1983/19. Pump tests on a water bore at Cygnet

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Abstract

A three-day pump test on a water bore near Cygnet shows that groundwater could supplement the town supply during dry periods. An iron content greater than is usually recommended for town supplies may be overcome by settlement before reticulation. Recharge of the aquifers is likely after winter rains.

INTRODUCTION

The Municipality of Port Cygnet had a water bore installed on the recreation ground [EN060216] north of the town centre to examine the possibility of using groundwater to supply part of the town's reticulated water needs during periods of peak usage. The bore was installed in late February-early March 1983 by Gerald Spaulding Drillers Pty Ltd of Devonport, and during a short test it was estimated that the bore had a capacity of about 450 *l*/min (6000 gallons per hour). The bore was drilled to a depth of about 56.4 m and water was reported to have been struck at 13.7 m, 39.6 m, 47.3m and 51.8 m from the surface. The Council requested a longer pump test to examine whether the bore would sustain the reported output over a summer period. It was suggested that pumping would be required for about six hours per day during the summer, when garden watering is at the maximum rate.

Acknowledgement is given to members of the Council who aided in the undertaking of this test, particularly Mr L. Clarke who recorded most of the pump test information.

RELIEF AND GEOLOGY

The bore is situated near Agnes Rivulet, which runs through the town. The catchment of the rivulet and its tributaries (fig. 1) consists of relatively steep and broken land covering an area of about 42 km². The bore is situated at an altitude of less than 20 m above sea level, while parts of the margin of the catchment rise to 440 m above sea level some five kilometres from the bore.

Alluvium occurs in the valley surrounding the stream. Tillite, the basal part of the Permian sequence, occurs at the bore site and this, together with higher formations of Permian age, underlies a large part of the catchment, with areas of Jurassic dolerite and Triassic sediments underlying parts of the northern half (Farmer, 1981). Dykes of Cretaceous syenite intrude the Permian rocks and a small outcrop of this material is situated upstream of the bore. Drill cuttings indicate that a syenite body was struck in the borehole and from discussions, it is probable that it was encountered to about 12 m, with the Permian sediments then being penetrated to the bottom of the hole. The Permian material consists largely of siltstone and mudstone fragments with occasional fragments of broken rounded pebbles.

NATURE OF THE AQUIFER

The driller's report shows there are four main zones where water was struck. From an examination of the material in the drill cuttings, the water that can be extracted is likely to be mainly fissure water rather

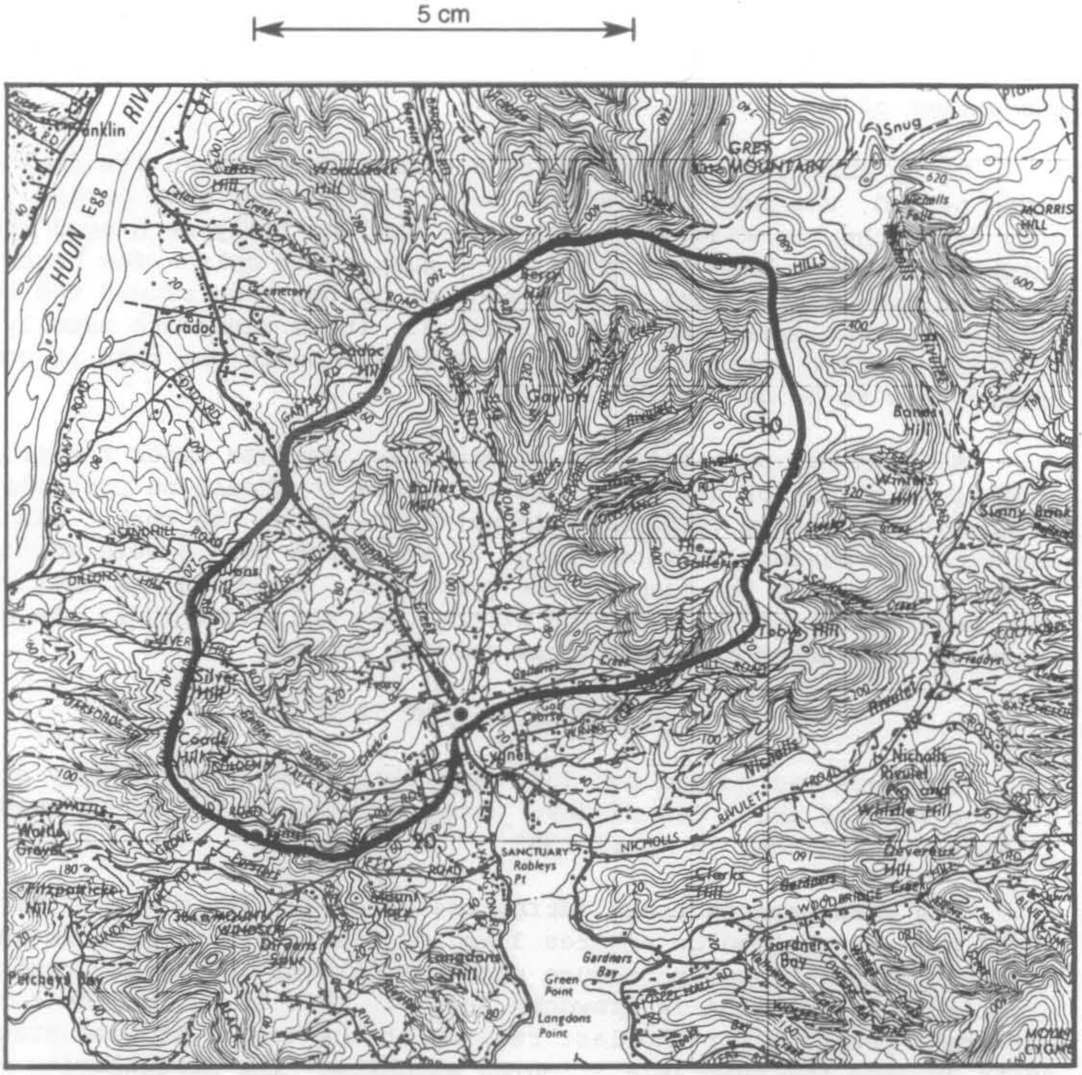


Figure 1. *Approximate catchment basin of Agnes Rivulet. Location of borehole shown by bold dot.*

than intergranular (*i.e.* it is stored in joints and fractures and in the case of sedimentary rocks, along bedding planes). The fissured zones where water is struck frequently only extend over small intervals in the bore-holes, and in most bores in Tasmania the aquifers are confined (*i.e.* the water level rises in the borehole above the level it is struck). The rate at which water can be extracted depends on the width of these fissures and the degree of interconnection.

DESIGN OF PUMP TEST

It was at first thought that the bore would be pumped continuously for the town supply, which would require a pump test of at least one week or more to warrant the expense of buying a pump and establishing the system to connect it to the town supply. However with the expected use being only a few hours per day, a shorter pump test was undertaken.

Fissure aquifers are more likely to have large variations in permeability laterally than extensive unconsolidated aquifers of sand and gravel. The function of a pump test is to determine whether the cone of depression in the potentiometric surface extends into zones of lower permeability (*i.e.* less fissures or less interconnection between them) than in the rock in the immediate vicinity of the bore. If lower permeability zones are encountered, the rate of output will decrease. If the cone of depression extends into zones of equal or greater permeability, the initial output is likely to be maintained. The longer the pump test, the greater the extent of the cone of depression.

To be absolutely certain that a bore will maintain its flow for a given period, the pump test should be conducted over that period. The only doubt then is whether the aquifers will be fully recharged with rain-water. In cases where a bore is being pumped for only a few hours each day, the non-pumping time allows recharge of the zone around the bore even if more distant areas are less permeable. It is therefore usually safe to consider shorter term pump tests under these conditions than if continuous pumping was to be undertaken.

A three-day pump test was regarded as adequate under the proposed conditions of use of the bore. In this time it should be possible to establish any nearby variations in permeability of the rock. Six bores are known at nearby locations (fig. 2) and water levels were monitored in these holes during the time of the pump test. Drawdown was measured in the pumped hole for the duration of the test and recovery in the hole was measured over about two days after pumping ceased.

RESULTS OF PUMP TEST

The bore was pumped for just over three days continuously at an average rate of about 620 m^3/day. Pumping took place from Wednesday 13 April to Saturday 16 April 1983.

The measurements taken during the pump test are given in Tables 1 and 2 and are plotted on Figures 3 and 4. Plots of drawdown in the pumped hole are often irregular because small variations in pumping rate can cause significant variations in drawdown trends. This is the reason for the off-trend position for the last reading of the test. At that stage the belts driving the pump were slipping slightly. The irregularity between 50 and 100 minutes is due to difficulty in obtaining a reliable result from the electrical measuring device used to measure drawdown at this depth. An aquifer was reported over this interval and water flow over the terminals created problems in determining drawdown accurately.

The drawdown rate was fairly regular till about 2600 minutes (43.3 hours) when it steepened sharply. This steepening is either due to the cone of depression extending to less permeable areas, or one of the aquifers being drained and not supplying water to the system, or a combination of both. The drawdown only extended below one of the reported aquifers (at about 13.7 m) where it was reported that a flow of about 150 *l*/min (2000 gallons per hour) was obtained. The recovery curve indicates that by the end of the test, this aquifer was supplying little, if any water. If 150 *l*/min of water were entering the bore from this aquifer, recovery to that level would be rapid. The change in the rate of drawdown may be largely due to the drainage of this aquifer.

After 2600 minutes, the drawdown rate again establishes a regular pattern which continues to the end of the test (except for the last reading - see explanation above). If this trend is extrapolated to 100 000 minutes (about 70 days), a time often considered for long-term pumping of a bore, the drawdown would extend to about 58 m or just below the bottom of the hole.

On this trend the bore could be pumped for about 56 days continuously at the rate pumped in the test before the drawdown would reach the bottom of the hole. This assumes that the cone of depression does not extend into less permeable zones, in which case the drawdown would increase more rapidly with time. However if the cone of depression extended into zones of greater permeability, the drawdown curve would flatten and the bore could be pumped continuously for a longer time.

The main risk is whether less permeable zones occur outside the area tested during the pump test. As it is proposed to pump the bore for about six hours per day, or about one quarter of the time, the risk of too great a drawdown being obtained becomes much less. The long non-pumping period allows recovery of the aquifers even from less permeable zones. The pump test shows that the bore is likely to be capable of supplying water for the periods required (*i.e.* for extended periods at six hours per day, pumping at the rate tested), and may be capable of being pumped for much longer periods.

WATER QUALITY

Three samples of water were taken for analysis during the pump test, one at the beginning, one about the middle, and the final sample before the pump was turned off. These analyses are shown in Table 3, together with an analysis undertaken by the Port Cygnet Council some time before the pump test was undertaken.

The main problem with using the water as a domestic supply is the iron content. The first three analyses show that nearly all the iron was in the suspended solids (TSS). It is not known whether the iron is coming out of solution by oxidation when it reaches the surface, as is usually the case, or whether the water is bringing small amounts of the rock aquifer material with it. In either case, the iron could be removed by settlement and/or filtration.

As the Government Analyst reports, the hardness is above the desirable limit for town supply water but below the maximum permissable limit.

EFFECT ON NEARBY BORES

Water levels on six nearby bores (fig. 2) were monitored throughout the pumping stage of the test. The results of these are plotted on Figure 4.

There is little positive evidence of the bores being affected during the period of pumping; in fact the main evidence is negative, as the water level in several bores rose towards the end of the pump test. This is probably due to either recharging of the aquifers by rain during the period of the test or, if the aquifers are also confined (as are those in the recreation ground bore), the fluctuations in water levels could be associated with air pressure changes. Heavy rain occurred from 1½-2 days after the pump test started.

Although no interference with nearby private bores was shown, some effects may be possible after pumping over long periods during the summer. Any effects are likely to be small, particularly to the more distant bores.

RECHARGE

No estimate of recharge can be given. The size of the surface catchment above the level of the bore suggests that recharge should not be a problem, although part of the available recharge will service other bores throughout the area. Assuming an average rainfall over the catchment of

875 mm and that 1% of this, or 350 000 m³ is available for recharge, at the proposed rate of withdrawal the bore would only require about 5% of this recharge. These figures are not regarded as reliable, except for the rainfall, but give an idea of the quantities that may be involved. It can be concluded therefore that there is a good chance the supply will be replenished each winter.

CONCLUSIONS

The pump test has shown that the bore should be capable of supplying the required amount of water (*i.e.* being pumped for about six hours per day and producing 140 to 160 m³ of water per day), for extended periods over the summer. Because fractured rock aquifers can have a widely varying permeability, it would be advisable to install a system that can be easily and cheaply dismantled in the first year or two of operation, in case the bore does not perform up to expectations. If account is kept of the amount of water used and water levels are monitored in the bore, an assessment of the bore performance can be made and output may be increased or decreased accordingly.

From the analyses undertaken, the iron content appears to be the main problem in using the water as a domestic supply. This problem can be overcome by settling before reticulation and perhaps aerating prior to settling if the iron is precipitating from solution on arrival at the surface.

Observations in nearby holes during the pump test suggest that mutual interference is unlikely to be a large problem and there may possibly be no effect at all on these bores. Any affects are likely to show up towards the end of dry summers after extensive use of the town bore.

Because of the large catchment area upstream from the bore, replenishment of the aquifers is likely over winter periods.

Additional water may be obtainable by the installation of one or more bores. The output will depend on the degree of fracturing in the rock at the points selected. To avoid serious interference any extra bores should be sited at least 300-400 m away from the present and any other bore.

REFERENCE

FARMER, N. 1981. Geological atlas 1:50 000 series. Sheet 88 [8311N]. Kingborough. *Department of Mines, Tasmania*.

[26 May 1983]

Table 1. DRAWDOWN AND RECOVERY DATA

PUMPING STAGE			RECOVERY STAGE			
Time (minutes)	Water level (m)	Output (m^3/day)	Time since pump stopped (t') (mins)	Total time (t) (mins)	t/t'	Water level (m)
0	2.59		0	4342		23.85
1	5.03		3.5	4345.5	1242	21.40
2	5.46		4.5	4346.5	966	20.98
3	5.78		5	4347	869	20.92
4	6.02		7	4349	621	20.79
5	6.29		10	4352	435	20.68
7	6.76		15	4357	291	20.41
10	7.02	596	23	4365	190	20.30
15	8.15		31	4373	141	20.13
20	8.71		65	4407	67.8	19.93
31	10.01	640	85	4427	52	19.76
47	11.32		195	4537	23.3	19.04
67	12.78		405	4747	11.7	17.83
97	12.65	640	1335	5677	4.3	12.83
157	12.90	618	1725	6067	3.5	11.13
220	13.89		2895	7237	2.5	7.34
343	14.38	618				
447	15.06					
1232	17.35	596				
1507	18.01	640				
1777	18.01	640				
2767	19.44	618				
3097	20.68	640				
3217	21.03	618				
4132	23.78	618				
4334	23.85	540				
4342	Pump stopped					

Table 2. WATER LEVELS MEASURED IN PRIVATE BORES

COAD (Hole 2)

Day	*Time (hours)*	*Time since first observation after pump started (mins)*	*Water level (m)*
Tuesday	∿1330	-	6.17
Wednesday	1028	0	6.13
	1610	342	6.12
Thursday	0930	1382	6.12
	1625	1797	6.10
Friday	1010	2862	6.10
	1620	3232	6.10
Saturday	0830	4202	6.07
	1100	4352	6.10

AREA SCHOOL (Hole 3)

Tuesday	∿1330	-	2.02
Wednesday	1023	0	1.99
	1600	337	1.93
Thursday	0925	1382	1.93
	1620	1797	1.93
Friday	1000	2857	1.91
	1615	3232	1.88
Saturday	0825	4202	1.85
	1055	4352	1.80

CRIPPS (over creek; Hole 4)

Tuesday	∿1330	-	0.51
Wednesday	1010	0	0.51
	1550	340	0.48
Thursday	0905	1375	0.48
	1610	1800	0.48
Friday	0950	2860	0.48
	1550	3220	0.48
Saturday	0815	4205	0.46
	1040	4350	0.46

CRIPPS (near dam; Hole 5)

Tuesday	∿1330	-	0.32
Wednesday	1005	0	0.34
	1545	340	0.31
Thursday	0910	1385	0.33
	1605	1800	0.33
Friday	0945	2860	0.36
	1545	3220	0.36
Saturday	0810	4205	0.36
	1035	4350	0.34

Table 2. (continued)

FITZPATRICK (Hole 6)

Day	*Time (hours)*	*Time since first observation after pump started (mins)*	*Water level (m)*
Tuesday	∿1330	-	1.69
Wednesday	0955	0	1.69
	1530	335	1.63
Thursday	0850	1375	1.70
	1550	1795	1.70
Friday	0930	2855	1.68
	1620	3245	1.68
Saturday	0805	4210	1.68
	1030	4355	1.67

FLAKEMORE (Hole 7)

Day	*Time (hours)*	*Time since first observation after pump started (mins)*	*Water level (m)*
Tuesday	∿1330	-	1.72
Wednesday	0946	0	1.68
	1520	334	1.68
Thursday	0850	1384	1.70
	1550	1804	1.70
Friday	0925	2859	1.68
	1605	3259	1.65
Saturday	0745	4199	1.63
	1020	4354	1.60

For location of holes see Figure 2.

Table 3. CHEMICAL ANALYSES OF WATER SAMPLES

Sample	1	2	3	4
pH	6.8	7.2	7.3	7.2
Conductivity (μS/cm)	800	960	960	
	mg/l	*mg/l*	*mg/l*	*mg/l*
CO_3	nil	nil	nil	
HCO_3	245	285	285	
Cl	145	185	180	146
SO_4	19	19	23	20
SiO_2	31	25	25	
Ca	48	49	49	51
Mg	23	26	27	21
Fe	<0.1	<0.1	<0.1	3
Al	<0.2	<0.2	<0.2	
K	3.8	5.5	5.5	
Na	91	130	130	91
TDS	500	590	590	483
Hardness - Permanent	15	nil	nil	) 215
Hardness - Temporary	200	230	235	)
Alkalinity	200	235	235	195
TSS	25	7	>12	14
Fe in SS	2.6	0.8	8.4	

1. Taken 25 minutes after start of pumping.

2. Taken about 29.5 hours after start of test.

3. Taken at end of test.

4. Analysis performed by Government Analyst from sample supplied by the Council. Additional determinations - colour 70 Hazen units, Mn 0.38 mg/*l*, Cu <0.01 mg/*l*, Zn 0.02 mg/*l*, NO_3 <1 mg/*l*, NO_2 <0.01 mg/*l*. In samples 1, 2, and 3 the Fe in the TSS has been expressed as mg/*l* in the original solution.

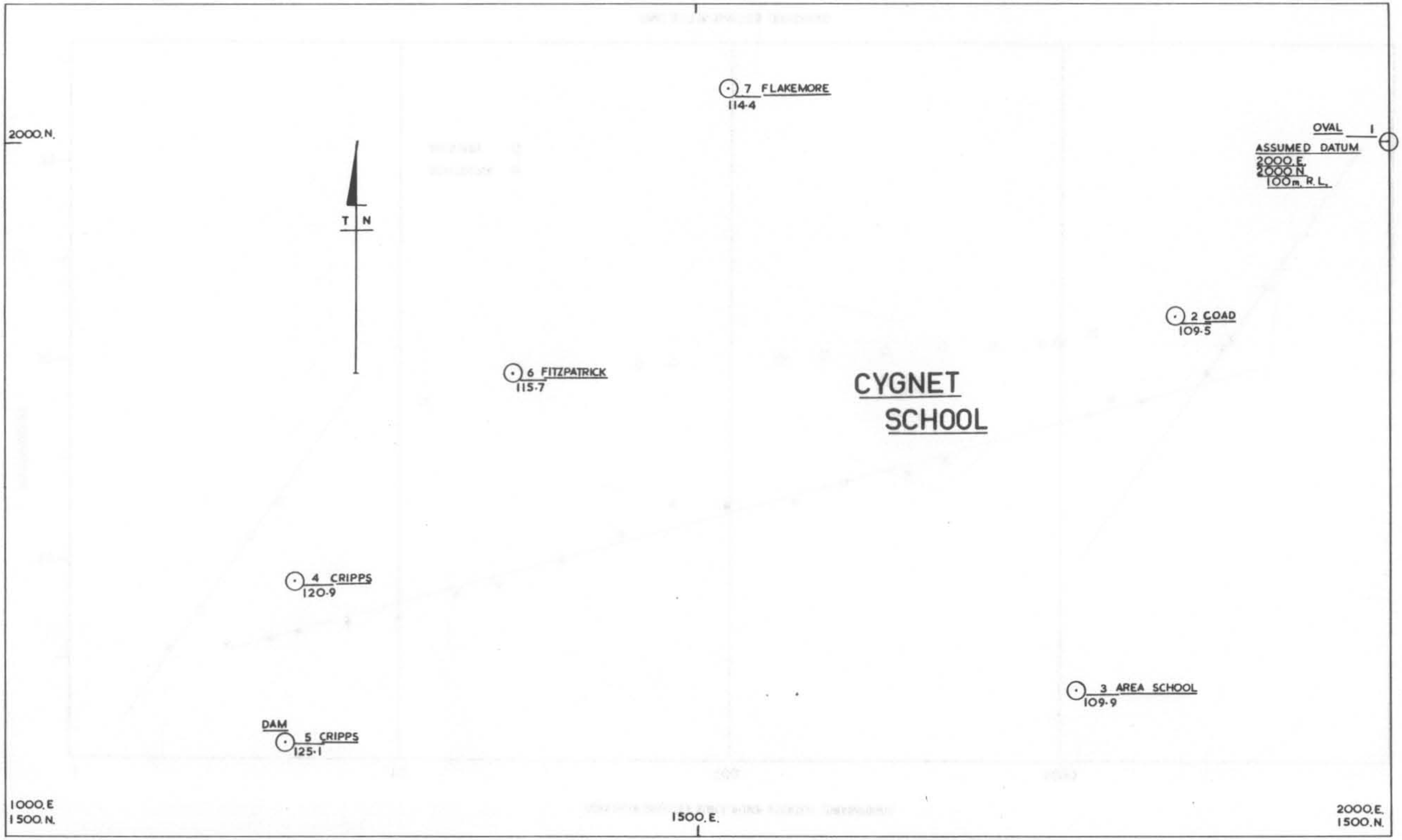
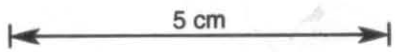


Figure 2. *Surveyed locations of water bores, Cygnet.*



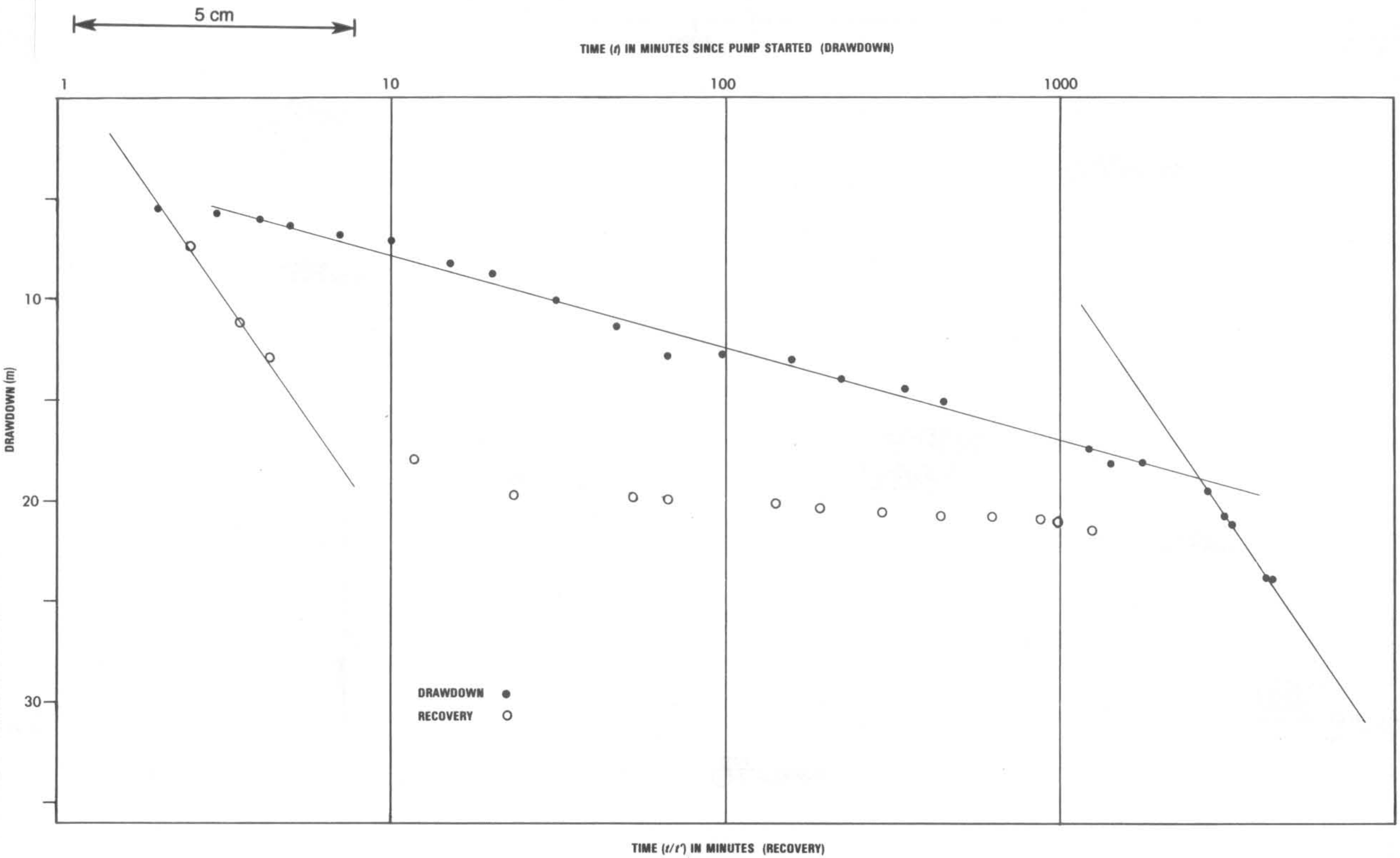


Figure 3. *Drawdown and recovery curves, Cygnet water bore pump test.*

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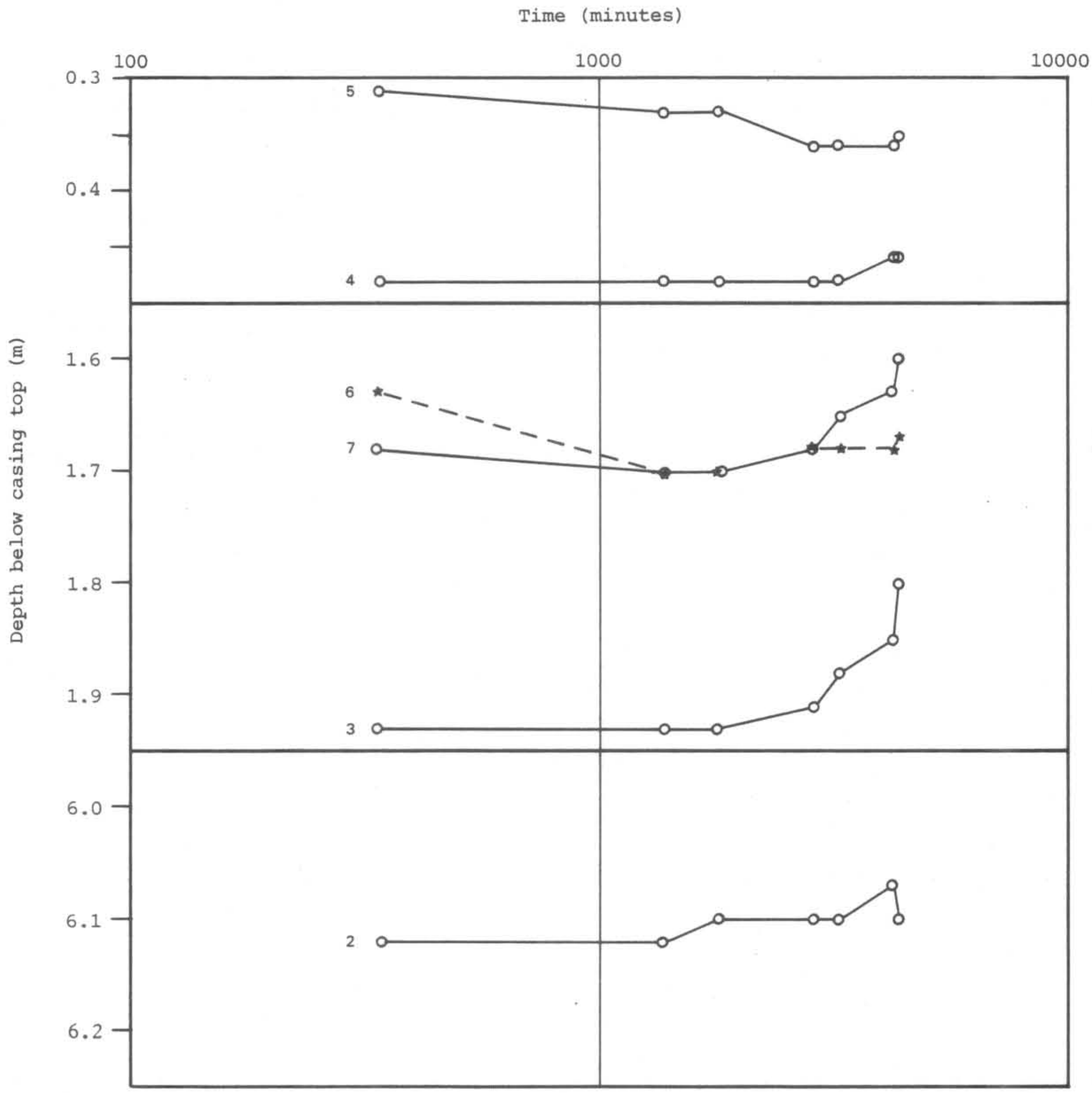

Figure 4. *Measured drawdowns in private water bores, Cygnet. Bore numbers and standing water levels are:*

- *(2) Coad, SWL 6.13 m*
- *(3) Area school, SWL 1.99 m*
- *(4) Cripps, SWL 0.51 m*
- *(5) Cripps (dam), SWL 0.34 m*
- *(6) Fitzpatrick, SWL 1.69 m*
- *(7) Flakemore, SWL 1.68 m*

5 cm