UR1976_65

//b

1976/65. Investigations of a landslip at Alexander Terrace, Stanley.

W.L. Matthews

Golder and Associates, consulting geotechnical engineers of Melbourne investigated subsurface conditions at this slip [CQ562858]. The work included seismic surveys, test pitting and diamond drilling. From the results of their surveys (Golder and Associates, 1975*a, b*) R.M. Foster and Associates of Devonport (1976), who are consulting engineers to the Circular Head Council, devised a drainage scheme which it was hoped would result in a permanently low water table and thus aid in maintaining stable conditions.

There was some doubt, from the information in the reports (Golder and Associates, 1975*a, b*) that the proposed system would drain the area as a test pit dug on the line of the proposed drain failed to encounter any water to a level deeper than that of the drain. It was therefore thought possible that the water affecting the slip may be pressure water contained in an aquifer below the level of the drain.

A report of the diamond drilling became available recently (Golder and Associates, 1975*b*) which showed that the location of the test pit was, coincidentally, dug in a position where there was a low zone in the water table. It was still not possible however to determine whether the water was stored in the talus or whether it was confined in the tuff beds and this needed to be resolved before it could be said that the drainage scheme would be effective. In other areas in Tasmania where landslips have been studied in detail, it is commonly found that the water associated with the slip is pressure water or confined. An alternative drainage scheme which involved drilling holes in the base of the trench and backfilling with gravel, was suggested (Golder and Associates, letter of 10 August 1976) as a means of dealing with this possibility. A study of the surrounding geology indicates that volcanic tuff probably underlies the area and if The Nut is considered a volcanic centre, dips on this tuff would be away from The Nut (*i.e.* downhill). This would make the likelihood of the occurrence of pressure water greater than if the tuff beds were flat-bedded.

Two additional holes have been drilled and a test pit dug by the Department of Mines to aid in determining the nature of the occurrence of the water.

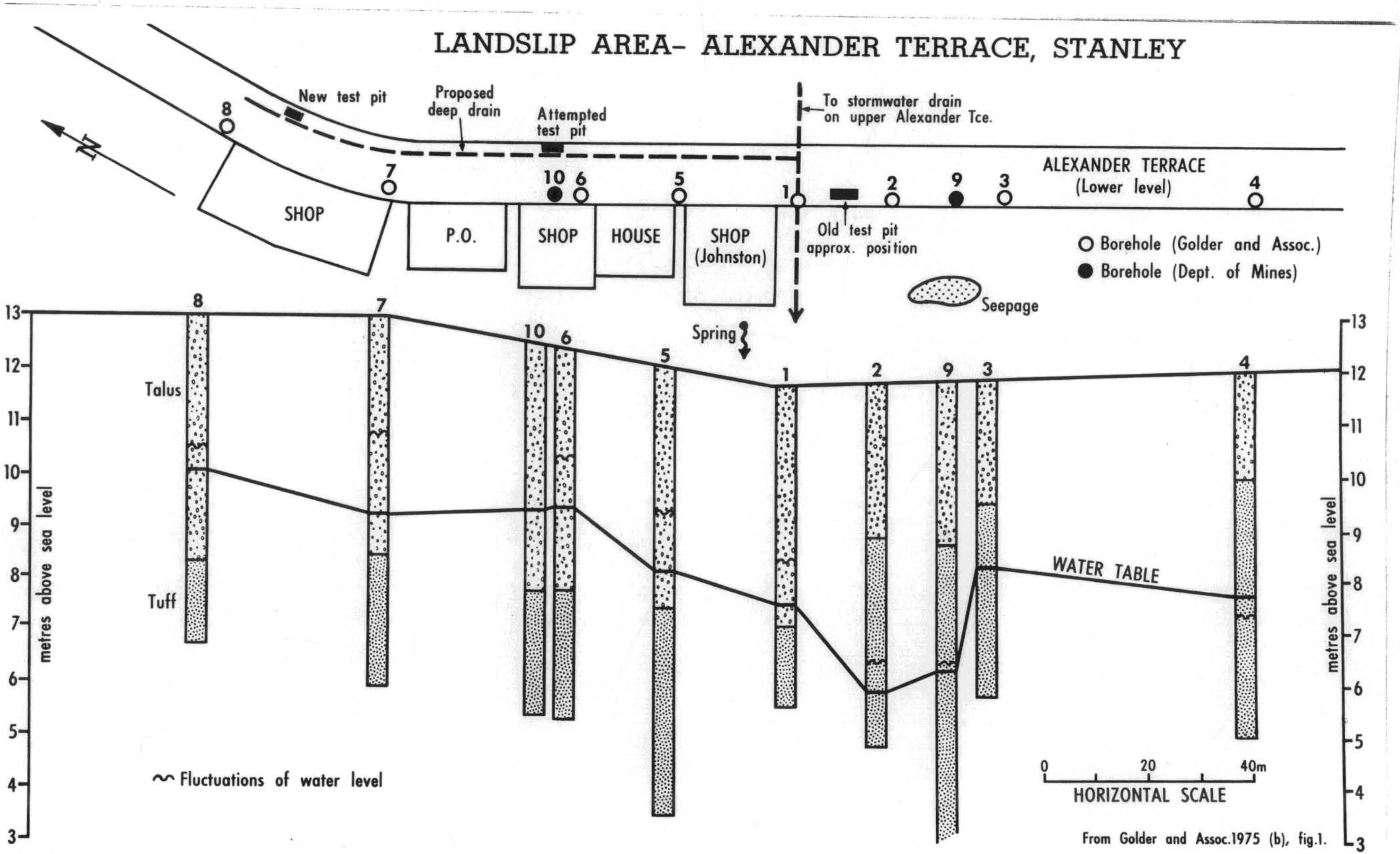
GENERAL GEOLOGY

The area where damage to buildings has taken place, lies between Wharf Road and Alexander Terrace where there is a sharp, steep slope 9-11 m high rising above the marine terrace. The slip area is underlain directly by talus, a mixture of boulders and soil derived from The Nut. From drill hole and test pit information, this extends to depths of about 4.5 m in the zone where signs of movement have taken place (holes 8 to 1 on fig. 1) and to 2-3 m further east (holes 2 to 4). Tuff underlies the talus (Appendix 1), although Golder and Associates referred to it as residual soil and weathered crinanite.

RESULTS OF RECENT INVESTIGATIONS

Prior to the latest investigations, the consultants had one test pit and eight holes drilled near the line of the proposed drain. The drill holes were lined with plastic pipe which was probably not slotted. In this situation water can enter the hole through the bottom of the casing.

Three of the older holes (5, 6 and 7) were bailed out and recovery



65-2

Figure 1.

2/8

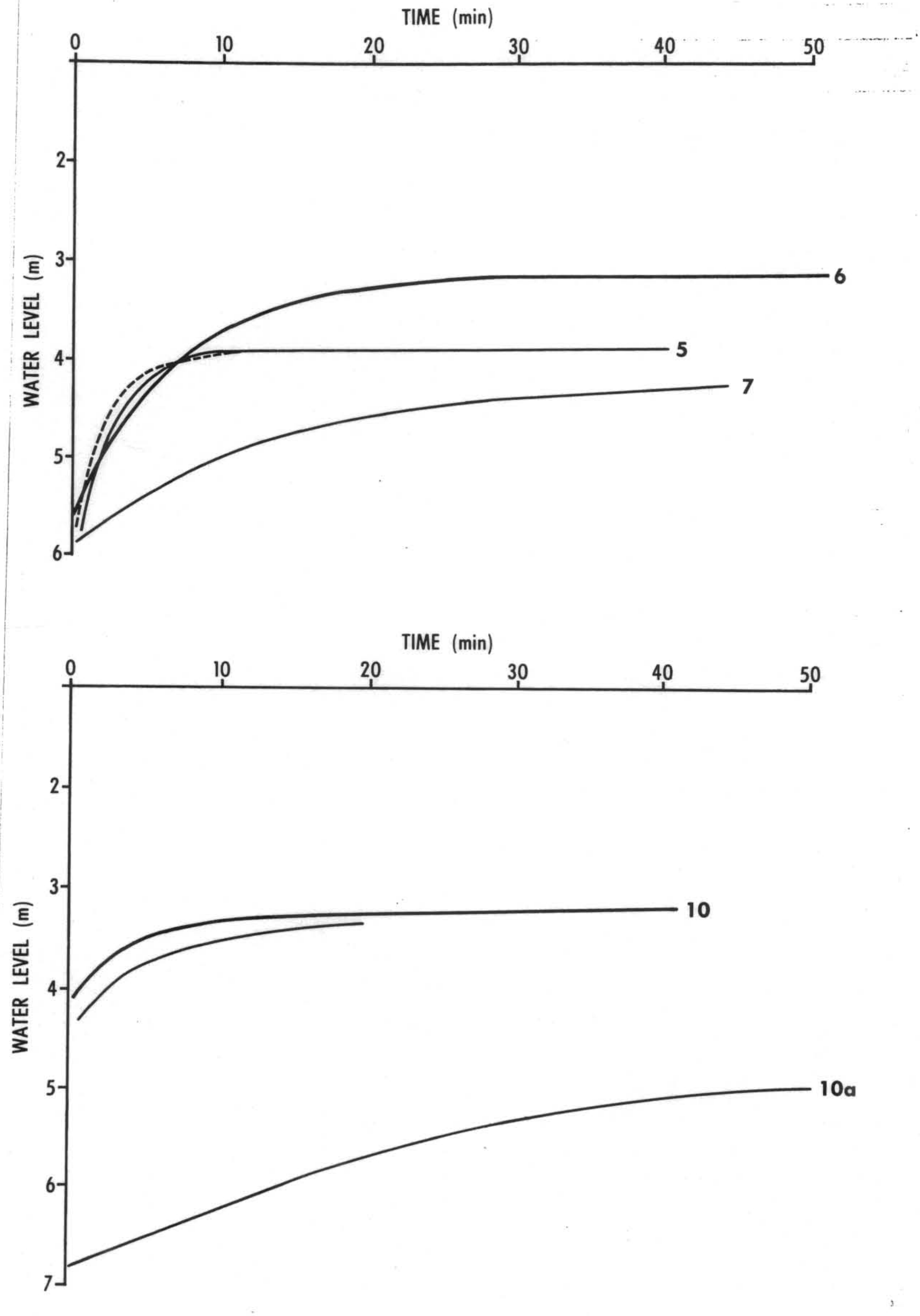


Figure 2. *Recovery curves for bore holes 5, 6, 7 and 10. (10a - results with drill casing left in place)*

5 cm

tests were made (fig. 2). There was insufficient depth of water in the other five holes for any useful information to be obtained from recovery tests. Although it is almost certain that water entered the holes through the bottom of the casing, some conclusions can be made from the plots of these recovery tests. In each case the change in water level with time has a more logarithmic than linear relationship. This indicates that it is unlikely that either a confined or perched unconfined aquifer occurs above the base of the hole. A logarithmic relationship could be due to a confined aquifer at the base of each hole or by a partially penetrated unconfined aquifer.

Table 1. DRILLING RESULTS FOR HOLE 9

Depth (m)	Recovery (m)	Material encountered
0-1.4	0.3	Clay and crinanite boulders up to 0.2 m across.
1.4 -3.0	0.83	Crinanite boulders, jointed and up to 0.2 m across.
3.0 -4.45	0.5	A few unweathered pebbles of crinanite at start of run but finishing in tuff.
4.45-5.0	0.3	Tuff-weathered.
5.0 -6.0	0.85	Tuff.
6.0 -7.52	1.0	Tuff, some limonite staining in upper 0.35 m.
7.52-9.05	1.44	Tuff, coarse-grained except lowermost 0.3 m.
9.05-10.0	1.0?	Coarser tuff.

Hole 9 (table 1) was drilled, near to but outside the area where damage has occurred, through about 3.2 m of surface talus with lapilli tuff to 10 m. During drilling there was water loss from about 5.5 m below the surface to the bottom of the hole, casing being only placed to about 3 m. This suggests permeable zones at these levels which are entirely in tuff. The hole was lined with slotted plastic casing. Pumping with a suction pump drew the water level down about 0.5 m from a standing water level of 5.7 m with a pumping rate of 27 *l*/min at the beginning of pumping. The rate of output fell to about 13 *l*/min after 15 minutes of pumping and remained at this rate for a further 15 minutes. The hole should be capable of delivering a large quantity of water if the total possible drawdown was used, *i.e.* the tuff in this area is very permeable.

Hole 10 was drilled in the middle of the affected area. Drilling was very difficult through the talus and there were collapses into the hole. Very little core was recovered apart from rock fragments in the talus. It is thought the tuff was entered about 4.6 m from the surface. The hole was very irregular in diameter to about this depth and then may have been of uniform diameter to the final depth of 7 m. Drill casing extended to 5.8 m and slotted plastic pipe was installed to 7 m. The hole was bailed out with the casing still in place. Very little water entered this section of the hole and recovery was very slow. The first part of the recovery up to 5.8 m is linear, indicating most if not all of the water was coming from further up the hole (fig. 2). Above this level the recovery curve loses its linearity and this could be due to a confined or unconfined aquifer. The casing was removed and further recovery tests were undertaken. Recovery was rapid in the lower part and it was not possible to take reliable level/time measurements in this section of the hole. It then slowed when the level reached the irregular section of the hole. The recovery curve is logarithmic above 4 m. The rate of flow into this bore, measured with a drawdown of 6.4 m was found to be 6 *l*/min.

A test pit was dug to 3.7 m (fig. 1) and a hole was augered in the base of this to 6.7 m. Basalt talus was penetrated to 3 m with the remainder of the hole in tuff. Moisture could be seen oozing from the talus over a 1.5 m section above the contact with the tuff. The rate of flow into the pit was slow. The augered hole was left open for 30 minutes and in that time no water could be seen collecting in the augered part indicating a very low permeability for the section of tuff intersected.

A further test pit was attempted but a telephone cable was struck and the hole was abandoned.

WATER LEVEL MEASUREMENTS

The standing water levels in the bores have been measured at various times but not at regular intervals (Appendix 2). Measurements prior to 28 September 1976 were taken by the consulting groups and later ones were measured during the present survey. The range of fluctuations is shown on Figure 1; the lowest level in each hole except for Hole 4 was recorded on 20 October 1976. The amount of fluctuation after the first measurement is not very great. The winter of 1975 was very wet and water levels were probably still high at the time of drilling in December. Rainfall has been below average since then. The depressed zone in the water table indicated by Holes 2 and 9 is probably due to the presence of a permeable zone in the tuff and this has resulted in the formation of a strong seepage in the embankment below these holes.

WATER ANALYSES

Water samples were collected for analysis (Appendix 3) mainly to try to determine whether sewerage water was contributing significantly to the groundwater. In only one hole was nitrate detected in these samples and this may not be due to sewerage (it could possibly be due to nitrate fertiliser).

CONCLUSIONS

The recent investigations have shown that some water is contained in the tuff and some is contained in the overlying talus. The tuff is very permeable in the vicinity of Hole 9 but is much less so where encountered in the test pit and in Hole 10. It has not been determined whether there is pressure water contained in the tuff but the drain as proposed will drain water from the talus and lower the water table.

As the tuff in the test pit and in Hole 10 has a low permeability (as opposed to the high permeability of the tuff around Hole 9) the gravel filled holes in the base of the drain suggested by Golder and Associates would probably not add significantly to the drainage in the tuff and are probably unnecessary.

Seepage from the drain may cause the water table to rise between Holes 1 and 9 as it is not proposed to extend the drain to the depth of this low point in the water table. This could produce slightly less stable conditions in this area.

Although it is planned to timber the drain and backfill it, extreme care should be taken in this operation. The digging of the drain around the slope will remove support for material uphill. Any movement that takes place during this operation because of the removal of this support, will result in a lowered strength of the material, perhaps for many years. The result could be that the houses uphill would be endangered and also eventually the buildings on the lower side of Alexander Terrace. In addition, there is some danger that the drain itself could form the heel of a new movement; however the effects of lowering the water table are expected to outweigh this possible danger.

From the chemical analyses it appears that water from septic tanks is not adding significantly to the groundwater.

REFERENCES

FOSTER, R.M., AND ASSOCIATES. 1976. *Stanley landslip area. Report on stabilization of landslip area, Alexander Terrace*. Devonport. [Report to Circular Head Council].

GOLDER AND ASSOCIATES. 1975*a*. *Investigation of a landslip area, Stanley, Tasmania*. Melbourne. [Report to R.M. Foster and Associates].

GOLDER AND ASSOCIATES. 1975*b*. *Investigation of a landslip area, Stanley, Tasmania. Supplementary report*. Melbourne. [Report to R.M. Foster and Associates].

[10 November 1976]

APPENDIX 1

Examination of diamond drill core samples.

G.B. Everard

Samples of diamond drill core from Hole 9, Stanley, taken at depths of 3-4.45, 4.45-5, 5-6, 7.82-9.05, 9.05-10 m were examined.

All rock samples are very weathered and under the microscope only feldspar, a small amount of ferromagnesian minerals and a trace of quartz were recognised, apart from white and dark greenish clay. There is little variation with depth. Indications of bedding are seen in places.

Weathering has left little of the original material, but it was clearly fragmental and of fine-grained, basic crystalline material. Much interstitial material has been washed out. Angular fragments up to 20 mm in length occur but the bulk of the material consists of rounded grains 1-5 mm across. The rounding may be due to weathering.

The rock is a weathered lapilli tuff.

[28 October 1976]

APPENDIX 2

Water levels in bore holes*

Date	8	7	10	6	5	1	2	9	3	4
After completion (December 1975)	2.9	2.7		2.1	2.7	3.25	5.35		3.95	4.55
June 1976	3.1			2.7	3.4					
August 1976	2.6	3.2		2.4						
11 August 1976	2.65	2.25		1.55	2.7	3.45	5.55		3.6	4.1
28 September 1976	2.97	3.68		2.92	3.71	3.81	5.80			4.34
1 October 1976	2.96	3.80		2.85	3.73	3.82	5.87	5.66		4.39
5 October 1976 (after rain)	2.95	3.81		2.88	3.84	3.84	5.87	5.66		4.27
20 October 1976	2.95	3.86	3.2	3.0	3.9	4.01	5.94	5.77		4.32
Depth to which bores are open	3.84	5.56	6.86	5.54	6.35	4.50	6.10	10.06	3.73	5.36

*All measurements are in metres.

APPENDIX 3

Analysis of water samples, 1 October 1976.

Sample No.	762083	762084	762085	762086*	762087
Bore No.	5	6	7	9	Spring water Johnson's house
Item					
pH	6.4	6.9	6.5	6.2	7.5
Conductivity	470 S ppm	420 S ppm	790 S ppm	405 S ppm	435 S ppm
CO_3	nil	nil	nil	nil	nil
HCO_3	120	120	95	70	105
Cl	78	67	140	74	56
SO_4	12	<5	51	14	19
NO_3	present	absent	absent	absent	absent
F	0.8	0.5	0.5	0.5	0.5
SiO_2	14	<5	18	18	<5
Ca	3.8	21	2.3	1.9	19
Mg	6.5	16	7.8	18	6.5
Fe	<0.1	<0.1	<0.1	<0.1	<0.1
Al	<0.1	<0.1	1	2	<0.1
K	2.8	3.5	4.1	3.9	5.4
Na	84	46	130	88	67
Total dissolved solids	260	250	570	340	260
Hardness (as $CaCO_3$)	37	120	38	79	74
Alkalinity (as $CaCO_3$)	100	100	80	60	90
Suspended solids	10		60	570	

*Insufficient sample for complete analysis and check of existing figures which do not balance.

Analyses by Department of Mines Laboratories, Launceston.