DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rept. Bk. No. 80/60

WILMINGTON WATER SUPPLY

DISCHARGE TEST ON SPRING CREEK MINE SHAFT

By

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D.M. No. 475/69

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DEPARTMENT OF MINES AND ENERGY
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WILMINGTON WATER SUPPLY

DISCHARGE TEST ON SPRING CREEK MINE SHAFT

ABSTRACT

A 26 hour test on the Spring Creek Mine Shaft well used for the Wilmington Town Water Supply has shown that the discharge of the existing pump is very close to the safe yield of the well.

Analysis of the drawdown curve shows that a second production well sited about 150 metres from the present well in the same fissure system would produce only minor interference with the existing well.

A scout drilling programme on the opposite side of Spring Creek to explore the potential for an additional supply is recommended.

INTRODUCTION

The Spring Creek Mine Shaft has supplied Wilmington with water since 1917. Recently the Engineering and Water Supply Department has been concerned that the installation may not be adequate for increased demand, and requested an investigation.

As a start to the investigation a discharge test was conducted by observing the decline in water level during 26 hours continuous pumping.

WELL DETAILS

The 'well' Unit NO. 6532004WW01005, is a rectangular shaft, 2.1 metres by 3.5 metres. The shaft was sunk between 1866 and 1874, and no details are recorded of the depths at which water was cut.

Access to the pump controls is by means of an adit about 9 metres above the level of the bed of Spring Creek.

Standing water level was 10.12 metres below the safety-grille at the adit level.

The only workings recorded as extending from the shaft below water level consist of a cross cut driven for 15 metres, 30 metres below the adit level.

The shaft bottom is 32 metres below the adit level, and the pump is set at 29.5 metres.

The pump had been switched off for about 18 hours prior to the test. Previous pumping had only been for short periods and it is considered that the well was close to full recovery at the start of pumping.

PUMPING

The pump in the shaft was run for 26 hours continuously. The pump is a submersible turbine and as a result pumping rate declines with increasing head.

Volume discharged was measured from a water meter on the discharge line.

Average discharge for the first 30 minutes was 1020 kL/day. This steadily declined to 870 kL/day at 900 minutes after which it remained constant.

Since the fluctuation in rate is relatively small and since it stabilized in the later part of the test the variation should not materially affect the results.

Water was pumped into the Wilmington water supply system and therefore there was no possibility of water returning to the aquifer.

HYDROGEOLOGY

The well is located in slates of the Tapley Hill Formation, just above the Rhynie Sandstone which forms a prominent ridge to the east (Fig. 1).

A large east-west fault has cut off the Rhynie Sandstone. The fault is exposed in a bench cut out for a water tank 30 m north of the well. Minor faults and bedding plane shears are exposed in the adit near the well.

Springs occur on the eastern side of the range, and also in Spring Creek about 200 metres downstream from the Mine Shaft.

This shows that recharge is by direct infiltration through outcrop on the range, and that there must be a groundwater divide roughly co-incident with the surface water divide.

Groundwater quality averages 600 mg/1 TDS.

ANALYSIS

The stored volume in the well is relatively large and can be seen to have affected the drawdown curve.

Type curves were published by Papadopolous and Cooper (1967) for pumped wells with significant storage.

The hydraulics are further complicated by the occurrence of leaky aquifer conditions, which have caused drawdowns to stabilize later in the test. The semi-log plot of drawdown (Fig. 2) cannot therefore be analyzed, but some conclusions can be reached from the loglog plot of drawdown (Fig. 3).

The following assumptions must be made:

1. That well loss is negligible; this is reasonable for a large well in a fractured rock aquifer.
2. That the effective radius of the well is similar to the radius of the excavation - less than about 2.5 metres (see Table 1).

The log-log plot of drawdown cannot be matched with any standard type curve since aquifer leakage has caused significant deviations from the Papadopolous and Cooper curve before the latter converged with the Theis curve. In other words leakage became significant while the large stored volume was still influencing drawdown.

Using the fact that any leaky aquifer curve must consistently diverge from the corresponding non leaky aquifer curve, rough matches were made with the Papadopolous and Cooper curves.

The maximum value of transmissivity is 48 m^2/day, and the best fit 13 m^2/day (see Fig. 3).

As a check, storage coefficients were calculated (Fig. 3) using the two above values of transmissivity. The results, 7×10^{-2} and 7×10^{-6} are near the limits of realistic values. It is therefore reasonably certain that the transmissivity also lies between the two values estimated.

Since this is a leaky aquifer maximum drawdowns in the aquifer can be predicted using the formula

$$s_m = \frac{Q}{2\pi T} K_o\left(\frac{r}{L}\right)$$

Where T = transmissivity

Q = discharge

$K_o(\frac{r}{L})$ is Hankel function

r = radius

L = leakage factor

s_m = 'steady state' drawdown

Since s_m for the pumped well is known, s_m at any distance 'r' from the pumped well can be estimated using different values of transmissivity and effective radius of the pumped well. These are tabulated in Table 1.

The 1.8 m effective radius represents the probable value and 2.5 m the extreme value.

TABLE 1

Estimates of drawdown in aquifer

Assumed transmissivity, m^2/day " well radius, r_w,m	48 2.5	48 1.8	13 2.5
Distance from pumped well metres			
10	9.8	8.6	2.7
100	3.2	2.4	<0.01
150	2.2	1.5	very small
200	1.6	1.0	very small

It can be seen that for the worst combination (T = 48 m^2/day, r_w = 2.5 m) drawdown at 100 metres would be 3 metres, reducing to 1.6 metres at 200 metres.

INTERPRETATION OF RESULTS

The leaky aquifer results obtained from the test must be interpreted in the light of the geological setting. The most likely hypothesis is as follows:

1. The well taps a fissure system parallel to the fault.
2. The fissure system is of considerable depth relative to the cone of drawdown, and acts as an planar-aquifer.
3. Drawdowns are stabilized by leakage before the cone of depression extends to the down dip or along strike boundaries of the system. (The phreatic boundary would occur too early to be detected).
4. Leakage is probably occurring from jointed slates adjacent to the fault zone.

Word of mouth evidence indicates that water level declines to near the pump intake in dry seasons. Although the water level stabilized

5.5 m above the pump intake at the end of this test the well is operating at near its safe yield.

CONCLUSIONS

1. The pump installed in the existing well is operating at the safe yield of the well, about 870 kL/day.
2. To increase the yield a new drilled well will be needed. This will have to be located close to the fault to obtain a suitable yield. Since permeability in this type of environment will vary widely several attempts may be needed.
3. The aquifer system should be able to provide a much larger yield. Under present conditions groundwater is discharging into Spring Creek. Although exploitation might lead to a cone of depression this would be recharged from the creek in the winter months.

RECOMMENDATIONS

Scout drilling to locate a site for a high yielding well should be undertaken. Drill holes should be located west of the existing well on the opposite side of Spring Creek.

RR:NK

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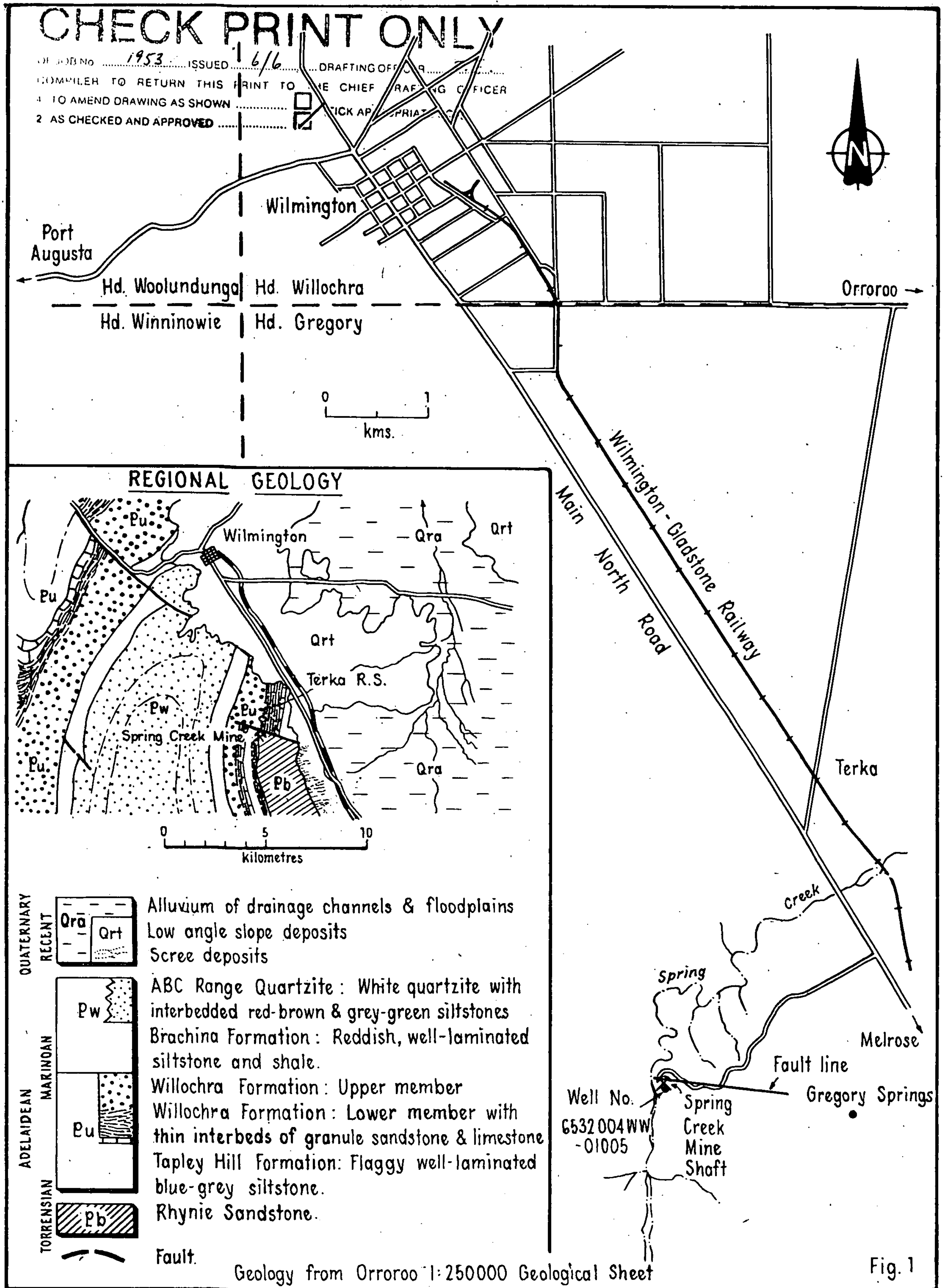
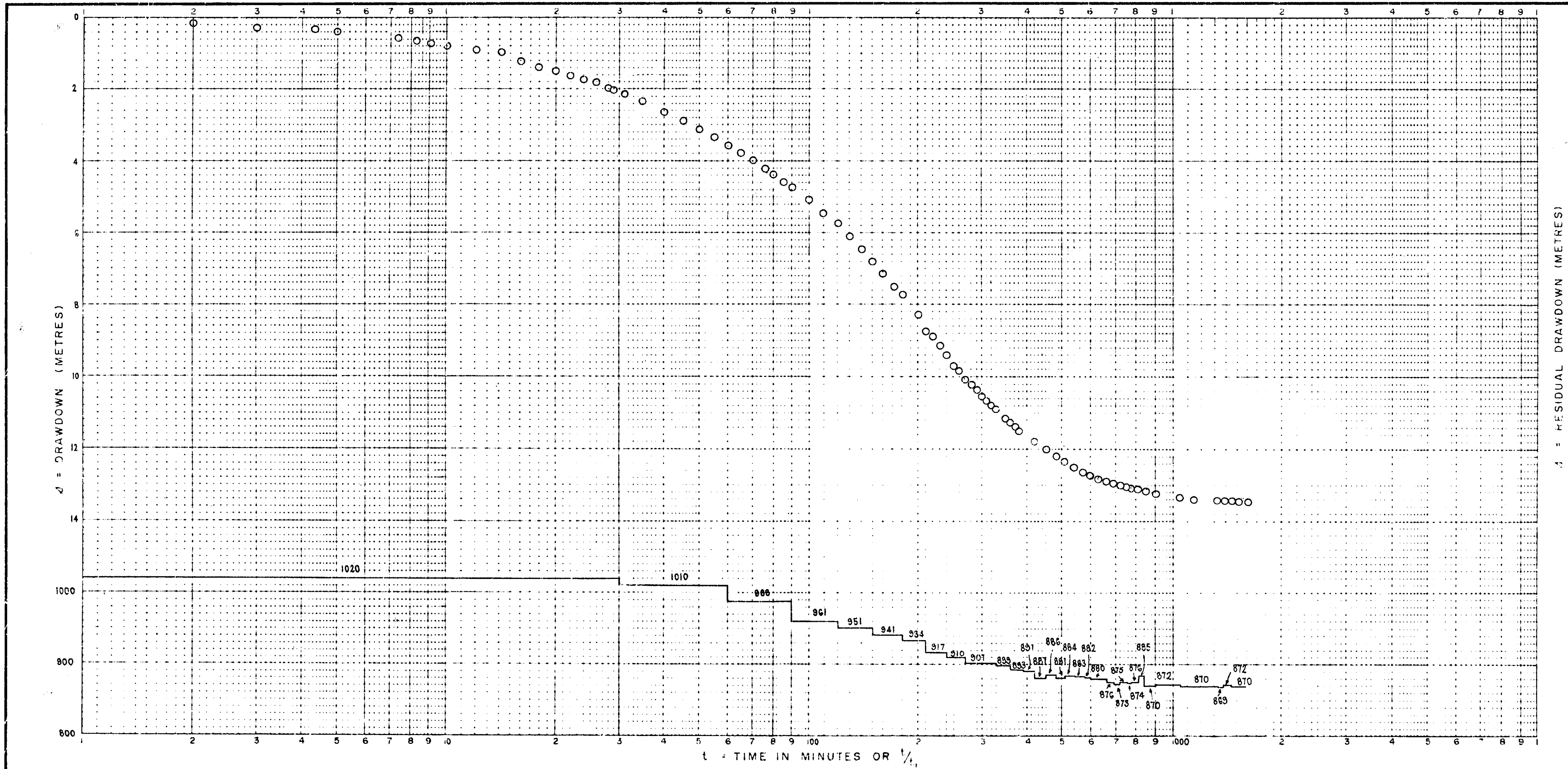
REFERENCES

Papadopolous, I.S. and Cooper H.H., Drawdown in a Well of Large Diameter. Water Res. Res. 1967 V3, no. 1 pp. 241-244.

Summers, K.W.A. Spring Creek Copper Mine. Mining Review no. 98.



	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE As shown
COMPILED: R. Read	WILMINGTON TOWN WATER SUPPLY	DATE 3rd June 1980
DRN. TE · CKD	LOCALITY PLAN	PLAN NUMBER S 14874



BOREHOLE STATE/UNIT No. 6532 004 WW01005

REF. PT. (m) above ground

AQUIFER FROM TO (m)

HOLE DEPTH 30 (m)

TYPE OF PUMP Submersible

LENGTH OF TEST 26 hours

DEPTH WATER LEVEL AT TEST START (ℓ_2) 10·12 (m)

DEPTH PUMP INTAKE (ℓ_1) 29·5 (m)

* AVAILABLE DRAWDOWN 19 (m)

EQUATIONS

$$T = \frac{0.183 \times Q}{\Delta_s} \qquad S = \frac{2.25 \times T t_0}{r^2}$$

In which

T = Transmissivity (m^3/day/m)

Q = Pumping Rate (m^3/day)

Δ_s = Drawdown per log cycle (m)

S = Storage Coefficient

t_0 = Zero drawdown time (mins)

r = Distance to Observation Bore (m)

1 day = 8.64×10^4 secs.

DATA

Q	Δ_s	t_0	r
870 m^3/day			

maximum drawdown 13·5 m

CALCULATIONS

This semi-log plot cannot be analysed.

See log-log plot

* Available drawdown = $\ell_1 - \ell_2$

Fig. 2

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

R. Read

WILMINGTON TOWN WATER SUPPLY

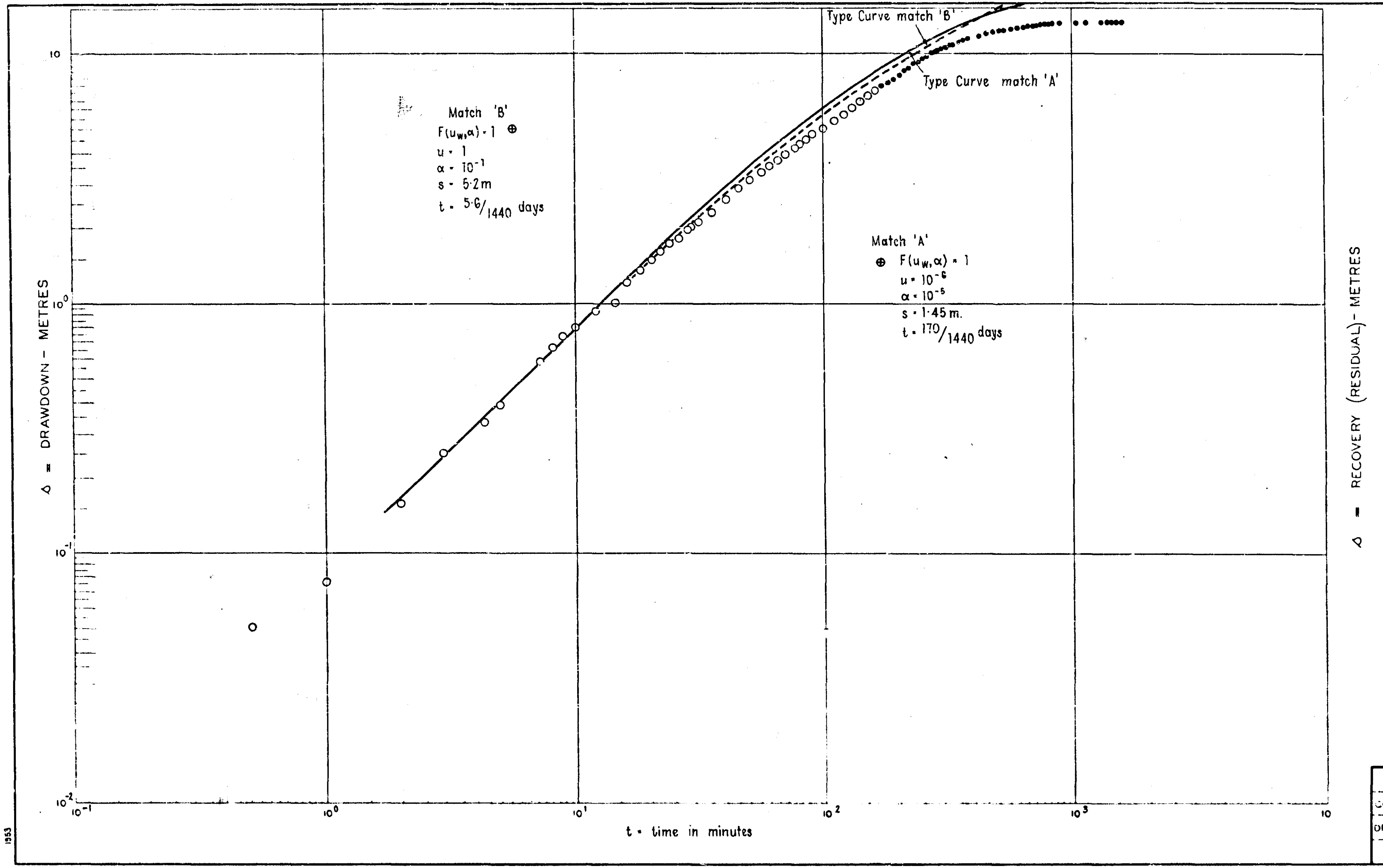
WELL No. 6532 004 WW01005

SEMI-LOG PLOT OF DRAWDOWN

4th June 1980

80-360

PF No. 69-953 MH



BOREHOLE STATE N° 6532004WW01005
DEPTH TO WATER LEVEL
AT TEST START 10·12 m (L)*
PUMP INTAKE DEPTH (L)
AVAILABLE DRAWDOWN (L)

TYPE OF PUMP Submersible
DISCHARGE STARTED AT 0908 ON 5·2·80
" STOPPED AT 1148 ON 6·2·80
AQUIFER FROM 10 m TO 32·6 m (L)
HOLE DEPTH 32·6 m (L)

BASIC EQUATIONS

$$T = \frac{Q}{4\pi\Delta} F(u_w, \alpha) \qquad \alpha = \frac{r_w^2}{r_c^2} S \qquad S = \frac{4Tut}{r^2}$$

In which
T = Transmissivity ($L^3/t/L$)
Q = Pumping Rate (L^3/t)
Δ = Drawdown (L)
$F(u_w, \alpha)$ is drawdown function of Papadopoulous and Cooper for a large diameter well.

S = Storage Coefficient (dimensionless)
t = time (t)
r_w = effective radius of the well in the aquifer
$r_c = \sqrt{A/\pi}$, where 'A' is area of the well at water level

CALCULATIONS

1. At Match Point 'A' for maximum estimate of 'T'

$$T = \frac{870}{4\pi \times 1{\cdot}45} \times 1 = 48\ m^2/day$$

a. from $S = \frac{4Tut}{r_w^2}$ $\qquad S = 7 \times 10^{-6}$

b. from $S = \frac{\alpha r_c^2}{r_w^2}$ $\qquad S = 7 \times 10^{-6}$

2. Match Point 'B' best fit

$$T = \frac{870}{4\pi \times 5{\cdot}2} \times 1 = 13\ m^2/day$$

a. from $S = \frac{4Tut}{r_w^2}$ $\qquad S = 0{\cdot}06$

b. from $S = \frac{\alpha r_c^2}{r_w^2}$ $\qquad S = 0{\cdot}07$

* L = unit of Length
t = time unit

Fig. 3

HYDROGEOLOGY SECTION	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	
COMPILED R Read	WILMINGTON TOWN WATER SUPPLY	DATE 4th June 1980
DRN T. E. CHD	WELL No. 6532004WW01005	
WR	LOG/LOG PLOT OF DRAWDOWN	80-361