DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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DETERMINATION OF TRANSMISSIVITY FROM AIRLIFT AND RECOVERY

GEOLOGICAL SURVEY

by

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DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

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DETERMINATION OF TRANSMISSIVITY FROM AIRLIFT AND RECOVERY

ABSTRACT

Reliable values of transmissivity and permeability can be obtained by analysing residual drawdown data after airlifting in small diameter wells at a constant discharge rate.

Considerable savings in drilling cost could be achieved in regional water resource assessment programmes using small diameter wells. A conventional rotary drilling rig with air compressor could drill, case, develop and provide useful aquifer transmissivity data with only minor additional equipment. The drilling and casing of expensive large diameter wells and mobilisation of a pumping test unit could therefore be avoided.

INTRODUCTION

Following the drilling and casing of a water supply well which failed to produce the yield required to augment water supply for the city of Mount Gambier, South Australia, (Fig. 1) the State water supply authority requested that maximum information be obtained at an alternative proposed site before committing funds for the construction of an expensive production well, Smith (1978).

Consequently, a small diameter exploration well was drilled into a confined aquifer of unconsolidated sand to a depth of 287 m to provide lithological, water quality and hydraulic data. After proving the site, a large diameter production well was drilled with the slim hole used as an observation well during production testing.

This paper briefly describes the hydrogeology of the area and the method used to obtain transmissivity from an airlift test.

HYDROGEOLOGY

Mount Gambier, in the southeast of South Australia is provided with a reticulated water supply from the Blue Lake, which is within a volcanic crater. The water is derived from two aquifer systems: A confined aquifer, the Dilwyn Formation providing 60 to 80% and the remainder from a locally contaminated, karstic unconfined aquifer, the Gambier Limestone. A hydrogeological summary of the test site is shown in Table 1.

Table 1: Site Hydrogeology

Interval (m)	Unit	Lithology	Aquifer Characteristics
0-12	Holocene Volcanics over Pleistocene. Bridgewater Formation.	Volcanic tephra over calcareous aeolianite.	Above water table.
12-139	Oligo-Miocene Gambier Limestone	Marine polyzoal limestone.	Main regional unconfined aquifer-locally karstic & polluted.
139-157	Eocene transition lithologies	Marine glauconitic marl & ferruginous sand.	Minor confining beds & aquifers.
157-287	Eocene Dilwyn Formation	Carbonaceous clays, silts, sands & gravels.	Major regional confined aquifer.

The production well site (No. 8) is located about 1.5 km east of Blue Lake and is intended to provide a standby water supply in the event of cessation of pumping from the Lake. The well cannot be used for long term production because of its influence on the hydraulic regime of the groundwater, which in turn could cause an increase in the proportion of polluted Gambier Limestone groundwater entering the Lake (Turner, 1979).

WELL CONSTRUCTION

The exploration well (No. 8b) was drilled using a cable tool rig to 155.5 m and was lined with 152 mm casing to prevent lost circulation problems. The well was completed at a depth of 287.3 m using rotary with mud circulation (Fig. 2).

The well was cased with 64 mm galvanised pipe from 242.3 m to surface with 76 mm diameter screen (0.5 mm aperture) from 242.3 to 244.3 m. The annulus between the pipe and hole was pressure cemented though a non-return valve from 295.3 m to surface.

Grouting of the annulus is required under regulations of the State Water Resources Act, 1976. Following construction the screen was developed using airlift for about 20 hours.

Geophysical logging indicated that a sand aquifer between 237.3 and 250 m had the best potential for water production. A standing water depth (S.W.D.) of 5.9 m was recorded in well No. 8b. Following proving of the site, production well No. 8 was drilled using similar drilling methods as used for the test well. Construction sketches of both wells are shown in Fig. 2.

AIRLIFT METHOD

The airlift headworks consist of a 64 mm T-piece attached to the female coupling of the 64 mm pipe with a split flange, clamp and gasket at the top of the T to secure 19 mm I.D. black polythene airline pipe (Fig. 2).

The outlet of the polythene airline pipe needs to be at a depth such that a submergence ratio of 2 : 1 is obtained, Johnson (1966). In this case, with a S.W.D. of about 6 m and the airline outlet at about 40 m the submergence ratio was about 6 : 1 i.e., efficient airlift was achieved. The polythene pipe was connected to a 7.1 m^3 min^{-1} (250 cfm) compressor with an operating pressure of between 560 and 700 kPa (80 to 100 psi).

After measurement of the S.W.D. the well was airlifted for six hours with discharge rate being determined every hour by measuring the time to fill a 900 Litre tank. This method of flow rate (Q) determination was required because of the pulsing, explosive nature of water discharge. An average value of Q of 300 $m^3 day^{-1}$ (3.5$Lsec^{-1}$) was recorded.

On completion of discharge the split flange was opened and the polythene pipe quickly withdrawn. Water level recovery measurements began within 2 minutes of discharge cessation and continued to 120 minutes. An electric water level probe was used for water level readings.

RESULTS

After six hours airlift at an average rate of 300 m^3 day^{-1} and two minutes of recovery, a residual drawdown of 0.48 m was measured which recovered to within 0.16 m of the S.W.D. after 120 minutes. Residual drawdown was plotted against t/t_1 where t is time from start of discharge and t_1 is time from cessation of discharge.

Using the Jacob Equation

$T = 0.183 \times Q/\Delta s$ where

T = transmissivity ($m^3 day^{-1} m^{-1}$)

Q = average discharge rate ($m^3 day^{-1}$)

Δs = drawdown per log cycle (m)

a value of T = 280 $m^3 day^{-1} m^{-1}$ was calculated. All transmissivity data are shown in Table 2 with time-residual drawdown plots shown on Fig. 3.

Table 2: Transmissivity Data

Test	$Q\ m^3 day^{-1}$	Δs m	$T\ m^2 day^{-1}$	Comments
Airlift	300	0.194	280	Recovery data
72 hr constant discharge	4260	3.1	250	Production well (No 8) drawdown data
"	4260	3.2	240	Production well (No. 8) - recovery data.
"	4260	3.2	240	No. 8b observation well-drawdown data
"	4260	3.3	235	No. 8B observation well-recovery data.

DISCUSSION

The results presented above for testing of the production well are valid for the first 500 minutes of pumping, at which time in the 72 hour constant pumping test, a discharge boundary was intersected. Transmissivities from all tests of the production interval ranged from 235 to 280 $m^3 day^{-1} m^{-1}$ with a mean value of 240 $m^3 day^{-1} m^{-1}$. The value obtained from the airlift test on well 8b is within 17% of the mean.

The cost savings in using small diameter wells to obtain hydraulic data are obvious. At current costs of drilling, casing, screen and development in South Australia, it is reliably estimated that the ratio of test well to production well cost is 1 : 2.

For water resource investigation programmes where reliable transmissivity values are required, but a large diameter well is likely to be pumped only once, thereafter to be used for monitoring only, considerable savings in cost can be made by using small diameter wells for the determination of T and permeability (k).

During a current investigation programme into the groundwater resources of the confined aquifer of the South East of South Australia this technique has been successfully used on about 10 wells. These are then incorporated into a water level observation network.

CONCLUSIONS

Small diameter wells can be airlifted at a constant rate and recovery monitored to obtain reliable values of transmissivity and hence permeability.

Together with minor, cheap, unsophisticated and reliable equipment a drilling rig equipped with a conventional air compressor can drill, complete, develop, and provide useful hydraulic data on small diameter wells. The need to install large diameter casing and mobilise test pump equipment is eliminated with substantial cost saving.

Hydraulic models generated for water resource evaluation are more sensitive to transmissivity changes than to changes in storage. Hence, the argument that sophisticated pumping tests with observation wells are required to obtain storage terms may not always be valid when these data can be reliably estimated.

Before recommending expensive large diameter wells to obtain hydraulic data from pumping tests it is suggested that consideration should be given to which data are needed, the accuracy required, and final use of the data. For the same cost approximately twice the drilling may be achieved in some investigation programmes if the method outlined above is employed.

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PCS/GU P.C. SMITH

for MM.

REFERENCES

Johnson, E.E., (1966). Groundwater and Wells. Saint Paul, Minnesota.

Smith, P.C., (1978). Mount Gambier Town Water Supply Completion Report for Standby Well No. 8. S.A. Dept. Mines & Energy Rept. Bk. 78/9 (unpub.).

Turner, J.V., (1979). The Hydrologic Regime of Blue Lake, South Eastern Australia. unpub. Ph. D. Thesis School of Earth Sciences, Flinders Univ.

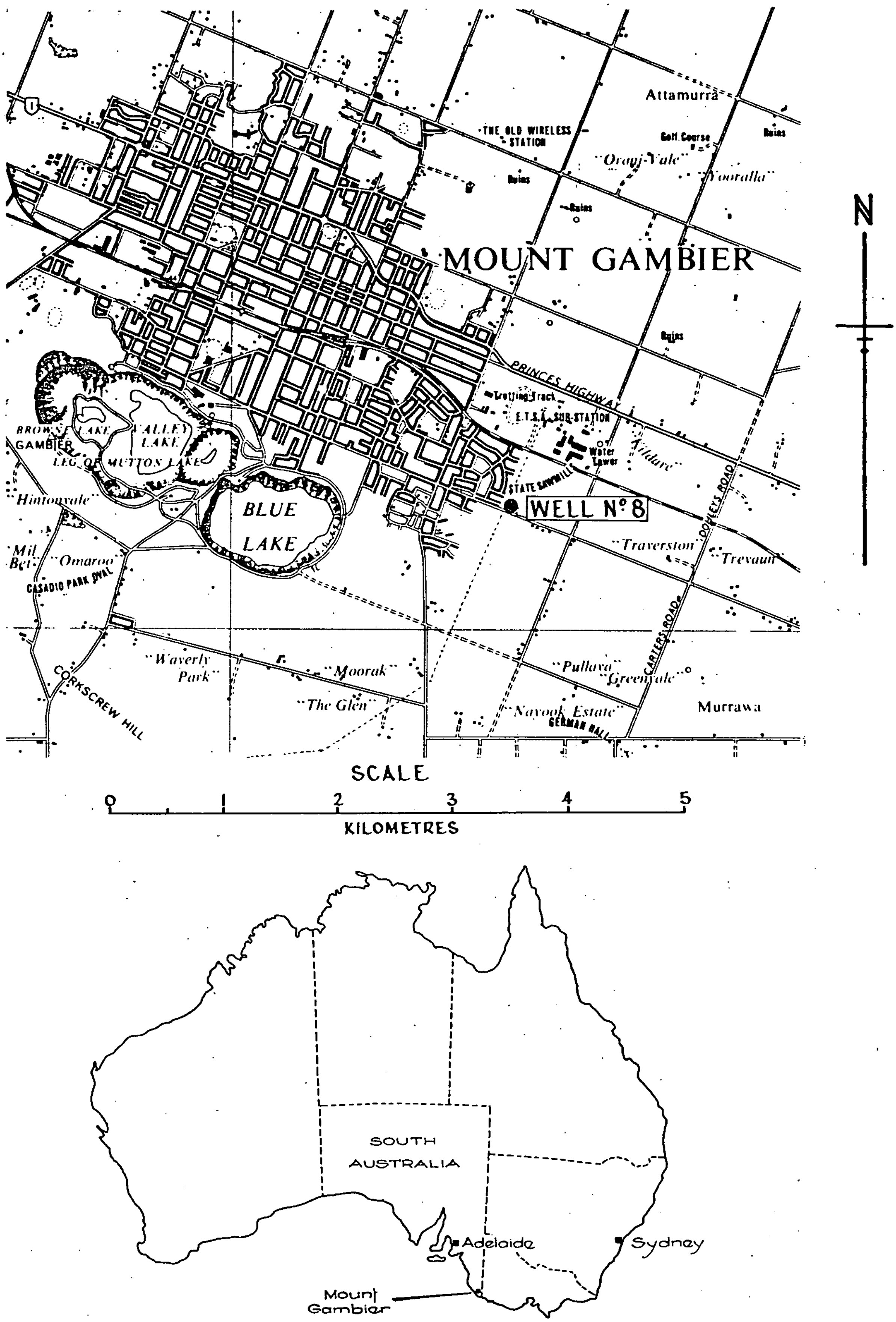

FIG. 1

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MT. GAMBIER TOWN WATER SUPPLY WELL Nº 8

LOCALITY PLAN

COMPILED P.C.S.	3 · 6 · 82 C.D.O. DATE
DRAWN R.H.	SCALE As shown
DATE Apr. 1982	PLAN NUMBER
CHECKED	S16136

2832

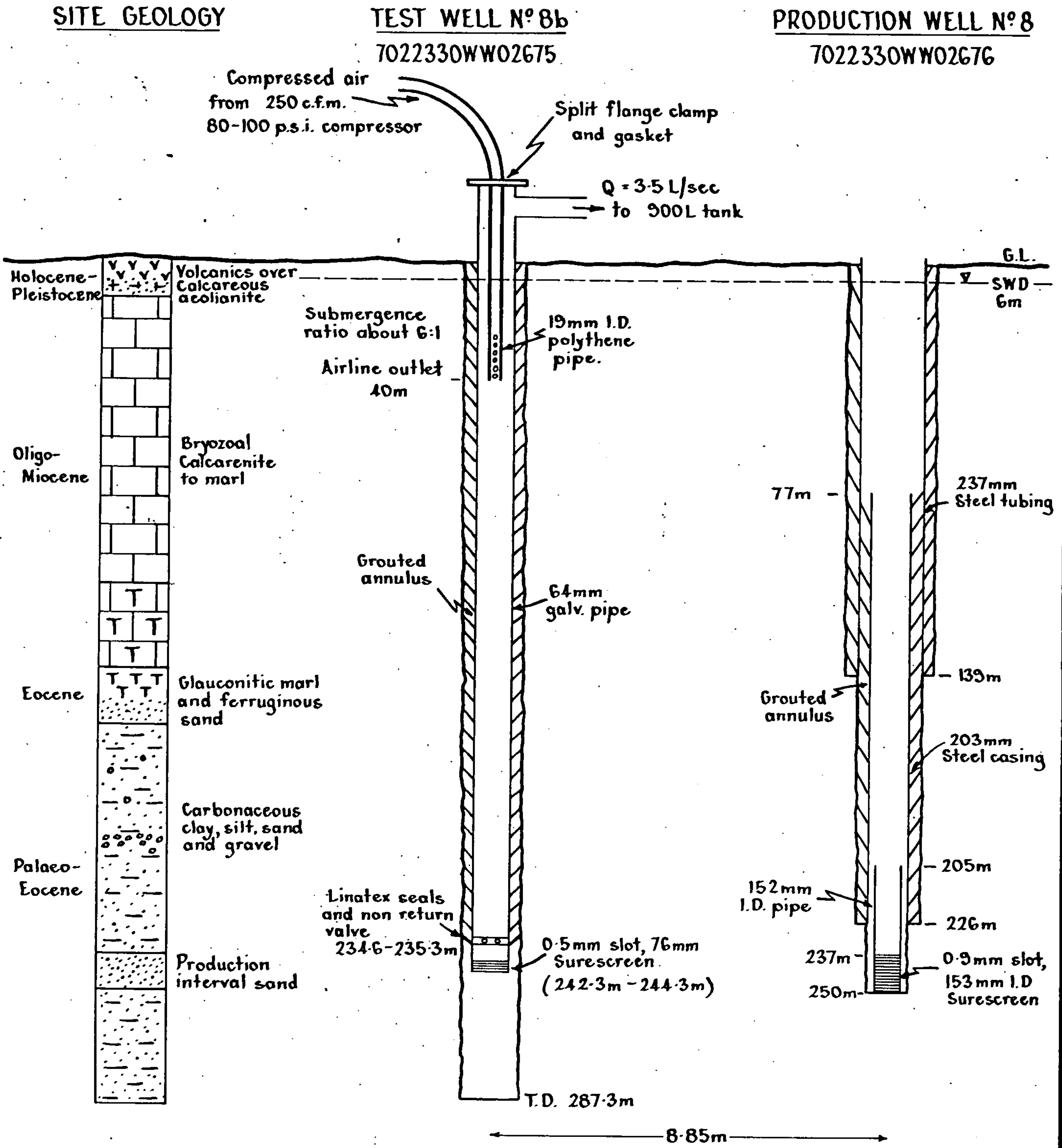

FIG. 2

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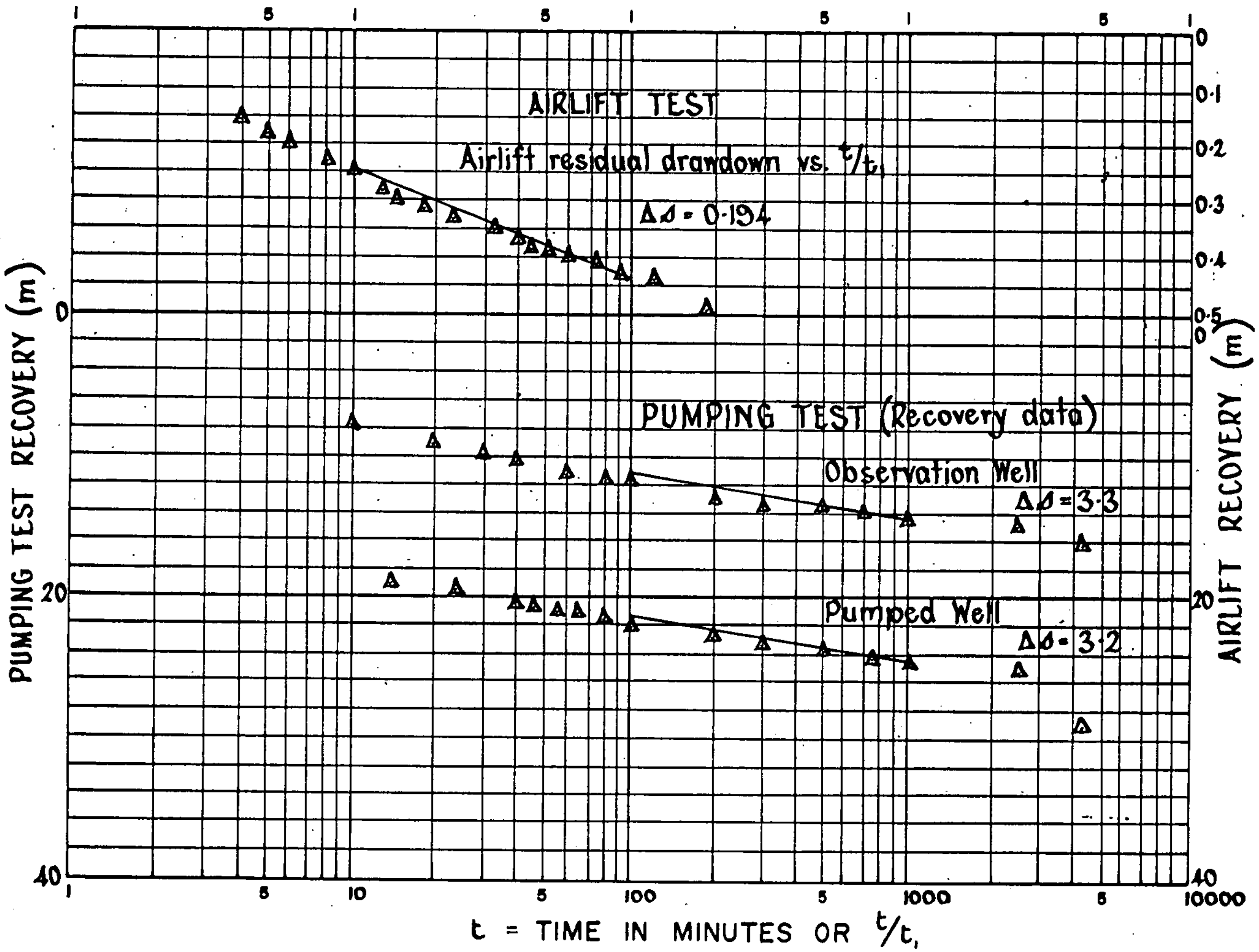
MT. GAMBIER TOWN WATER SUPPLY WELL Nº 8

GEOLOGY AND WELL CONSTRUCTION DETAILS

COMPILED P.C.S.	C.D.O. 3·6·82	DATE
DRAWN R.H.	SCALE	N.T.S.
DATE Apr. 1982	PLAN NUMBER	
CHECKED	S16137	

2832



STATE/UNIT No. 7022330WW02676

PRODUCTION/OBSERVATION WELL

INTERVAL TESTED

From 237·3 m. to 250 m.

HOLE DEPTH 250 m.

AQUIFER THICKNESS 12·7 m.

Notes: 1. See data shown in Table 2.

2. t/t_1 = time (in minutes) since airlift or pumping started / time since airlift or pumping stopped.

* Check applicability of this method

FIG. 3

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MT. GAMBIER TOWN WATER SUPPLY WELL No 8

WELL No. 7022330WW02676

TIME - RESIDUAL DRAWDOWN PLOTS

COMPILED: P.C.S.

DRN: R.H.

CKD:

SCALE: -

DATE: April 1982

PLAN NUMBER S16138

2832

MF 89