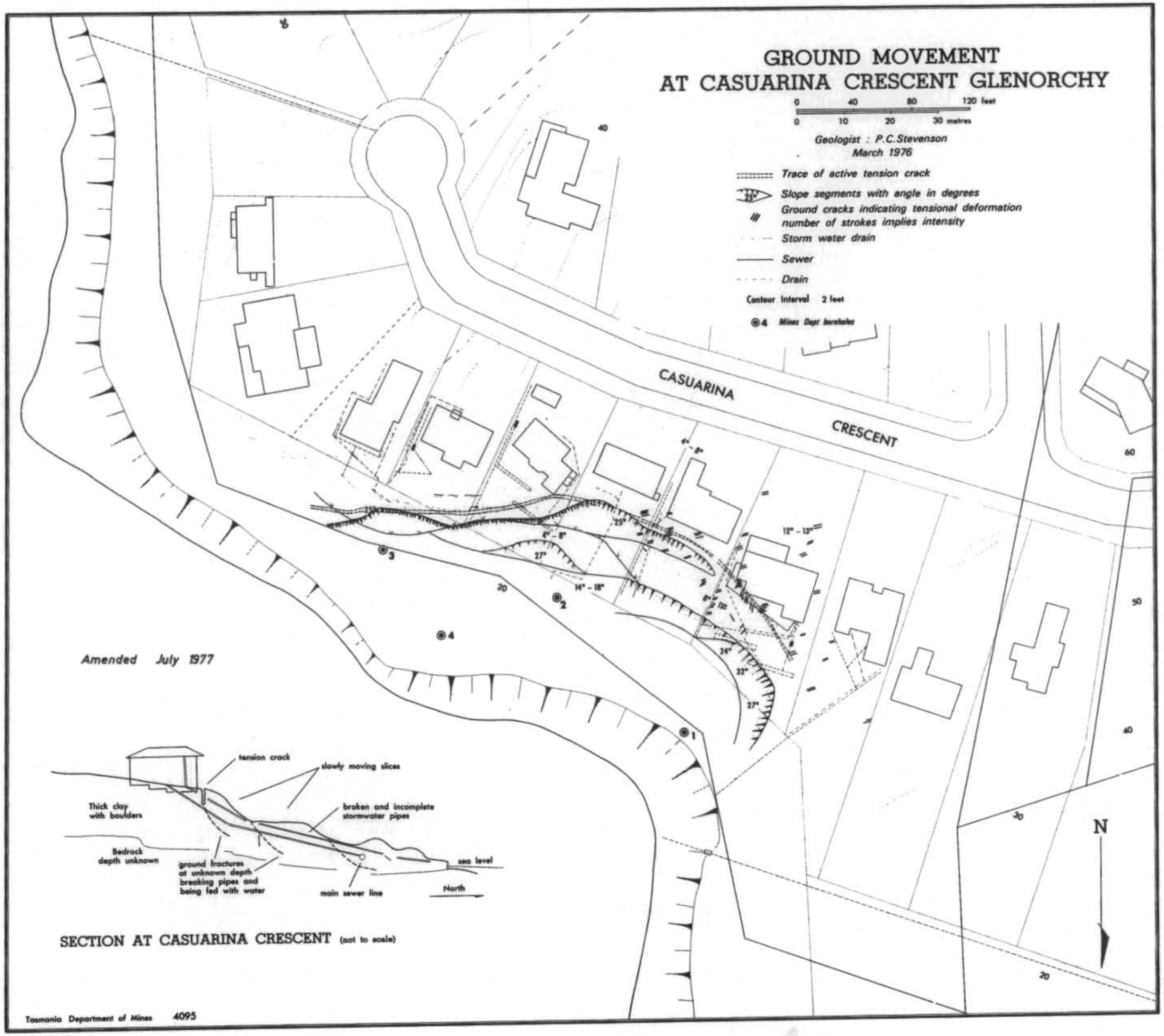
GROUND MOVEMENT
AT CASUARINA CRESCENT GLENORCHY
0 40 80 120 feet
0 10 20 30 metres
Geologist : P.C.Stevenson
March 1976
Trace of active tension crack
Slope segments with angle in degrees
Ground cracks indicating tensional deformation
number of strokes implies intensity
Storm water drain
Sewer
Drain
Contour Interval 2 feet
Mines Dept boreholes
CASUARINA
CRESCENT
N
Amended July 1977
tension crack
slowly moving slices
Thick clay
with boulders
broken and incomplete
stormwater pipes
Bedrock
depth unknown
ground fractures
at unknown depth
breaking pipes and
being fed with water
main sewer line
sea level
North
SECTION AT CASUARINA CRESCENT (not to scale)
Tasmania Department of Mines 4095

Figure 1.

5 cm

Table 2. CHEMICAL ANALYSIS OF WATER FROM CASUARINA CRESCENT, GLENORCHY.

Constituent		761280 (B.H. 3, 30.4.76) mg/*l*	meq/*l*	% meq/*l*	761281 (B.H. 4, 30.4.76) mg/*l*	meq/*l*	% meq/*l*
Silica	(SiO_2)	23.0			55.0		
Iron	(Fe)	0.1	0.0	0.0	0.1	0.0	0.0
Aluminium	(Al)	0.2	0.02	0.0	0.2	0.02	0.0
Calcium	(Ca)	29.0	1.45	1.5	47.0	2.35	2.0
Magnesium	(Mg)	78.0	6.39	6.8	210.0	17.21	15.2
Sodium	(Na)	920.0	40.0	43.0	830.0	36.08	31.8
Potassium	(K)	20.0	0.51	0.5	32.0	0.81	0.7
Carbonate	(CO_3)	0.0	0.0	0.0	0.0	0.0	0.0
Bicarbonate	(HCO_3)	1270.0	20.81	22.4	1170.0	19.18	16.9
Sulphate	(SO_4)	110.0	2.29	2.4	180.0	3.75	3.3
Nitrate	(NO_3)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Chloride	(Cl)	760.0	21.4	23.0	1200.0	33.80	29.8
Total dissolved solids		2640.0	92.9		3210.0	113.2	
Total hardness		290.0			980.0		
Alkalinity		1040.0			960.0		
pH		8.2			7.9		
% difference of anion and cation equivalents		4.1			0.2		
Na adsorption ratio		20.1			11.5		
% Na		83.7			65.3		

Analyses by Department of Mines Laboratory, Launceston

Table 2. (continued)

Constituent		761282 (B.H. 3 pump test, 4.6.76) mg/l	meq/l	% meq/l	761283 (B.H.4 pump test, 4.6.76) mg/l	meq/l	% meq/l
Silica	(SiO_2)	25.0			59.0		
Iron	(Fe)	0.1	0.00	0.0	0.1	0.00	0.0
Aluminium	(Al)	0.2	0.02	0.0	0.2	0.02	0.0
Calcium	(Ca)	20.0	1.00	1.0	72.0	3.60	2.5
Magnesium	(Mg)	88.0	7.21	7.4	290.0	23.77	16.5
Sodium	(Na)	920.0	40.00	41.3	1020.0	44.34	30.8
Potassium	(K)	20.0	0.51	0.5	36.0	0.92	0.6
Carbonate	(CO_3)	0.0	0.00	0.0	0.0	0.00	0.0
Bicarbonate	(HCO_3)	1390.0	22.78	23.5	1150.0	18.85	13.1
Sulphate	(SO_4)	110.0	2.29	2.3	240.0	5.00	3.4
Nitrate	(NO_3)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Chloride	(Cl)	810.0	22.81	23.6	1670.0	47.04	32.7
Total dissolved solids		2750.0	96.60		4460.0	143.5	
Total hardness		410.0			1375.0		
Alkalinity		1140.0			940.0		
pH		7.9			7.5		
% difference of anion and cation equivalents		0.8			1.2		
Na adsorption ratio		19.7			11.9		
% Na		83.1			62.3		

The analyses (table 3) suggest that the groundwater is only slightly polluted, with bacterial levels in the River Derwent at Conneware Bay being between six and twelve times as great. One conclusion to be drawn is that sewage is probably not flowing into the ground from pipes fissured as the result of ground movement. Alternatively, it may be concluded that bacterial analysis is an inappropriate method to employ, as numerous studies have shown that a high percentage of bacteria can effectively be removed through percolation, within several metres of the place of discharge, given favourable conditions.

Table 3. BACTERIAL ANALYSIS OF WATER FROM CASUARINA CRESCENT, GLENORCHY

Location	Date	Time	Coliforms per 100 ml	Faecal Coliforms per 100 ml	Faecal Streptococci per 100 ml
B.H. 3	21.6.76	09.50	80	46	22
B.H. 4	21.6.76	09.55	122	92	40
Conneware Bay	21.6.76	10.10	810	530	70

DISCUSSION

Ground movement at Casuarina Crescent appears to be confined to the northern slope of the small peninsula protruding eastward into the River Derwent. Triassic sandstone is exposed in cliffs on the south side of the peninsula, less than 200 m from the area drilled. However, drilling encountered sandstone below river level, suggesting the possibility of an erosional surface developed on the sandstone and sloping locally to the north, in the direction of movement. The post-Tertiary clay deposit in which movement is occurring was subsequently deposited on this surface.

The influence of the inferred slope of the bedrock surface on the movement of the overlying clay is not known. However it appears that the presence of water is the main mechanism producing ground movement. Water entering the slip area is fed principally from groundwater moving through the sandstone and into the clay (as evidenced by chemical analysis) and also from vertical fissures close to the surface, which receive surface waters. This readily produces a situation of saturated subsurface materials together with a variable hydraulic pressure generated at the interface of the sandstone and confining clays, and within the clays themselves. The net result is a reduction in the stability of the slope.

CONCLUSIONS

The influence of water pressure and to a lesser extent the nature of the clays and the slope of the ground are considered to be the major factors producing ground movement at Casuarina Crescent.

RECOMMENDATIONS

Water pressure reduces the stability of slopes by reducing the shear strength of potential failure surfaces. By providing effective surface and subsurface drainage of the slip area, there would be minimal water pressure in either the tension cracks or along the sliding surfaces, thereby greatly increasing the stability of the slope. Moisture tends to make the clays plastic, but provided no pressure is generated, the stability of the slope will generally be maintained.

Assuming the erosional surface of the Triassic sandstone to be locally sloping to the north (in the direction of ground movement), it is recommended that horizontal drains be driven through the slip mass into the Triassic sandstone. This would relieve groundwater pressure confined presumably at the interface of the sandstone and the less permeable clays, and within the clays themselves. Alternatively, a series of vertical holes could be drilled and fitted with down hole pumps. The success of this second alternative relies on the frequency of pumping. Some additional drilling may be required to confirm the findings of this report.

With respect to the control of water entering at the surface, the recommendations set out by Stevenson (1976) are confirmed.

REFERENCE

STEVENSON, P.C. 1976. Ground movements at Casuarina Crescent, Glenorchy. *Unpubl.Rep.Dep.Mines Tasm.* 1976/16.

[16 July 1976]