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Pump testing an unconfined coastal aquifer, Currie, King Island.

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Abstract

A fourteen day pump test in the aeolian coastal dunes near Currie, King Island has shown that a circular array of eight shallow bores will yield 340 m^3/day continuously for long periods. Calculated aquifer transmissivity is about 124 m^2/day and the specific yield about 0.26.

The bores are unscreened, consisting of slotted 50 mm PVC casing. These are cheap and easy to install. The existing array will provide a reliable and supplementary groundwater supply to the town. To ensure continuity of operation, the resource should be pumped on a sustained yield basis and the overall water budget in the area assessed by continuous monitoring.

INTRODUCTION

The unconfined aeolian sand aquifers near Currie on King Island's west coast have been the subject of various investigations to supplement the existing town groundwater supply. In recent reports, Matthews (1978*a*, 1978*b*) recommended two favourable areas north and south of Currie and conducted pump tests on individual bores and sets of bores. The results were encouraging and suggested a longer pump test was warranted on a larger bore array. This report describes the results of a fourteen day pump test subsequently made on an eight bore array in sand dunes north of Currie.

The installation of the pumped and observation bores was arranged by Mr N. Towns (King Island Council), who also conducted the pump test and collected water samples for analysis.

TEST SITE

The test site [BR302772] is 2 km north of the jetty in Currie Harbour and about 1 km south-west of the racecourse. This coincides with the site of bore 1 (one of 16 exploratory holes) in Figure 1 of Matthews (1978*a*). The log of this hole was:

Depth (m)	*Description*
0 - 0.5	dark brown soil
0.5 - 5.5(?)	yellow medium-size sand; mainly shell fragments
5.5(?) - 7.2	light brown-grey shelly sand
7.2 - 7.3	Clayey micaceous grit with definite granite fragments

Most of the other holes showed similar logs, indicating that the aquifer is unconfined, about 7 m thick, and resting on a clayey confining bed, probably of weathered granite. Its saturated thickness varies between 4-5 m.

Matthews (1978*a*) initially pump-tested a single shallow bore (50 mm in diameter, screened between 1.2 and 4.8 m, 4.8 m deep) at 45 *l*/min for 200 minutes. From drawdowns observed in a nearby observation bore, the transmissivity was calculated at 205 m^2/day, a value which was expected to decrease as the period of pumping increased. Subsequently, Matthews (1978*b*) reported the results of an eight day test made at the same site on an array of 4 bores; he calculated the transmissivity at 80-95 m^2/day and recommended a longer pump test on a larger array.

FOURTEEN DAY TEST

Four extra bores were installed at the site, so that the array (fig. 1) consisted of eight pumped bores in a roughly circular pattern. With the exception of one (the original screened hole), all consist of slotted 50 mm PVC casing bailed to an average depth of 5.6 m. Three observation bores were installed. During June 1978 the array was pumped at a constant 235 *l*/min (338 m^3/day) for 19860 minutes (13.8 days). Observed and corrected drawdowns for each of the three observation bores are listed in Appendix 1. Depths of bores and total drawdowns after 13.8 days are shown in Table 1.

Table 1. DEPTHS OF BORES AND TOTAL DRAWDOWNS

Bore	*Total depth (m)*	*Depth of water in bore before test (m)*	*Approximate depth of water in bore at end of test (m)*
1	4.8	n.d.	n.d.
2	5.8	3.2	1.5
3	5.5	2.7	1.4
4	5.6	3.0	1.6
5	5.6	2.8	1.3
6	5.4	2.8	1.4
7	5.7	2.9	1.5
8	5.6	3.0	1.6

ANALYSIS OF THE RESULTS

The corrected drawdowns (Appendix 1) for each observation bore are plotted on a log-linear graph against time in Figure 2. By applying the Modified Non-equilibrium Equation to the straight line segments of the curves, transmissivity (T) and specific yield (S) are calculated as 124 m^2/day and 0.26 respectively. Despite the length of the pump test and the linearity of the curves after after 1600 minutes (observation bore 1) and 13000 minutes (observation bore 3), these figures should be regarded as approximate only; they give an indication of the characteristics of the aquifer at the test site only and probably vary from place to place. [Theoretically it would be better to analyse the pump test results using a variety of standard methods, but the data from observation bore 1 are subject to interference and should not be used and those from observation bores outside the array are insufficient. Techniques which account for slow gravity drainage (Boulton's method) and partial penetration of pumped and observation bores (Stallman's method) would probably produce higher and more realistic S values].

Nevertheless, the results are useful. Extending the time-drawdown curve for observation bore 1 shows that corrected drawdown at the centre of the array would be 1.43 m after 70 days pumping. This corresponds to an actual central drawdown of 1.87 m which is within acceptable limits. After 70 days, observed drawdown at observation bore 3 (59 m from the array centre) will be 0.75 m. The radius of influence of the array is unlikely to extend more than 100 m from its centre.

Hydrologically, the array is capable of yielding about 340 m^3/day indefinitely. This corresponds to about 40 m^3/day/bore, which should not be exceeded. Higher daily yields may be obtained by installing extra arrays.

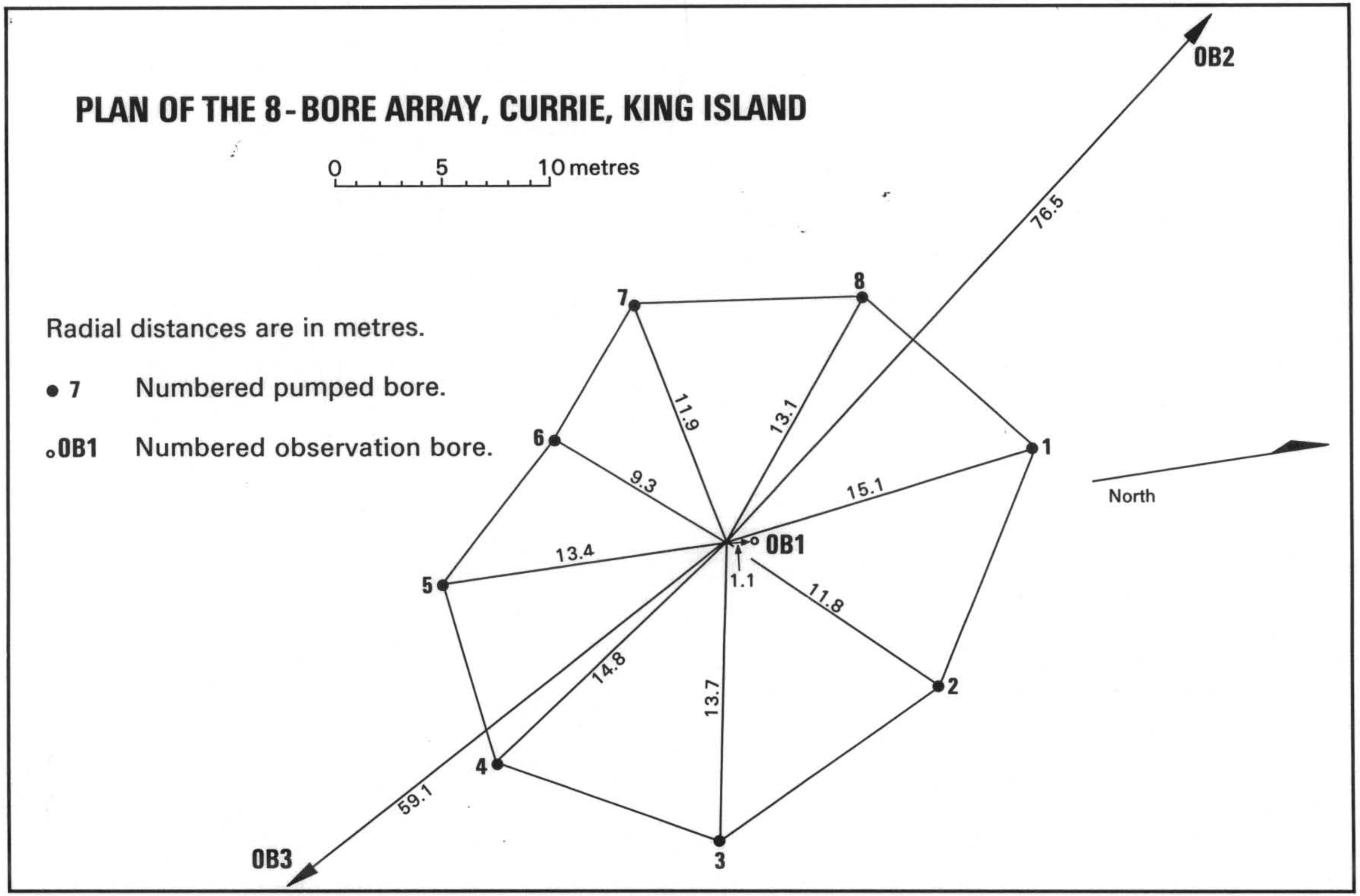

Figure 1.

5 cm

29–3

3/8

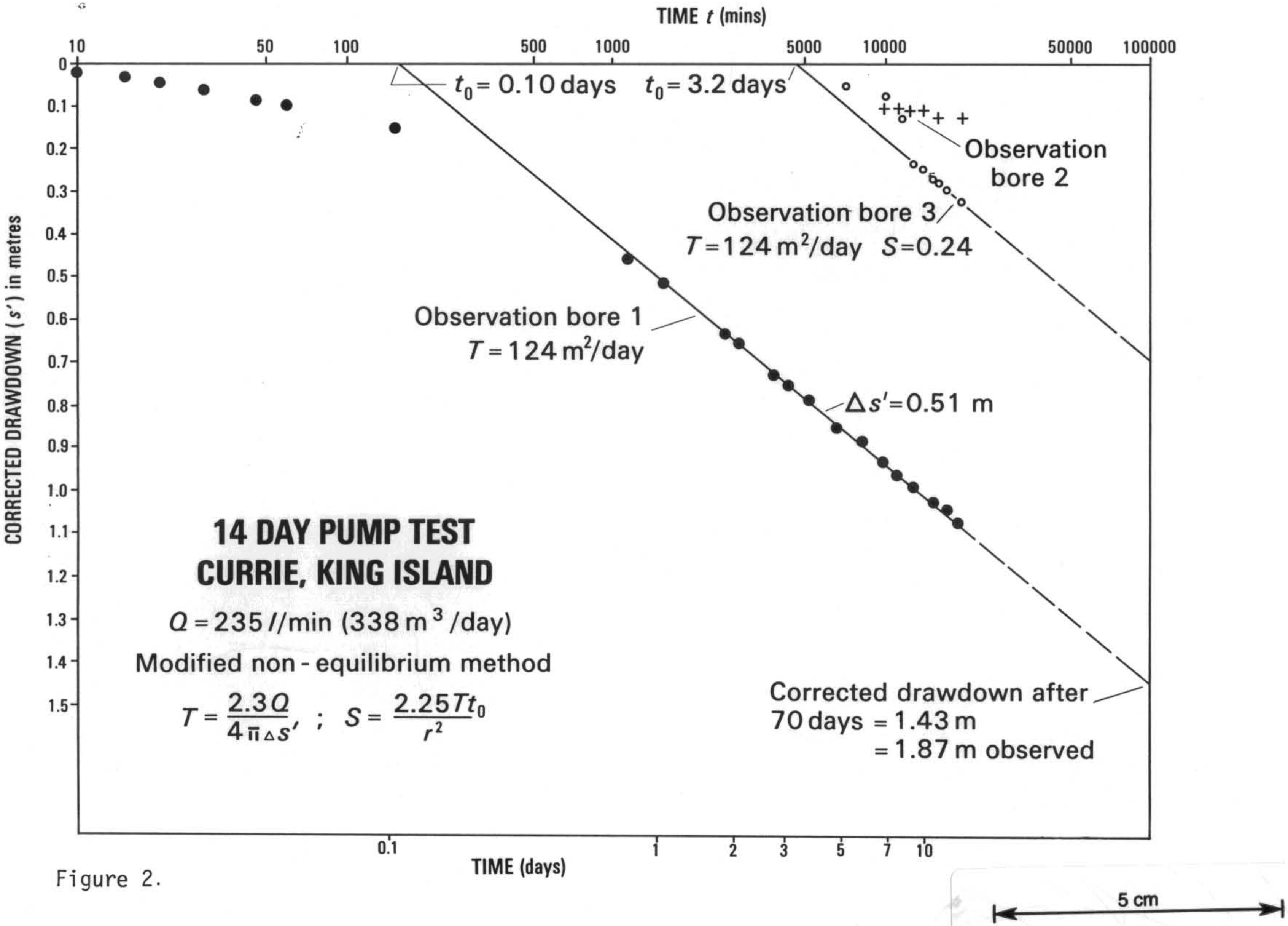
TIME t (mins)
10
50
100
500
1000
5000
10000
50000
100000
CORRECTED DRAWDOWN (s') in metres
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
t0 = 0.10 days
t0 = 3.2 days
Observation bore 2
Observation bore 3
T = 124 m2/day S = 0.24
Observation bore 1
T = 124 m2/day
Δs' = 0.51 m
14 DAY PUMP TEST
CURRIE, KING ISLAND
Q = 235 l/min (338 m3/day)
Modified non - equilibrium method
T = 2.3Q / 4πΔs' ; S = 2.25Tt0 / r2
Corrected drawdown after
70 days = 1.43 m
= 1.87 m observed
0.1
1
2
3
5
7
10
TIME (days)
5 cm

Figure 2.

Matthews (1978*b*) discusses aquifer yields in more detail and the results of this report should be read with his comments in mind. The value of specific yield (S = 0.26) calculated here does not significantly affect the total volume of extractable water calculated by Matthews (1978*a*) when he assumed a specific yield of 0.23.

WATER QUALITY

Three water samples, collected at 260, 280 and 331 hours after pumping started and chemically analysed show identical results (Table 2). This analysis is very similar to that listed by Matthews (Table 2, 1978*a*) for hole 1A, which apparently corresponds to observation bore 1 in Figure 1 of this report. The salinity of the water may decrease with pumping and Matthews' original comments on water quality remain. If the water is to be used for drinking, it will be wise to test it for bacterial contamination.

Table 2. CHEMICAL ANALYSIS OF THREE WATER SAMPLES COLLECTED DURING PUMPING

Item		
pH	7.4	
conductivity (μS/cm)	1390	
	mg/l	*meq/l*
CO_3	nil	nil
HCO_3	390	6.4
Cl	310	8.7
SO_4	44	0.9
SiO_2	5	0
Ca	110	5.5
Mg	31	2.5
Fe	<0.1	0
Al	<0.2	0
K	8.3	0.2
Na	180	7.8
Total dissolved solids	900	32.0
Permanent hardness as $CaCO_3$	86	
Temporary hardness as $CaCO_3$	320	
Alkalinity as $CaCO_3$	320	

CONCLUSIONS

The existing eight bore array is capable of yielding 340 m^3/day continuously for long periods. This is considered a maximum not to be exceeded, except for brief periods of high demand. Lower yields are preferable. Additional bores or bore arrays may be installed at suitable sites to increase the total yield, but each new site should be assessed to determine its safe yield since individual yields/bore will vary.

The long-term continuity of the supply also depends on the water balance in the aquifer. Continually falling groundwater levels during operation of the array should be viewed with concern and may be indicative of regional depletion of the resource. The aquifer should be considered an integral part of the overall hydrologic cycle and pumped on a sustained yield basis so that on average, groundwater reserves are untouched and only the recharge component of the aquifer is pumped. Such a balance between input and output is probably important at Currie where annual extraction is likely to be a large proportion of annual recharge. Consideration should be given to assessing the overall water budget in the area. This involves stream gauging, as well as monitoring the aquifer by automatic water level recorders at sites removed from the influence of pumped arrays. Long-term groundwater deficits will occur if excessive water is used and will not easily be made up.

REFERENCES

MATTHEWS, W.L. 1978*a*. Drilling for water at Currie, King Island. *Unpubl.Rep.Dep.Mines Tasm*. 1978/10.

MATTHEWS, W.L. 1978*b*. Pump tests at Currie, King Island. *Unpubl.Rep.Dep.Mines Tasm*. 1978/13.

[23 August 1978]

APPENDIX 1

Drawdowns in observation holes, Dolman's property, King Island.

Observation hole 1

Time			Drawdown (m)		Remarks
Mins.	Hours	Days	Observed (s)	Corrected (s')	
0.0	0	0	0	0	Pumping rate = 235 l/min = 338 m^3/day
1			0.003	0.003	
3			0.006	0.006	
5			0.009	0.009	
10			0.021	0.021	
15			0.032	0.032	
20			0.044	0.044	
30			0.064	0.063	
45			0.089	0.088	
60	1		0.100	0.099	
150	2.5		0.150	0.147	
1140	19		0.483	0.454	
1320	22		0.508	0.476	
1560	26	1	0.546	0.509	
2580	43		0.679	0.621	
2820	47	2	0.699	0.638	
3000	50		0.711	0.648	
4020	67		0.800	0.720	
4500	75	3	0.832	0.745	
5460	91		0.876	0.780	
5940	99	4	0.908	0.805	
6900	115		0.953	0.839	
7140	119		0.959	0.844	
7320	122	5	0.965	0.849	
8340	139		1.016	0.887	
8760	146	6	1.028	0.896	
9780	163		1.054	0.915	
10020	167		1.066	0.924	
10200	170	7	1.072	0.928	
11220	187		1.099	0.948	
11460	191		1.105	0.952	
11640	194	8	1.111	0.957	
12660	211		1.129	0.970	
12900	215	9	1.141	0.978	
13080	218		1.147	0.983	
14100	235		1.177	1.004	
14580	243	10	1.183	1.008	
15600	260		1.201	1.021	Water sample collected
16080	268	11	1.207	1.025	
16980	283		1.225	1.037	Water sample collected
17220	287	12	1.231	1.042	
17400	290		1.237	1.046	
18420	307		1.249	1.054	
18660	311	13	1.255	1.058	
18840	314		1.261	1.062	
19860	331		1.267	1.066	Water sample collected

Observation hole 3

Time			Drawdown (*m*)		Remarks
Mins.	Hours	Days	Observed (*s*)	Corrected (*s'*)	
0	0	0	0	0	
7200	120	5	0.050	0.050	
10020	168	7	0.075	0.074	
11520	192	8	0.127	0.125	
12960	216	9	0.241	0.234	
14100	235		0.241	0.234	
14580	243	10	0.254	0.246	
15600	260		0.279	0.269	
16080	268	11	0.286	0.276	
16980	283		0.305	0.293	
17220	287	12	0.305	0.293	
17400	290		0.305	0.293	
18420	307		0.318	0.305	
18660	311	13	0.322	0.309	
18840	314		0.324	0.311	
19860	331		0.337	0.323	

Observation hole 2

0	0	0	0	0	
7200		5	0.050	0.050	
10020		7	0.102	0.101	
11520		8	0.102	0.101	
12960		9	0.114	0.112	
14100	235		0.114	0.112	
14580	243	10	0.114	0.112	
16080	268	11	0.127	0.125	
	268-331	11-13+	0.127	0.125	