UR1974_73

Groundwater investigations at the Shearwater Golf Club, Port Sorell.

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The management of the Shearwater Golf Club requested an investigation into the groundwater potential of land used by the club at Port Sorell. This area (fig. 1, 2) extends over some 50 ha, and includes a 9-hole golf course and a section of undeveloped Crown land. The project falls within the field of studies currently being undertaken by the Department of Mines as part of a regional groundwater programme.

At present the greens and fairways are irrigated by up to ten sprinklers, each capable of delivering 20 *l*/min, but supplies are inadequate during the warmer months. The club estimates that a bore supplying 120 000 *l*/day of suitable quality water would alleviate the summer shortage.

GEOLOGY

The course has been constructed on a section of a low-lying coastal fringe of wind blown Quaternary sand which forms an arcuate deposit 4 km in length and 0.5-1 km in width extending from Hawley to Port Sorell. It is composed of medium- to fine-grained quartz sand 4-5 m thick. The sand abuts against and overlies Tertiary sediments. The latter are predominantly well-sorted water-worn quartz gravels (with occasional well-preserved shells) but sands and minor patches of clay are also present. The Tertiary rocks form the low-lying escarpment on the western boundary of the course, and cover most of the Port Sorell area. Seismic interpretation and drilling results indicate that they rarely attain a thickness of more than 20 m, but south of the township, in the deeper parts of the Port Sorell basin, considerable (>300 m) sequences are present.

The basement rock of the region is generally assumed to be Jurassic dolerite. It has been inferred from seismic investigations (Table 1) and gravity surveys (Leaman, 1973) and encountered during exploratory and groundwater drilling operations. It crops out at a number of widespread localities to the north, west and south of Port Sorell. The nearest exposure to the golf course is at Hawley, one kilometre to the north. Drilling on the course has, however, revealed that the basement rocks beneath that locality are fine-grained siliceous sediments, probably of Permian age.

SEISMIC REFRACTION SURVEY

Eight seismic spreads were located in and around Port Sorell (fig. 1) as part of the regional groundwater programme. The survey was designed to indicate both the position of the water table in the Quaternary and Tertiary sediments, and the depth to basement. Geophone spacings of 7.6 m were used throughout, and extension and centre shots employed. Table 1 is a summary of the results obtained and profiles of four of the spreads are presented in Figure 3.

Refractor velocities in the range 300-350 m/s are typical of dry top soil and, or, sand. Those of about 1500 m/s are generally recorded from saturated sand and gravel, although clay produces similar velocities. Drilling suggests, however, that in Port Sorell at least, gravel and sand predominate, and the interface between layers 1 and 2 in Table 1 is assumed to approximate the position of the water table.

Refractor velocities in the range 2200-6000 m/s are interpreted as resulting from basement rocks, probably Jurassic dolerite in various stages of weathering. The lower figure may however be represented by weathered

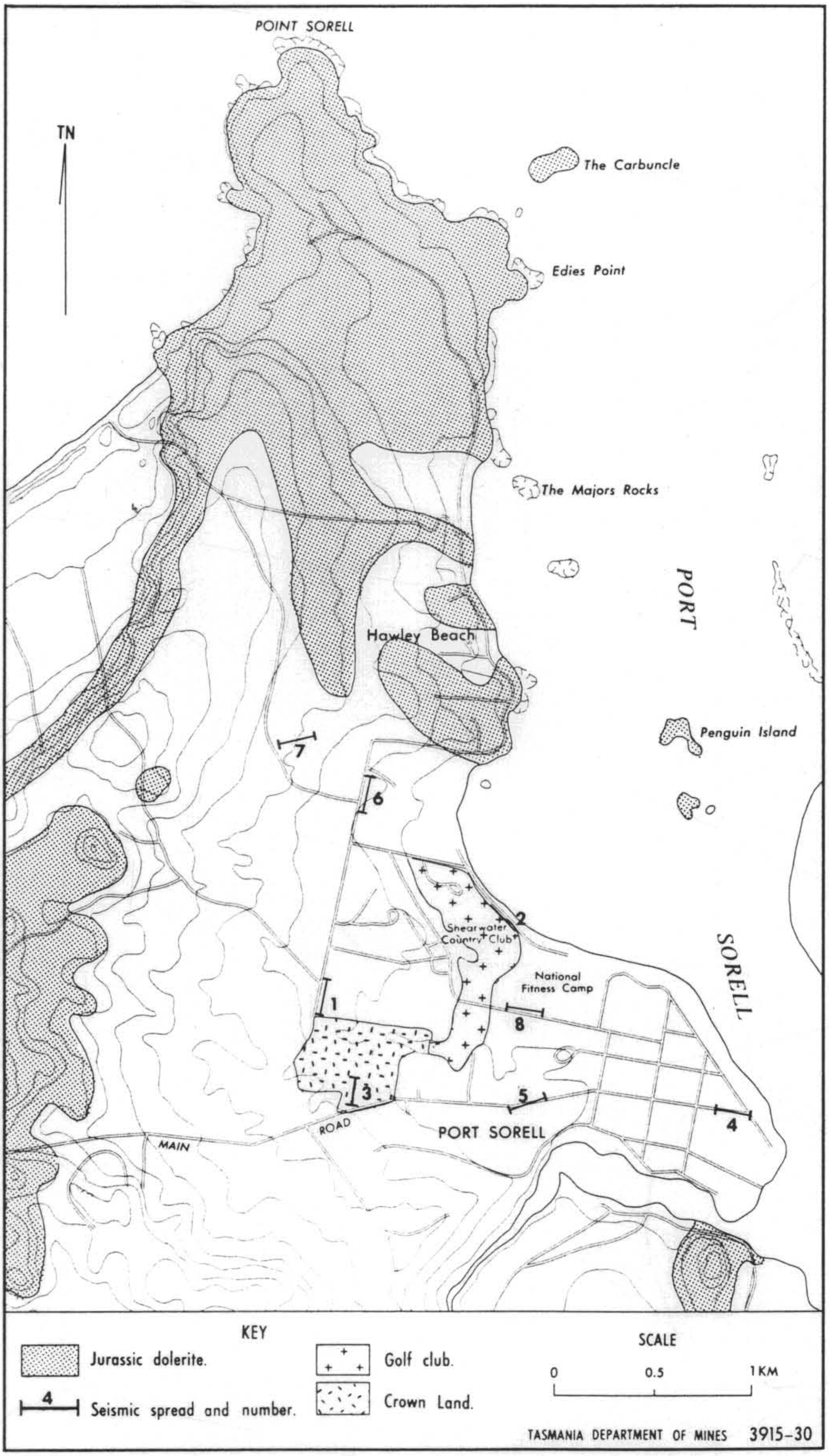

Figure 1. *Locality maps of the Port Sorell area showing the location of seismic spreads.*

5 cm

Table 1. SUMMARY OF REFRACTION SEISMIC RESULTS, PORT SORELL AREA.

Spread No.	Grid Ref.*	Refractor	Refractor Velocity (m/s)	Refractor Thickness (m)	Interpretation
1	608430	1	300	2	Dry sandy soil.
		2	1500	0-10	Saturated gravel, sand and clay.
		3	3600-5000	-	Jurassic dolerite?
2	616434	1	300	2.2	Dry sand.
		2	1500	16-20	Saturated sediments (Tertiary?)
		3	3670	-	Jurassic dolerite?
3	610426	1	300	2-3	Dry sandy top soil.
		2	1490	>20	Saturated sediments (Tertiary?)
4	628424	1	300	2-3	Dry Quaternary sand.
		2	1600	>50	Saturated sediments.
5	618425	1	300	2-3	Dry sandy top soil.
		2	1550	7-12	Saturated sediments (Tertiary?)
		3	2220-2440	-	Weathered Jurassic dolerite?
6	609440	1	360	1-2	Dry sandy top soil.
		2	1900	0-10	Saturated sediments (Tertiary?)
		3	4200-6000	-	Jurassic dolerite.
7	607443	1	360	3	Dry Tertiary gravels and soil.
		2	2000	4-6	Saturated Tertiary gravels.
		3	4900	-	Jurassic dolerite.
8	617429	1	330	1.5-2.5	Dry Quaternary sands.
		2	1400	12	Saturated gravels (Tertiary?)
		3	2590	-	Dark fine-grained sediments (Permian?)

*All locations in this report lie within the 100 kilometre grid square DQ.

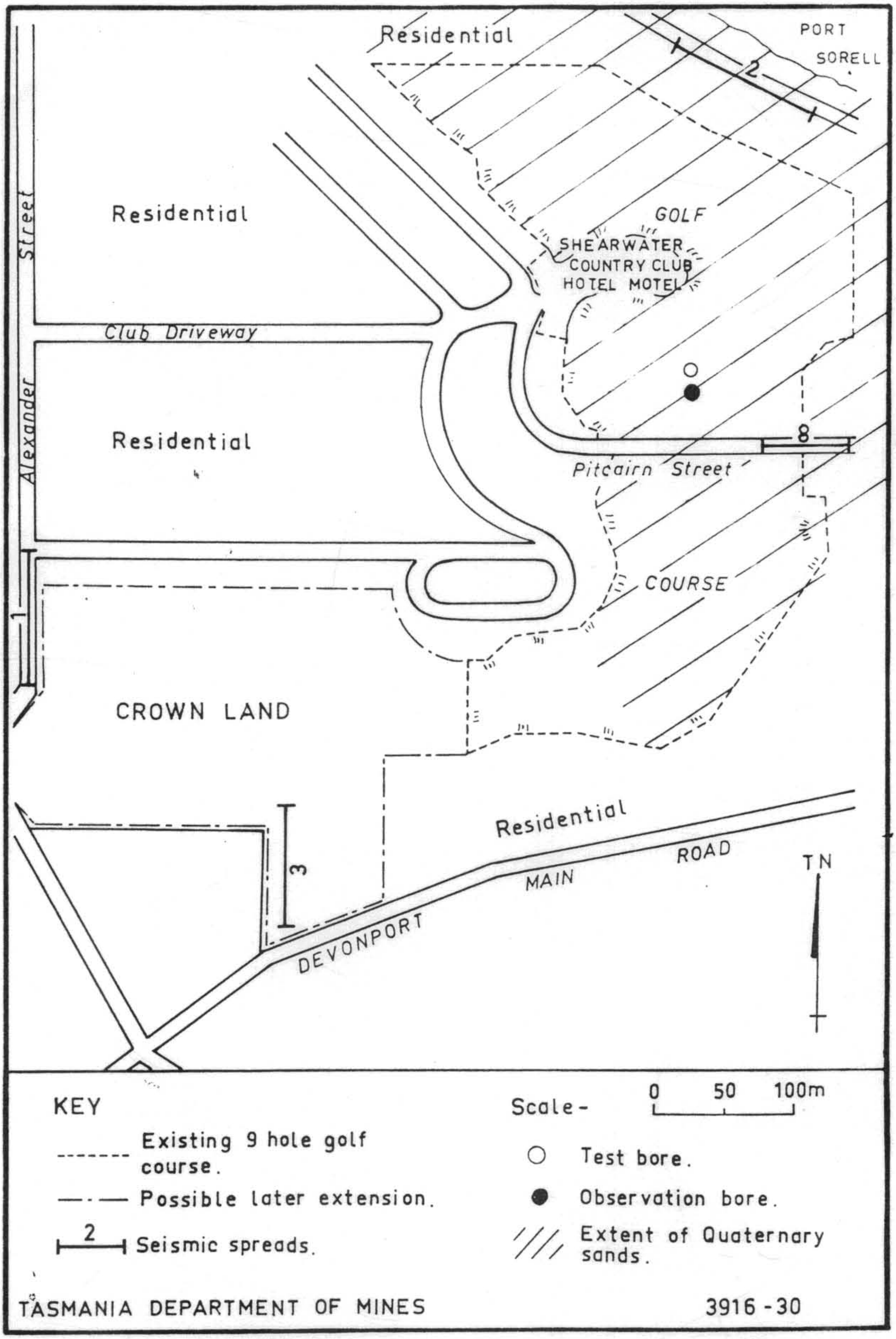

Figure 2. *Shearwater Golf Course. Location of seismic spreads and bore holes.*

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Table 2. BORE HOLE DATA

	Pumped Bore	Observation Bore
Grid Reference	DQ615431	
Situation	gently undulating to level ground	
Altitude	approx. 7-10 m asl.	
Log	0-0.3 m Grey sandy loam 0.3-5.0 m Medium-grained Quaternary sand 5.0-14.5 m Well rounded Tertiary quartz gravel 14.5- Dark fine-grained siliceous sediments	
Diameter (m)	0.15	0.15
Casing	0-6.0 m - solid 6.0-14.5 m - slotted	0-6.0 m - slotted 6.0-12.0 m - 500 μm Johnson screen
Status	Operating	Casing/Screen removed
Safe yield (*l*/min)	400	-

Table 3. PUMPING AND RECOVERY TEST DATA

Aquifer	:	Tertiary gravels/Quaternary sands, 0-14.5 m.
Type	:	Unconfined?
Standing Water Level (m)	:	2
Pump Test	:	Constant discharge
Discharge rate (*l*/min)	:	400
Duration test	:	17.25 h
Total drawdown (m)	:	5
Duration recovery	:	8 h
Transmissivity	:	117 $m^2.day^{-1}$.
Specific yield	:	*c.* 10^{-4}.

sediments, similar to the material encountered beneath the golf course.

In two spreads (1 and 6) the basement exhibits a relatively steep apparent slope to the south, but on the golf course, spreads 2, 5 and 8 suggest an almost horizontal surface with a gentle northerly slope. Spreads 2 and 8 also show that about 13-14 m of water-bearing sediments are present beneath the fairways. At least 20 m of Tertiary gravel and sand underlie the block of undeveloped Crown land. Both areas are considered very favourable localities for obtaining groundwater.

ROTARY DRILLING

A drill site (fig. 2) was selected on the golf course with the aim of providing control for the seismic survey, determining the thickness and nature of the Quaternary and Tertiary sediments, and estimating by pumping procedures the hydrological parameters of the latter.

The bore bottomed at 14.5 m in dark, fine-grained siliceous Permian(?) basement rocks and was initially pump-tested for 18 hours at 200 *l*/min. Subsequently a second (observation) hole was sited 21.5 m to the south. Drilling details are summarised in Table 2.

HYDROLOGY

The behaviour of an aquifer under any given set of pumping conditions is determined not only by bore design but also by two fundamental properties of the aquifer: its ability to store and transmit water. The former is described by the *storage coefficient (S)* which is the percentage, by volume, of water which will drain from a unit volume of the material under gravity. Unconfined aquifers containing water under atmospheric pressure have values of S in the range 0.1-0.3. Confined aquifers, where the water pressure is greater than atmospheric pressure, exhibit S values in the range of 10^{-3}-10^{-5}. For the calculation of the storage coefficient, data from an observation bore must supplement those from the pumped bore.

The ability of an aquifer to transmit water is known as its *transmissivity (T)*, defined as the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is measured in cubic metres per day per metre, which reduces to square metres per day (m^2/day; one cubic metre is equivalent to 1000 litres). Values of T can be calculated from observations in a pumped hole alone. Values for T for Tertiary sediments in Tasmania range widely, from 1-2 m^2/day in fine clayey sand, to about 2000 m^2/day in coarse clean gravel.

Initial pumping test

An 18-hour pumping and 5-hour recovery test was conducted on the bore. Total drawdown was approximately 4 m at a pumping rate of 200 *l*/min. The salinity of the water was tested at frequent intervals using a portable meter*; the quality remained constant at 700 ppm of total dissolved solids. Two water samples were collected, at the start and end of the pumping period, and the analyses of these are shown in Table 4. The temperature of the water remained constant at 13.4°C. An observation hole was subsequently drilled 21.5 m to the south.

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*The conductivity meter gives approximate salinities only. Conversion graphs supplied with it apply only to water at 25.0°C.

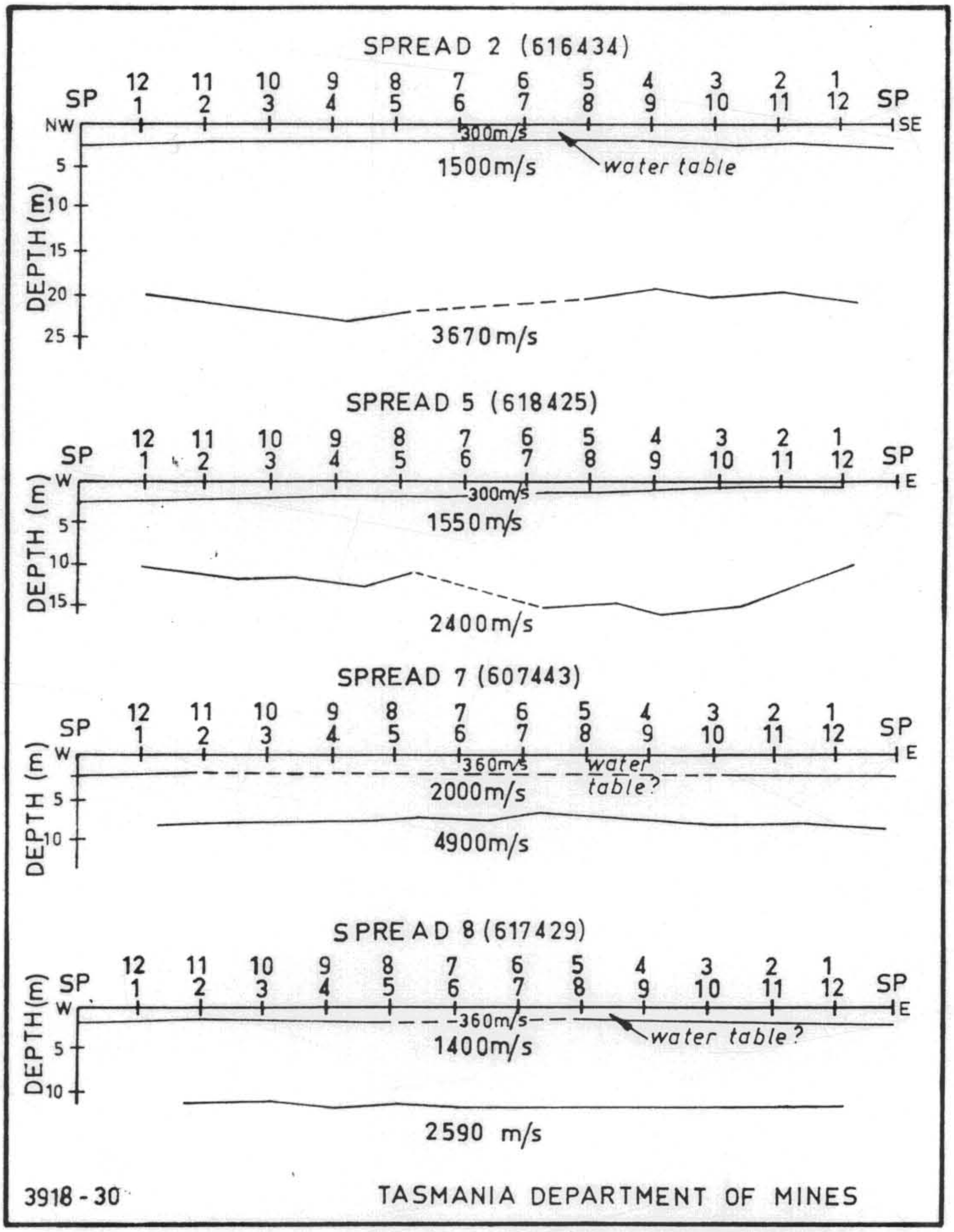
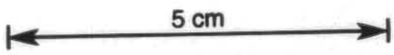


Figure 3. *Seismic profiles in the Port Sorell area.*



Final pumping test

The bore was pumped at 400 *l*/min for 17.25 hours, and drawdown and recovery measurements were taken in both the pumped and observation holes. Total drawdown was 5 m in the former, and 3 m in the latter. Water quality remained constant at 700 ppm, but a salinity of 900 ppm was recorded towards the end of the test. A sample was collected for analysis at the commencement of the pumping period, but a pump failure at 17.25 hours prevented the taking of a second sample. An 8-hour recovery test was conducted on both holes.

INTERPRETATION OF PUMPING RESULTS

Values of transmissivity and storage coefficient are calculated from time-drawdown or time-recovery graphs plotted on semi-logarithmic paper. The relevant pumping data have been summarised in Figure 4.

The values of T (about 120 m^2/day) and S (10^{-4}) are both at variance with expectations considering the nature of the aquifer (which was assumed to be unconfined, with S values between 0.1 and 0.3). However, it is probable that poor design factors of the bore itself have contributed to excessive drawdowns during pumping, and to slow recoveries. Both S and T are functions of drawdown. Two design factors are considered significant in this case: 140 mm diameter slotted casing used has less than 1% open area, compared with an open area of 25% for the same diameter Johnson well screen. The small intake area of the casing results in excessively high entrance velocities and a greater than normal head loss and drawdown; and poor distribution of slot openings results in abnormal convergence of water flow near individual openings, producing a marked effect on drawdown and recovery.

It is probable that construction factors, as distinct from design factors, were not a major reason for the low T and S values: the aquifer was cased to its full depth, and the pump intake setting of 12.2 m was the most efficient for the situation. It was originally intended that the observation bore be used for pumping tests since the lower 6 m of it was cased with 500 µm Johnson well screens. Unfortunately, the latter did not have sufficient internal clearance for the pump used. The efficiency of the pumped hole is estimated from distance-drawdown data to be about 55%.

QUALITY OF THE WATER

Chemical analyses of water collected during pumping are presented in Table 4. Results are expressed both in milligrams per litre (mg/*l*) and milliequivalents per litre (meq/*l*). Some variations in the proportions of constituents are evident among the three samples, but most are not considered important and are probably within the range of analytical error. The change in Na and Cl contents may be significant, suggesting an improvement in water quality with pumping, but no definite conclusions can be based on the data collected so far. In order to monitor any possible changes in water quality with time and pumping, it is strongly advised that samples for analysis be taken *during* pumping at regular intervals over an extended period.

The water can be described as a 'sodium chloride' type, although this terminology is somewhat misleading in that it tends to obscure the fact that significant amounts of Ca, Mg and HCO_3 are also present. The total hardness (permanent and temporary, obtained by multiplying by 50 the meq/*l* of Ca + Mg) is 300 mg/*l* $CaCO_3$, which is considered to be very hard according to the following scale:

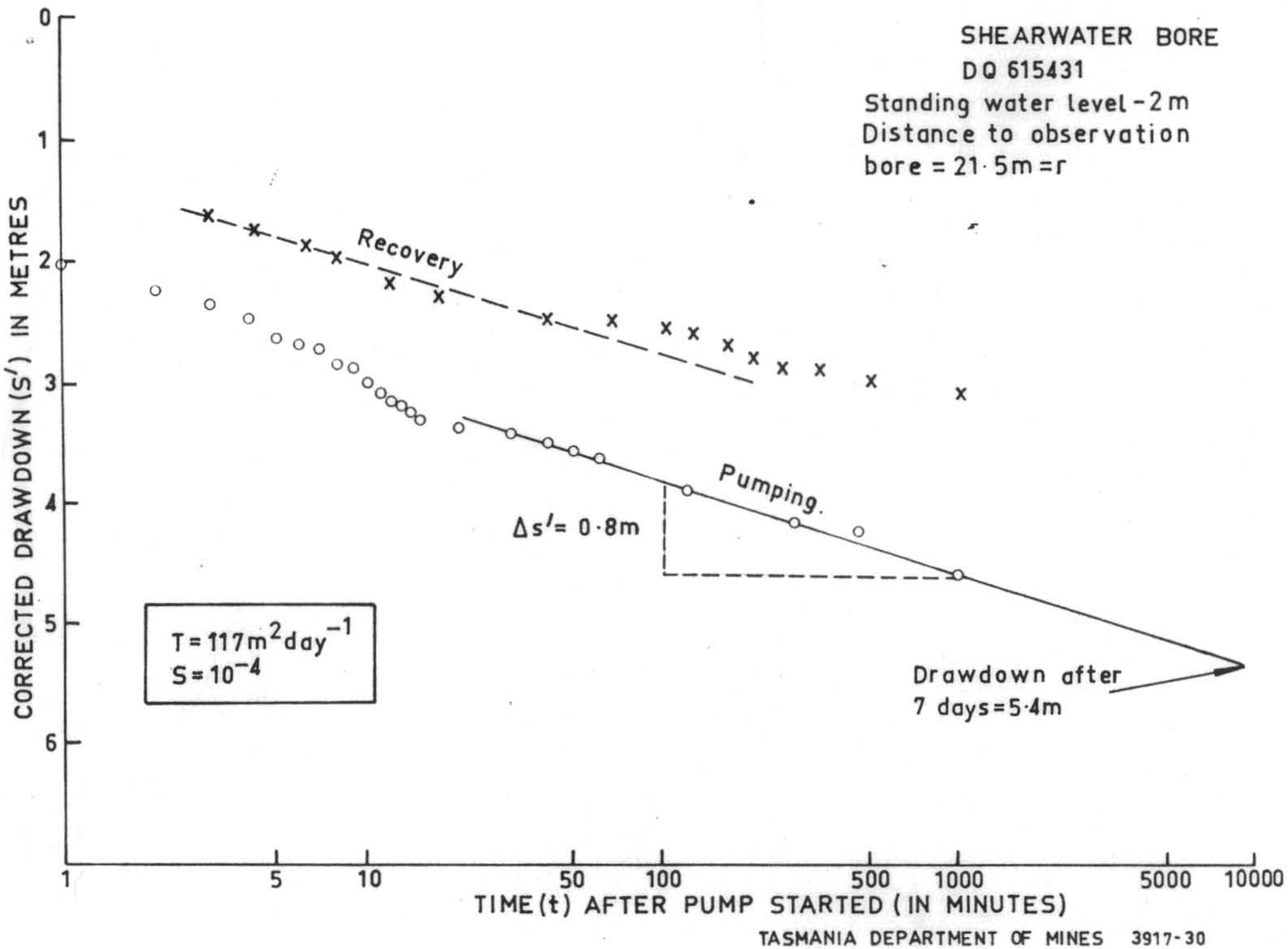


Figure 4. *Time - drawdown and recovery graph.*

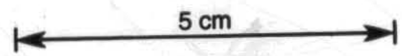


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Table 4. CHEMICAL ANALYSES OF WATER FROM SHEARWATER GOLF CLUB*

Constituent	A 18/9/74 at 1700 hrs mg/*l*	 meq/*l*	B 19/9/74 at 0715 hrs mg/*l*	 meq/*l*	C 24/9/74 at 1515 hrs mg/*l*	 meq/*l*
Silica (SiO_2)	10	-	13	-	13	
Iron (Fe)	<0.1	0.0	<0.1	0.0	0.5	0.02
Calcium (Ca)	50	2.5	43	2.15	43	2.15
Magnesium (Mg)	43	3.5	43	3.5	40	3.3
Sodium (Na)	250	10.9	265	11.5	200	8.7
Potassium (K)	18	0.46	18	0.46	16	0.41
Bicarbonate (HCO_3)	200	3.38	180	2.95	205	3.38
Sulphate (SO_4)	50	1.04	44	0.92	41	0.85
Chloride (Cl)	460	13.0	460	13.0	410	11.6
Total Dissolved Solids	1050	-	1040	-	950	-
Permanent Hardness	140	-	130	-	110	-
Temporary Hardness	160	-	150	-	160	-
Alkalinity as $CaCO_3$	160	-	150	-	160	-
pH	7.3		7.0		7.4	
Sodium Absorption Ratio (SAR) = $\frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$ =		6.3		6.9		5.3

*Analyses by Department of Mines, Launceston.

[Date and time below sample letter are those of collection during pumping].

Total Hardness (mg/l $CaCO_3$)

0-60	Soft
61-120	Moderately hard
121-180	Hard
>180	Very hard

However, the water should not be detrimental to the grasses used on the greens and fairways. The course is underlain by well-drained sandy soils, and leaching by frequent irrigation should prevent excess salts depositing in the root zone of the grasses.

CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the Shearwater Golf Club purchase the present bore from the Department of Mines. The bore is capable of supplying irrigation water of adequate quality for the uses envisaged at a rate of 300-400 *l*/min for extended periods. This is well in excess of present needs. To ensure continued efficient operation of the hole, however, it is recommended that high rates of pumping for short periods be avoided, and that rates be kept to a continuous workable minimum. Should water requirements increase markedly in the future, yields from the bore could be increased considerably by installing slotted casing with a higher intake area (about 5-7%) or screens (20-25%) inside the existing casing, and removing the latter. A monopump of about 400 *l*/min capacity is recommended, with the pump intake set at a depth of 12 m below the collar of the hole.

Although salt water contamination is considered unlikely, the possibility of a progressive change in water quality should not be overlooked. Changes should be monitored by regular sampling and analysis.

REFERENCE

LEAMAN, D.E. 1973. Devonport-Port Sorell gravity survey. *Tech.Rep.Dep.Mines Tasm.* 16:97-106.

[15 October 1974]