DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
ENGINEERING DIVISION

COMPLETION REPORT IRRIGATION WELL SECT. 11 HD. KINGSFORD, CO. CHANDOS (D.J. & N.P. MOUNT)

By

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GEOLOGIST

Rept.Bk.No. 79/17
G.S. No. 6136
D.M. No. 537/77
Eng. No. 1978/AN-3

CONTENTS

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ABSTRACT

The well has been drilled into an area of low salinity groundwater occurring within the Tertiary limestone aquifer at Karte, northwest of Pinnaroo. A 48-hour well test was carried out at an average pumping rate of 2600 m^3/day (23,800 gals/hr), and results indicate that the required amount of 6,300 m^3/day (57,750 gals/hr) should be obtainable from the well - this final production rate should be reached gradually to minimise the risk of hole collapse.

Chemical analyses of the water show that its salinity (average 1450 mg/l TDS) and other properties should make it suitable for lucerne irrigation, but it is recommended that further advice be obtained on this matter from the Department of Agriculture. Regular samples should be taken to check for any increase in salinity during the life of the well.

Regional effects of the intended pumping are likely to be negligible outside a radius of 2 km from the well, but reappraisal of the situation should be made after the well has been in operation for a while.

Data from the underlying aquifer show that it is unlikely to be recharging the Tertiary limestone in the Karte area as was originally thought.

INTRODUCTION

Late in 1977 Mr. D.J. Mount requested this Department to investigate an area of anomalously low groundwater salinity in the limestone aquifer in the Karte area, 30 km North West of Pinnaroo (Fig. 1). His aim was to develop a property in the area for spray irrigation of lucerne provided an adequate long-term supply of groundwater of suitable quality could be proved.

Departmental records showed the existence of a roughly oval shaped zone of good quality water (<1000 mg/l TDS) in the area, surrounded by a region of radially increasing salinity (Fig. 4). O'Driscoll (1960) attributed this to upward leakage of better quality water from a confined aquifer lying below the unconfined limestone aquifer. He stated that a clay layer which acted as the confining layer between the two aquifer systems elsewhere was missing in this area.

In a letter to Mr. Mount dated 20th December 1977, it was stated that Departmental records indicated that a supply of up to 5,000 m^3/day (45,000 gph) should be obtained from a suitably constructed well.

The final programme agreed upon was for Mr. Mount to pay for the construction of an irrigation well to the base of the limestone aquifer. This Department would then bear the cost of deepening the well to investigate the pressure head and quality of the confined aquifer and of a production test on the final irrigation well.

In addition a water well field survey was undertaken in the surrounding areas to obtain data on water levels and salinity of the unconfined ground water.

DRILLING PROGRAMME

Drilling with a cable-tool rig commenced on the 27th May 1978 and was completed on the 22nd July, 1978.

A 203 mm diameter hole was initially drilled into the top of the limestone to 60 m. This was done to see whether any saline water occured above the limestone, which would require pressure cementing of the final casing. As this was not the case the casing was then removed and the hole collared with 13 m of 343 mm OD pipe and re-drilled to 60 m. 273 mm casing was run and its shoe cemented by dump bailing. Open hole drilling was then completed to the base of the limestone at 182 m.

To undertake the second exploratory phase of the programme 152 mm casing was run into the hole with drilling continuing to a total depth of 214 m. Upon completion the 152 mm casing was withdrawn and a cement plug set at 207 m from the surface, thus separating the two aquifer systems.

HYDROGEOLOGY

During drilling sludge samples were collected at 2 m intervals and water samples generally at 5 to 10 m intervals. A summary well log is given in Appendix 1.

Limestone Aquifer

It is important to note that the limestone aquifer found from 56-180 m is not uniform in its nature and properties, since it varies from a clean open limestone to a marl (calcareous clay). Thus some zones in the aquifer will be contributing a higher proportion of the water pumped from the well than others. It is water from these zones that will determine the chemistry of the water pumped.

Groundwater in the limestone aquifer is unconfined and, upon completion of drilling, had a water level below the ground surface of 47.75 m. The regional direction of groundwater flow is to the northwest where the River Murray acts as a groundwater sink. Hydraulic gradients are very low and cannot be shown on a map without levelling all water wells in the area. A list of water levels recorded during the well survey is given in Table 2 and their location shown in Fig. 5.

TABLE 1

SUMMARY OF WELL DETAILS

(all depths below ground level)

Depth	: 207 m
Casing	: (a) 343 mm drillpipe to 13 m
	(b) 273 mm casing cemented to 60 m
Static Water Level	: 48 m
Recommended pump depth	: 120 m
Water Salinity	: 1450 mg/1
Aquifer	: Variable sandy and marly limestone

Estimated Pumping Water Levels:

Rate in m^3/day (gals/hr)	Drawdown after 2 months	Pumping water level below ground.
3000 (27500)	14 m	62 m
4900 (44900)	27 m	75 m
6300 (57750)	37 m	85 m
7000 (64150)	43 m	91 m
8000 (73320)	51 m	99 m

<u>Note</u>

Pumping water levels have been obtained from an equation derived from the well tests. Certain assumptions have been made in deriving the equation and these estimates should be regarded as approximate only.

Confined Aquifer

The confined sand aquifer was intersected at a depth of 212m beneath a clay confining layer. The water level for this aquifer rose to a height of 64.25 m below ground surface i.e. about 16.5 m below the unconfined groundwater level. Thus with a downward hydraulic gradient, O'Driscoll's (1960) vertical upward leakage model for explaining the low salinity groundwater is untenable; however Lawrence (1975) indicates natural discharge from the confined aquifer is by regional upward leakage in the vicinity of the River Murray.

WELL TESTS

Upon completion of drilling the well was subjected to:

... a 3 x 100 minute multiple stage test to investigate the efficiency of the well and to obtain an equation relating expected drawdown to both pumping rate and time;

... a 48 hour constant discharge test to obtain estimates of any hydraulic boundaries that may alter the drawdown rate with time.

The field and interpretive details of the testing are given in Appendix 2 and plots of the measured drawdown in Figs. 2 and 3. The equation derived from an analysis of the test results allows the calculation of expected drawdowns for various pumping rates and pumping times (Table 1).

WATER CHEMISTRY

In the Karte area (Fig. 1) O'Driscoll (1960) noted the existence of a roughly oval shaped zone of groundwater in the limestone aquifer with a salinity less than the surrounding groundwater (Fig. 4). However, data from all available full chemical analyses, when plotted on Stiff comparison diagrams, show that this lower salinity groundwater is also of quite distinct ionic composition compared to the surrounding water (Fig. 5).

It should be noted that the other wells in the area do not penetrate more than 10 m into the limestone aquifer. These data are therefore only representative of the upper portion of the aquifer.

Water Stratification

During drilling of the irrigation well water samples were collected at intervals to determine if water quality changes occur with depth. The results are given in Appendix 3.

The samples collected through the limestone aquifer averaged 600 mg/l TDS and showed no significant water quality variations with depth, neither in total salinity nor in ionic ratios. However, since the well was being drilled open-hole below 60 m, mixing of samples could readily occur during the bailing of the well.

The sample collected from the confined aquifer is considered representative since casing was installed to the bottom of the well and the hole bailed actively to remove any contaminating waters. This sample shows the confined groundwater as being not only of different salinity (1024 mg/l) but with a different ionic composition to the unconfined groundwater. For example, the confined groundwater is depleted in calcium, magnesium, and bicarbonate, and enriched in chloride compared to the uppermost unconfined groundwater.

The Well Test

Water samples were collected at regular intervals during development and testing and the results (Table 3) show a distinct increase in total dissolved salts (TDS). This may be explained as follows: -

1. The geological log of the well indicates that zones of higher permeability in the limestone aquifer occur at various depths. Thus the contribution of groundwater to the pumped well is greatest from these parts of the aquifer.
2. The well was drilled open hole through the limestone and mixing of groundwater from all levels occured, giving an average value of 600 mg/l TDS.
3. When pumping commenced more water was drawn from the higher permeability parts of the aquifer and this, presumably having a higher salinity, causes the overall value of pumped water to rise to about 1450 mg/l TDS in the early stages of the test.

Table 3 shows that the salinity stabilised within a short time and was not rising at the end of the test. Values for pH also remained fairly constant, although some higher values indicate that the water may be slightly encrusting.

Suitability for Irrigation

A discussion of the suitability of the water for irrigation is given in Appendix 3.

It is considered that the salinity of the water (1450 mg/l TDS) will be suitable for irrigation of lucerne which can normally tolerate water up to twice this salinity. The minor constituents of boron, fluoride and iron are also well within the limits given by Hart (1974). The sodium absorption ratio (SAR) of 7.9 gives a corresponding exchangeable sodium percentage (ESP) of 9.3 - both values being safely below the limit for lucerne and falling with the medium sodium water range (Hart, 1974).

INTERFERENCE WITH OTHER WELLS

Calculations using data from the well test show that after two years of continuous pumping the expected drawdown at a distance of 2 km from the well will be only about half a metre (Appendix 2). Certain assumptions have been made in obtaining this result, which must be regarded as very approximate.

The well survey showed that all nearby wells are used for stock and domestic purposes only and it is considered unlikely that their yields will be significantly affected by pumping from this irrigation well. In any case, if regional drawdowns are greater than expected, it should be possible to deepen them at reasonable cost.

TABLE 2

Water Levels in adjacent wells

Well No.*	Water level below ground (metres)	Date
371	50.0	6.9.78
441	52.2	6.9.78
442	66.4	5.9.78
448	57.02	1.9.78
455	51.84	1.9.78
456	41.90	31.8.78
457	48.33	30.8.78
458	44.27	31.8.78
459	44.48	31.8.78
460	43.92	30.8.78
461	43.43	29.8.78
466	57.19	6.9.78
467	65.15	6.9.78
514	50.97	29.8.78
515	50.92	20.8.78
518	52.24	1.9.78

*To obtain Department of Mines and Energy number prefix with 1: 50 000 map no. 7027-4.

TABLE 3

Water salinity results during development and testing

Time after started (mins)	Salinity (mg/1 TDS)	pH
development	929	7.4
100	1470	7.7
200	1415	7.6
300	1470	7.6
600	1415	7.6
900	1420	7.6
1200	1470	7.6
1500	1430	7.6
1800	1415	7.6
2100	1425	8.0
2400	1410	7.6
2700	1425	7.6
2880	1355	8.4.

DISCUSSION

This investigation has shown that the area of low salinity groundwater in the Karte area is not caused by upward leakage from an underlying confined aquifer as previously thought. It is possible that it represents an area of more permeable limestone which has been more effectively recharged by present and past rainfall.

Although the water salinity more than doubled during the test to 1450 mg/l TDS, water of this quality is suitable for lucerne irrigation. It is likely that this salinity will rise under heavy withdrawal rates and for this reason it is essential that salinity testing be carried out at least four times a year during the life of the well. Further advice should be obtained from the Department of Agriculture as to the suitability of the water for its proposed use.

An attempt has been made to predict the effect that pumping will have on existing local wells. Significant ill-effects are considered to be unlikely, but a reappraisal of the situation will be made after the first season's pumping.

It is important to remember that the well has been tested at a maximum rate of 3,300 m^3/day only. The required abstraction rate is 6,300 m^3/day and predictions of the well behaviour at this rate are based on extrapolation of results obtained from the well test. It is essential therefore that the final production rate be reached gradually to minimise the risk of hole collapse. Installation of an air line is also recommended so that pumping water levels can be checked regularly.

MAC:GU

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GEOLOGIST

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APPENDIX 1

Geological Well log.

MF32

PROJECT: D.J. & N.P. MOUNT IRRIGATION WELL

LOCATION OR COORDS: KARTE AREA

SEC. 11 HD. KINGSFORD

El. Surface m

El. Ref. Point m Datum

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA
ENGINEERING DIVISION

WATER WELL LOG

HOLE NO: Permit 3226

UNIT / STATE NO. 7027004WW00512

DM 537/77

AQUIFER SUMMARY:	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL TESTED From:	INTERVAL TESTED To:	SUPPLY kilolitres/day*	SUPPLY Test Length (hrs)	SUPPLY Method	TOTAL DISSOLVED SOLIDS milligrammes/litre	TOTAL DISSOLVED SOLIDS Analysis No:
	51	49	51	60	30	Bailed dry	Bailer	508	W 3420/78
	57	49							
	98	48	51	180	2590	48	Pump	1355	4093/78
	212	64.3			Not tested				3596/78

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK / SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION / AGE	DEPTH CORE SAMPLE	CASING Dia (mm)	CASING From (m)	CASING To (m)
0	16		Quartz sand	Orange-brown to yellow. Quartz clear, orange, angular to well rounded, spherical. 0.1-1 mm average 0.4-0.5 mm. Some clay.	Parilla sand U. Pliocene		343 273	0 0	13 60
16	50		Quartz sand	Reddish-yellow to red. Quartz poorly sorted from silt size to 2.5 mm, gravelly in parts. Grains clear, white, orange stained; angular to rounded, gravelly, sub-spherical. Micaceous; some opaques.	Loxton sands M. Pliocene				
50	56		Clayey Quartz sand	Olive-brown to greenish-grey. Quartz fine grained, silt, size to 0.4 mm, generally 0.1-0.2 mm; clear, orange stained, white; angular. Glauconite (dark green) to 15%. Micaceous. Minor pyrite.	Bookpurnong Beds				
56	180		Limestone Sandy limestone Marly limestone Marl	Pale grey, pale yellow, off white. Limestone generally bryozoal, sponge and calcareous chips and echinoid spines. Marly and sandy in part. Some glauconite and pyrite. Marls generally medium to dark grey.	Pata-Morgan-Mannum Limestones L-M Miocene				

REMARKS:

*NOTE: 110 kl / day = 1000gals / hr.

DRILL TYPE: Cable tool

COMPLETED: 22.7.78

CIRCULATION: Water

LOGGED BY: M.A.Cobb

SHEET 1 OF 2

DATE: on site.

PROJECT: D.J. & N.P. MOUNT IRRIGATION WELL

LOCATION OR COORDS: KARTE AREA

SEC. 11 HD. KINGSFORD

EL Surface m

EL Ref. Point m Datum

MINES DEPARTMENT — SOUTH AUSTRALIA
ENGINEERING DIVISION

WATER WELL LOG

HOLE NO: Permit 3226

UNIT / STATE NO 2072004WW00512

DM

AQUIFER SUMMARY:	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL TESTED From:	INTERVAL TESTED To:	SUPPLY kilolitres/day*	SUPPLY Test Length (hrs)	SUPPLY Method	TOTAL DISSOLVED SOLIDS milligrammes/litre	Analysis No:
									W—

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK / SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION / AGE	DEPTH CORE SAMPLE	CASING Dia(mm)	CASING From(m)	CASING To(m)
180	206		Sandy Marl Marly limestone Sandy clay	Light olive-grey passing down to dark olive-grey. Upper part a sandy marl and marly limestone with calcareous chips and fossil fragments to 50%. Some ? dolomite/calcite crystals. Minor glauconite. Passes down to a sandy clay, slightly calcareous, sandy (quartz 30%, clear, brown stained, 0.1-0.2mm) Glauconite.	Ettrick formation Olig-Miocene		343 273	0 0	13 60
206	214		Sandy clay Clayey Quartz sand	Sandy clay from 206-212 m very dark grey to black, plastic, sticky, silt/sand 30%. Glauconitic, pyritic clayey quartz sand from 212 to 214 m (end of hole) medium grey. Quartz even grained, fine (0.1-0.2 mm); clear, orange angular to sub-angular Micaceous, glauconitic.	Buccleuch Beds or Renmark Beds Eocene-Oligocene				

REMARKS:

*NOTE: 110 kl / day = 1000gals / hr.

DRILL TYPE: Cable tool

CIRCULATION: Water

SHEET. 2 OF. 2

COMPLETED: 22.7.78

LOGGED BY: M.A.Cobb

DATE: on site.

APPENDIX 2

Well Test Details

APPENDIX 2

Field Measurements:

1. Pumping Equipment

The well was equipped with a line-shaft pump with its inlet set at 100 m below ground level. On its discharge side a centrifugal pump was connected in series to pump the discharge water approximately 1500 m away into a dam and a roadside drain.

2. Discharge Measurements

Accumulated discharge was measured by an in-line meter calibrated in gallons (the metric meter blocked early in the development stage). Readings were taken at the same frequency as drawdown measurements. Fluctuations in pumping rate of greater than 10% were noted.

3. Water-level (drawdown) measurements

All drawdown measurements were made with a standard electric water-level probe. Readings were taken at the following spacings:

Time since pump stopped/started (mins)	Reading frequency (mins)
0-3	½
3-10	1
10-30	2
30-60	5
60-100	10
100-200	20
200-2850	50
2850-2880	30 (final)

Well Tests

To estimate the well's efficiency and to obtain an equation that enables drawdowns for various pumping rates at selected times to be calculated, a 3 x 100 minute multistage test at discharge rates of 899, 1400 and 2131 m^3/day, and recovery between stages, was performed. Plots of the drawdown measured against the log of time for this test are given in Fig. 2.

It can be seen that there is a lot of scatter in the data particularly for the early stages. Thus the fitting of straight lines to the semi-log plots leaves significant leeway for personal interpretation. These plots were consequently not used to derive the well equation.

The usual equation relating drawdown to both pumping rate and time in a pumping well is of the form: -

$$S_t = (a + b \log t)\, Q + cQ^2$$

where

S_t = drawdown in well (metres) at time t.

t = time in minutes

Q = pumping rate in m^3/min

a.b.c. = constants

For analysis the equation can be re-arranged to

$$\frac{S_t}{Q} = (a + b \log t) + cQ$$

By plotting St/Q vs Q for each stage for selected times, generally t = 1, 10, 100 minutes, a series of parallel lines are constructed (Fig. 2). The slope of these parallel lines is equal to c and the intercept of the $S_{t=1}$ plot on the Q=0 axis is equal to a. The value of b is given by the difference in intercept values on the Q=0 axis between the $S_{t=1}$ plots, and the $S_{t=10}$ plots.

For the data in question the determination of the well equation has been based on discharge rates greater than 1.4 m^3/min when drawdowns greater than 5.5 m occur. The parallel lines shown in Fig. 2 are constructed only on the data for stage 3 and the main test. Deviation of the earlier stages suggests different aquifer characteristics in the upper 5.5 m of the saturated zone.

Thus the equation for the well relating drawdown to both time and pumping rate is given by -

$$S_t = (2.9 + 0.55 \log t)\, Q + 0.65\, Q^2$$

This has been used to predict drawdown as given in Table 1.

The step-drawdown test was followed by a constant rate, 48 hour test to obtain approximate hydraulic characteristics of the limestone aquifer and to observe if there were any close-by hydraulic boundaries. None of the latter were noted.

Analysis of the data by a semi-log, time-drawdown plot, yields a value of Transmissivity of 475 m^3/day/m (Fig. 3).

It is interesting to calculate three parameters related to the long-term usage of the well, namely water entrance velocity, radius of influence, and particulate water velocity in the aquifer.

1. <u>Water entrance velocity</u>

Since the well in question is open-hole from 60m to approximately 180 m an idea of the water entrance velocity is useful in assessing the stability of the well wall.

Assuming a maximum pumping rate of 8175 m^3/day (approximately 75 000 gph), a well diameter of 300 mm and an effective aquifer thickness of 100m, then the entrance velocity is given by -

$$V = \frac{Q}{A} = \frac{8175}{2\pi\ 0.15 \times 100 \times 1440} = 0.06 \text{ m/min.}$$

Whilst little qualitative data are available on wall stability it is felt that the velocity is low enought to prevent collapse.

These factors should, however, be born in mind:

... The well has only been developed (pumped) to a maximum of 3300 m^3/day. Thus after production pump installation the maximum pumping rate must be reached gradually to prevent collapse.

... At a lower pumping rate than indicated in the calculation, the velocity will be proportionately less.

... The limestone aquifer is not isotropic and hence some zones yielding more than adjacent zones will have proportionately higher entrance velocities.

2. <u>Radius of influence</u>

Every well when pumped develops an inverted drawdown cone around it, centred on the well. The shape of this cone (radius, magnitude of drawdown etc.) is important for determining the interference (if any) between adjacent wells. To show the order of magnitude of this effect the following has been calculated.

Assuming:

Storage co-efficient (s)	= 0.2 (reasonable for water table aquifer)
Transmissivity (T)	= 475 m^3/day/m (from well test)
Time (t)	= 700 days (say 2 years)
Radius (r)	= 2000 m (any value can be chosen to see the effects)

then using $u = \dfrac{r^2 s}{4tT}$ (Theiss non-equilibrium formula) a value for u = 0.60 is obtained

From published tables this gives a value for W(u) in the following equation of 0.4544.

$$S = \frac{Q\,W(u)}{4\pi\ T}$$

Q = pumping rate in m^3/day

$$= \frac{8175 \times 0.4544}{4 \times \pi \times 475}$$

$$= 0.62m$$

Thus at a distance of 2000 m from the irrigation well pumping at 8175 m^3/day a drawdown of 0.62 m will be noted after 700 days continuous pumping.

3. Particulate Water Velocity

To obtain an estimate of the actual velocity of a water particle in the aquifer under steady-state (approx.) or long-term pumping, use is made of the following equation:

$$V = \frac{Ti}{me}$$

where T = transmissivity = 475 m^3/day/m

i = hydraulic gradient = 0.02 (average)

m = aquifer thickness = 100 m (assume)

e = aquifer porosity = 0.3 (assume)

then $V = \dfrac{475 \times 0.02}{100 \times 0.3}$

$= 0.32$ m/day.

This is the average rate at which a water particle will migrate towards the well under the assumed conditions given above.

APPENDIX 3

Water analysis results

Fig.		Drg. No.
1	Water quality criteria for Sodium water	S13851

APPENDIX 3

The suitability of a particular water for irrigation depends on the concentration and composition of dissolved constituents in the water. It is the effects of these constituents on both the plant and the soil that are of importance. In summary, the deleterious effects of water quality on plant growth can result directly from the effects of salts preventing water uptake by plants (osmotic effects) and from chemical effects upon metabolic reaction of plants (toxic effects), and indirectly by changes in soil structure, permeability, and aeration.

This section will discuss the suitability of the pumped water for irrigation in general terms only since soil type, land management etc., all influence strongly the long term effects of such irrigation. Professional agricultural advice should be sought for detailed analysis.

The total dissolved solids (salinity = 1 400 - 1 500 mg/l) of the water pumped is suitable for lucerne irrigation. An upper limit of 3 000 mg/l is generally accepted.

The minor constituents of boron (B), fluoride (F), and iron (Fe) are well within the tolerance for irrigation of lucerne as given by Hart (1974).

Thus any problems that may arise from continuous irrigation with the water quality given will more likely be related to the sodium, calcium and magnesium ions and their relative proportions.

Two indicators of the potential hazardous effects of sodium concentration are the sodium absorption ratio (SAR) and the exchangeable sodium percentage (ESP). The SAR is given by

$$SAR = \frac{Na^{+}}{\sqrt{\frac{(Ca^{++} + Mg^{++})}{2}}}$$

where all values are in milliequivalents per litre (meq/l) and for the pumped water a value of 7.9 is given. Using this value and the nomogram in Fig. 1 a value for ESP of 9.3 is obtained. Both values are safely below the limits for lucerne as given by Hart (1974) i.e. ESP 40 and SAR 46. Fig. 1 also shows the classification of the irrigation water as a 'medium-sodium water' and the problems that may be associated with it in relation to reduced soil permeability with continuous use. However, the salinity of the water appears sufficiently high to prevent this reduction in soil permeability. The salinity required to prevent deflocculation is given by:

$$\text{salinity (meq/l)} > \frac{0.56\text{Na} + 0.6}{\sqrt{\text{Ca}^{++}}} \qquad \text{(see Hart (1974) p.290)}$$

which for the irrigation water in question gives a value of 5.33. The actual irrigation water salinity is 47.2 meq/l i.e. significantly above the required value.

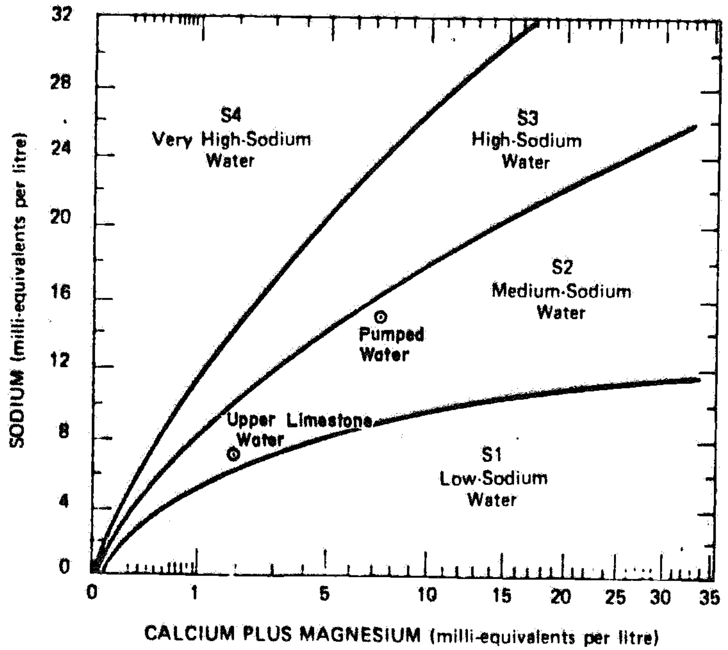
The long term irrigation use of water containing a high concentration of bicarbonate may seriously affect soil permeability. To gauge the magnitude of this problem use is made of the residual sodium carbonate (RSC) given by:

$$\text{RSC} = (\text{HCO}_3^- + \text{CO}_3^{2-}) - (\text{Ca}^{2+} + \text{Mg}^{2+})$$

where all concentrations are in millequivalents per litre. For the irrigation water in question a negative value is obtained suggesting no bicarbonate hazard exists.

It is interesting to note however, that the water samples collected <u>during drilling</u> showed a water quality that has a significant bicarbonate hazard. Thus, whilst the pumped water has a higher salinity it appears more suitable for actual irrigation.

The above is meant only as a guide to the suitability of the water for irrigation. Since the water is going to be used for a significant period of time it is strongly recommended that professional agricultural advice be sought to determine its suitability for long term usage on the plants and soils to be irrigated.



Source: *Wilcox, 1958* **Determining the Quality of Irrigation Water. U. S. Dept. Ag.; Ag. Inf. Bull. 197**

Low-sodium water (S1) can be used for irrigation on almost all soils, with little danger of the development of a sodium problem. However, sodium-sensitive crops such as stone-fruit trees and avocados, may accumulate injurious amounts of sodium in the leaves.

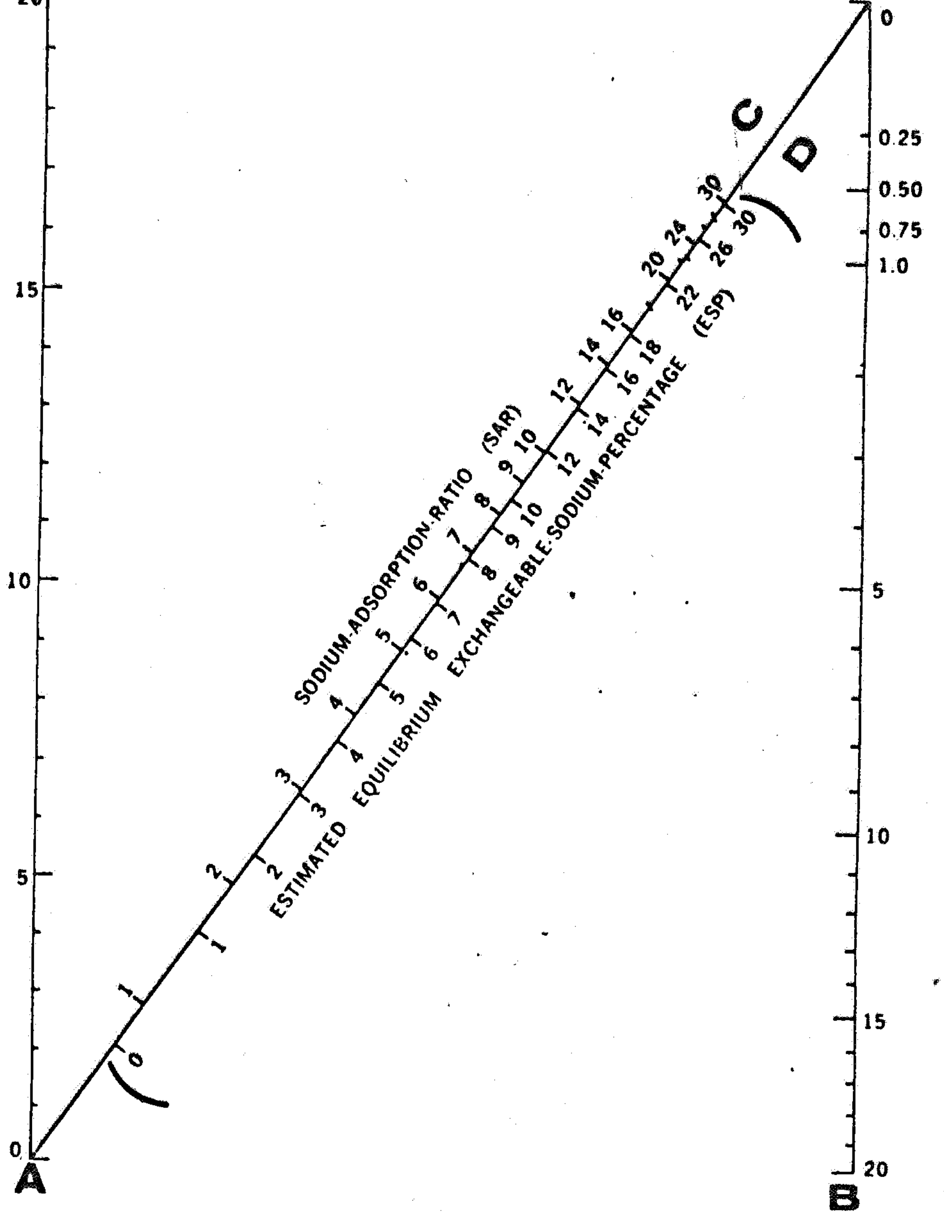
Medium-sodium water (S2) may present a moderate sodium problem in fine-textured (clay) soils unless there is gypsum in the soil. This water can be used on coarse-textured (sandy) or organic soils that take water well.

High-sodium water (S3) may produce troublesome sodium problems in most soils and will require special management, good drainage, high leaching and additions of organic matter. If there is plenty of gypsum in the soil, a serious problem may not develop for some time. If gypsum is not present, it, or some similar material, may have to be added.

Very high-sodium water (S4) is generally unsatisfactory for irrigation except at low or medium salinity levels, where the use of gypsum or some other additive makes it possible to use such water.

Fig. 6A Water Quality Criteria for Sodium Water

Fig. 6B Nomogram for determining the SAR value of irrigation water and for estimating the corresponding ESP value of a soil that is at equilibrium with the water



Source: *Richards, 1954* **Diagnosis and Improvement of Saline and Alkali Soils. U. S. Sal. Lab. Staff, U. S. Dept. Ag. Handbook 60. Washington**

APPENDIX III, FIG. I

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE: —
COMPILED: M. A. Cobb	IRRIGATION WELL — D. J. MOUNT, KARTE SECTION II HD. KINGSFORD	DATE: 16th JAN 1979
DRN T. E. / CKD	WATER QUALITY CRITERIA FOR SODIUM WATER AND SAR AND ESP NOMOGRAMS	PLAN NUMBER S 13851

WATER ANALYSIS REPORT — AMDEL COMPUTER SERVICES

SAMPLE ID. W4093/78 — JOB NO. 1286-79

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE MG/L	MILLIEQUIVS. PER LITRE ME/L
CATIONS			
CALCIUM	(CA)	65	3.2
MAGNESIUM	(MG)	49	4.0
SODIUM	(NA)	348	15.1
POTASSIUM	(K)	11	.3
IRON	(FE)	.10	.0
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO3)	9	.3
BICARBONATE	(HCO3)	249	4.1
SULPHATE	(SO4)	148	3.1
CHLORIDE	(CL)	602	17.0
BROMIDE	(BR)		
FLUORIDE	(F)	.95	.0
NITRATE	(NO3)	<1	
PHOSPHATE	(PO4)	.24	.0

TOTALS AND BALANCE

CATIONS (ME/L) 22.7 DIFF = 1.8
ANIONS (ME/L) 24.5 SUM = 47.2

DIFF*100. / SUM = 3.8 %

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.) MICRO-S/CM AT 25 DEG. C 2315.

	MILLIGRAMS PER LITRE MG/L
TOTAL DISSOLVED SOLIDS	
A. BASED ON E.C.	
B. CALCULATED (HCO3=CO3)	1355.
C. RESIDUE ON EVAP. AT 180 DEG. C	
TOTAL HARDNESS AS CACO3	364.
CARBONATE HARDNESS AS CACO3	204.
NON-CARBONATE HARDNESS AS CACO3	160.
TOTAL ALKALINITY AS CACO3	218.
FREE CARBON DIOXIDE (CO2)	
SUSPENDED SOLIDS	
SILICA (SIO2)	
BORON (B)	0.30

	UNITS
REACTION - PH	8.4
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	
SODIUM TO TOTAL CATION RATIO (ME/L)	66.7 %

REMARKS

48 HOUR PUMP TEST
2880 MINS

NAME- D.J.& N.P.MOUNT
ADDRESS-MOUNT ACRES

DATE COLLECTED 05/09/78
DATE RECEIVED

HUNDRED-KINGSFORD
SECTION-11
HOLE NO-
SUPPLY-
SAMPLE COLLECTED BY-E.H.

WATER CUT- 100 M
WATER LEVEL-
DEPTH HOLE-

WATER ANALYSIS REPORT

SAMPLE No. W3420/78 JOB No. 259-79

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	15	.7
MAGNESIUM	(Mg)	14	1.2
SODIUM	(Na)	164	7.1
POTASSIUM	(K)	9	.2
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)	1	.0
BICARBONATE	(HCO_3)	312	5.1
SULPHATE	(SO_4)	40	.8
CHLORIDE	(Cl)	109	3.1
FLUORIDE	(F)	2.05	.1
NITRATE	(NO_3)	<0.4	
PHOSPHATE	(PO_4)	.03	.0

TOTALS AND BALANCE

CATIONS	(me/ℓ)	9.3	DIFF =	.1
ANIONS	(me/ℓ)	9.2	SUM =	18.4

$\frac{\text{DIFF } 100}{\text{SUM}}$ = .5%

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.) MICRO-S/cm AT 25 DEG.C 914.

	MILLIGRAMS PER LITRE mg/ℓ
TOTAL DISSOLVED SOLIDS	
A. BASED ON E.C.	
B. CALCULATED (HCO_3=CO_3)	508.
C. RESIDUE ON EVAP. AT 180 DEG.C	
TOTAL HARDNESS AS $CaCO_3$	95.
CARBONATE HARDNESS AS $CaCO_3$	95.
NON-CARBONATE HARDNESS AS $CaCO_3$	≤1.
TOTAL ALKALINITY AS $CaCO_3$	258
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	0.35

	UNITS
REACTION - pH	8.3
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	

SODIUM TO TOTAL CATION RATIO(me/ℓ) 77.0%

NAME - MR. D.J. MOUNT
ADDRESS P.O. BOX 744, MURRAY BRIDGE
DATE COLLECTED 14/06/78
SAMPLE COLLECTED BY: R.HALL

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. μ-S/cm

OBS. No. Permit
HOLE No. 7027004WW00512
D.M. No. 537/77

WATER ANALYSIS REPORT

SAMPLE No. W3421/78 JOB No. 259/79

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	23	1.1
MAGNESIUM	(Mg)	15	1.2
SODIUM	(Na)	158	6.9
POTASSIUM	(K)	10	.3
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)		
BICARBONATE	(HCO_3)	362	5.9
SULPHATE	(SO_4)	30	.6
CHLORIDE	(Cl)	105	3.0
FLUORIDE	(F)	1.65	.1
NITRATE	(NO_3)	<0.4	
PHOSPHATE	(PO_4)	.16	.0

TOTALS AND BALANCE

CATIONS	(me/ℓ)	9.5	DIFF =	.1
ANIONS	(me/ℓ)	9.6	SUM =	19.1

$\frac{\text{DIFF } 100}{\text{SUM}}$ = .5%

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.) MICRO-S/cm AT 25 DEG.C 919.

TOTAL DISSOLVED SOLIDS	MILLIGRAMS PER LITRE mg/ℓ
A. BASED ON E.C.	
B. CALCULATED ($HCO_3=CO_3$)	521.
C. RESIDUE ON EVAP. AT 180 DEG.C	
TOTAL HARDNESS AS $CaCO_3$	119.
CARBONATE HARDNESS AS $CaCO_3$	119.
NON-CARBONATE HARDNESS AS $CaCO_3$	<1.
TOTAL ALKALINITY AS $CaCO_3$	297.
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	0.40

	UNITS
REACTION - pH	8.1
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	

SODIUM TO TOTAL CATION RATIO(me/ℓ) 72/3%

NAME - MR. D.J. MOUNT
ADDRESS P.O. BOX 744, MURRAY BRIDGE
DATE COLLECTED 15/06/78
SAMPLE COLLECTED BY: R. HALL

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. μ-S/cm

OBS. No.
HOLE No.
D.M. No.

WATER ANALYSIS REPORT

SAMPLE No. W3424/78 JOB No. 259-79

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	24	1.2
MAGNESIUM	(Mg)	15	1.2
SODIUM	(Na)	169	7.4
POTASSIUM	(K)	10	.3
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)		
BICARBONATE	(HCO_3)	306	5.0
SULPHATE	(SO_4)	40	.8
CHLORIDE	(Cl)	153	4.3
FLUORIDE	(F)	1.55	.1
NITRATE	(NO_3)	<0.4	
PHOSPHATE	(PO_4)	.03	.0

TOTALS AND BALANCE

CATIONS	(me/ℓ)	10.0	DIFF =	.2
ANIONS	(me/ℓ)	10.2	SUM =	20.3

$\frac{\text{DIFF } 100}{\text{SUM}}$ = 1.0%

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.) MICRO-S/cm AT 25 DEG.C 1027.

	MILLIGRAMS PER LITRE mg/ℓ
TOTAL DISSOLVED SOLIDS	
A. BASED ON E.C.	
B. CALCULATED (HCO_3=CO_3)	563.
C. RESIDUE ON EVAP. AT 180 DEG.C	
TOTAL HARDNESS AS $CaCO_3$	122.
CARBONATE HARDNESS AS $CaCO_3$	122.
NON-CARBONATE HARDNESS AS $CaCO_3$	<1.
TOTAL ALKALINITY AS $CaCO_3$	251.
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	0.25

	UNITS
REACTION - pH	8.1
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	

SODIUM TO TOTAL CATION RATIO(me/ℓ) 73.2%

NAME - MR. D.J. MOUNT
ADDRESS P.O. BOX 744, MURRAY BRIDGE
DATE COLLECTED 07.07/78
SAMPLE COLLECTED BY: R. HALL

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. μ-S/cm

OBS. No.
HOLE No.
D.M. No.

WATER ANALYSIS REPORT

SAMPLE No. W3559/78 JOB No. 359-79

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	23	1.1
MAGNESIUM	(Mg)	15	1.2
SODIUM	(Na)	176	7.7
POTASSIUM	(K)	10	.3
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)		
BICARBONATE	(HCO_3)	305	5.0
SULPHATE	(SO_4)	35	.7
CHLORIDE	(Cl)	157	4.4
FLUORIDE	(F)	1.50	.1
NITRATE	(NO_3)	<0.4	
PHOSPHATE	(PO_4)	.01	.0

TOTALS AND BALANCE

CATIONS	(me/ℓ)	10.3	DIFF =	.1
ANIONS	(me/ℓ)	10.2	SUM =	20.5

$\frac{\text{DIFF } 100}{\text{SUM}}$ = .3%

DERIVED AND OTHER DATA

	MILLIGRAMS PER LITRE mg/ℓ
CONDUCTIVITY (E.C.) MICRO-S/cm AT 25 DEG.C	1091.
TOTAL DISSOLVED SOLIDS	
A. BASED ON E.C.	
B. CALCULATED (HCO_3=CO_3)	568.
C. RESIDUE ON EVAP. AT 180 DEG.C	
TOTAL HARDNESS AS $CaCO_3$	119.
CARBONATE HARDNESS AS $CaCO_3$	119.
NON-CARBONATE HARDNESS AS $CaCO_3$	<1.
TOTAL ALKALINITY AS $CaCO_3$	250.
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	0.30

	UNITS
REACTION - pH	8.1
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	

SODIUM TO TOTAL CATION RATIO(me/ℓ) 74.4%

NAME - D.J. & N.P. MOUNT
ADDRESS P.O. BOX 744, MURRAY BRIDGE
DATE COLLECTED 07/07/78
SAMPLE COLLECTED BY: R. HALL

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. μ-S/cm

OBS. No.
HOLE No.
D.M. No.

WATER ANALYSIS REPORT

SAMPLE No. W3565 JOB No. 537-79

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	23	1.1
MAGNESIUM	(Mg)	19	1.6
SODIUM	(Na)	188	8.2
POTASSIUM	(K)	12	.3
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)		
BICARBONATE	(HCO_3)	308	5.1
SULPHATE	(SO_4)	37	.8
CHLORIDE	(Cl)	175	4.9
FLUORIDE	(F)	1.50	.1
NITRATE	(NO_3)	<1.0	
PHOSPHATE	(PO_4)	.50	.0

TOTALS AND BALANCE

CATIONS	(me/ℓ)	11.2	DIFF =	.4
ANIONS	(me/ℓ)	10.8	SUM =	22.0

$\frac{\text{DIFF } 100}{\text{SUM}}$ =

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.) MICRO-S/cm AT 25 DEG.C 1195.

TOTAL DISSOLVED SOLIDS	MILLIGRAMS PER LITRE mg/ℓ
A. BASED ON E.C.	
B. CALCULATED (HCO_3=CO_3)	607.
C. RESIDUE ON EVAP. AT 180 DEG.C	
TOTAL HARDNESS AS $CaCO_3$	136.
CARBONATE HARDNESS AS $CaCO_3$	136.
NON-CARBONATE HARDNESS AS $CaCO_3$	<1.
TOTAL ALKALINITY AS $CaCO_3$	253.
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	0.42

	UNITS
REACTION - pH	8.1
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	

SODIUM TO TOTAL CATION RATIO(me/ℓ) 73.0%

NAME - D.J. & N.P. MOUNT
ADDRESS BOX 744, MURRARY BRIDGE
DATE COLLECTED 10/07/78
SAMPLE COLLECTED BY:

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. μ-S/cm

OBS. No.
HOLE No.
D.M. No.

WATER ANALYSIS REPORT

SAMPLE No. W 3597 JOB No. 537-79 (CONFINED AQUIFER)

CHEMICAL COMPOSITION

		MILLIGRAMS PER LITRE mg/ℓ	MILLEQUIVS. PER LITRE me/ℓ
CATIONS			
CALCIUM	(Ca)	20	1.0
MAGNESIUM	(Mg)	22	1.8
SODIUM	(Na)	330	14.4
POTASSIUM	(K)	18	.5
IRON	(Fe)		
ANIONS			
HYDROXIDE	(OH)		
CARBONATE	(CO_3)	2	.1
BICARBONATE	(HCO_3)	265	4.3
SULPHATE	(SO_4)	85	1.8
CHLORIDE	(Cl)	416	11.7
FLUORIDE	(F)	.95	.0
NITRATE	(NO_3)	<1.0	
PHOSPHATE	(PO_4)	.07	.0

TOTALS AND BALANCE

CATIONS	(me/ℓ)	17.6	DIFF =	.3
ANIONS	(me/ℓ)	18.0	SUM =	35.6

$\frac{\text{DIFF } 100}{\text{SUM}}$ = 1.0%

DERIVED AND OTHER DATA

CONDUCTIVITY (E.C.) MICRO-S/cm AT 25 DEG.C 2043.

	MILLIGRAMS PER LITRE mg/ℓ
TOTAL DISSOLVED SOLIDS	
A. BASED ON E.C.	
B. CALCULATED (HCO_3=CO_3)	1024.
C. RESIDUE ON EVAP. AT 180 DEG.C	
TOTAL HARDNESS AS $CaCO_3$	140.
CARBONATE HARDNESS AS $CaCO_3$	140.
NON-CARBONATE HARDNESS AS $CaCO_3$	<1.
TOTAL ALKALINITY AS $CaCO_3$	220.
FREE CARBON DIOXIDE (CO_2)	
SUSPENDED SOLIDS	
SILICA (SiO_2)	
BORON (B)	0.17

	UNITS
REACTION - pH	8.4
TURBIDITY (JACKSON)	
COLOUR (HAZEN)	

SODIUM TO TOTAL CATION RATIO(me/ℓ) 81.5%

NAME - D.J. MOUNT,
ADDRESS BOX 744, MURRAY BRIDGE
DATE COLLECTED
SAMPLE COLLECTED BY: R.E. HALL

FIELD TEMP. °C
FIELD pH @ °C
FIELD COND. μ-S/cm

OBS. No.
HOLE No.
D.M. No.

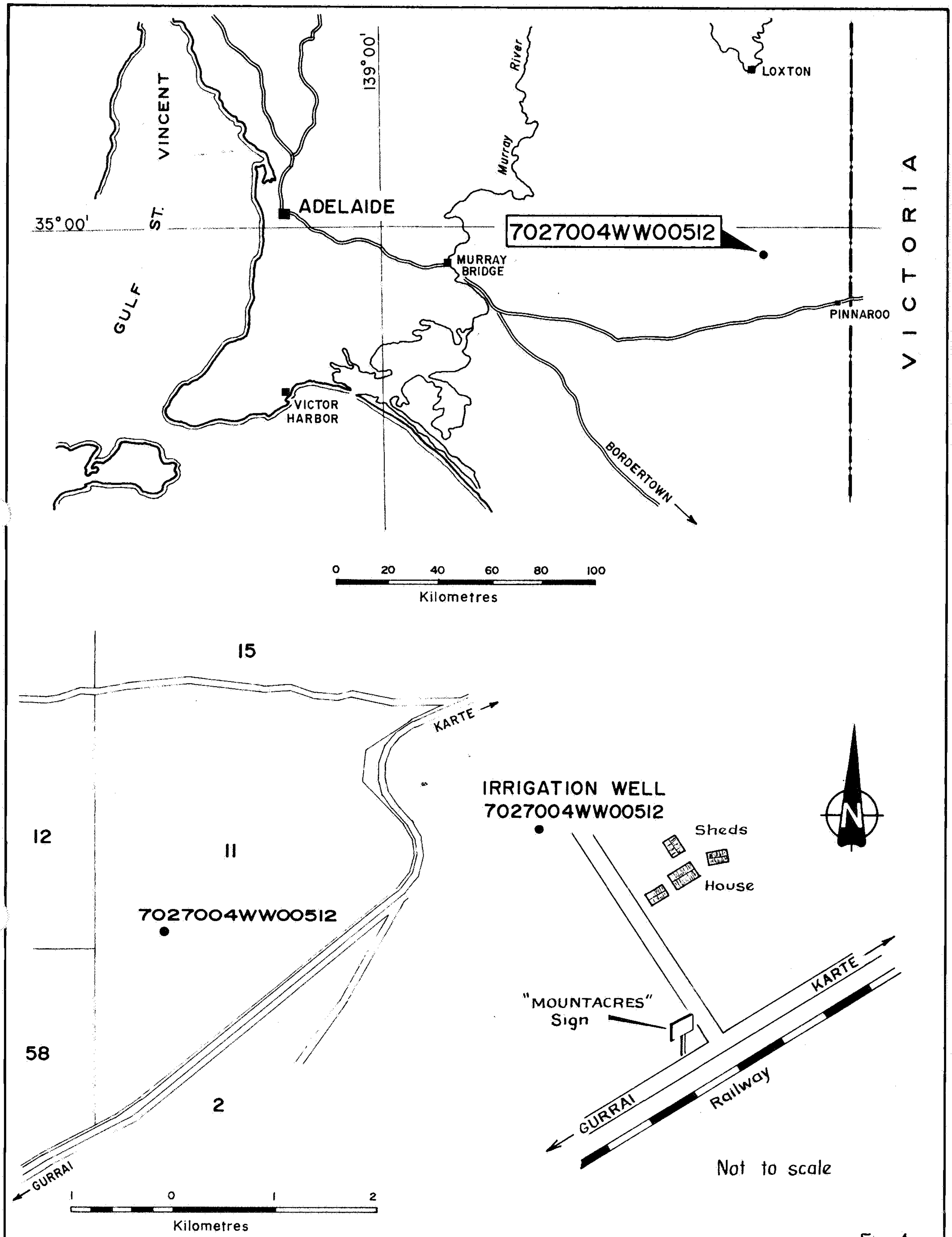
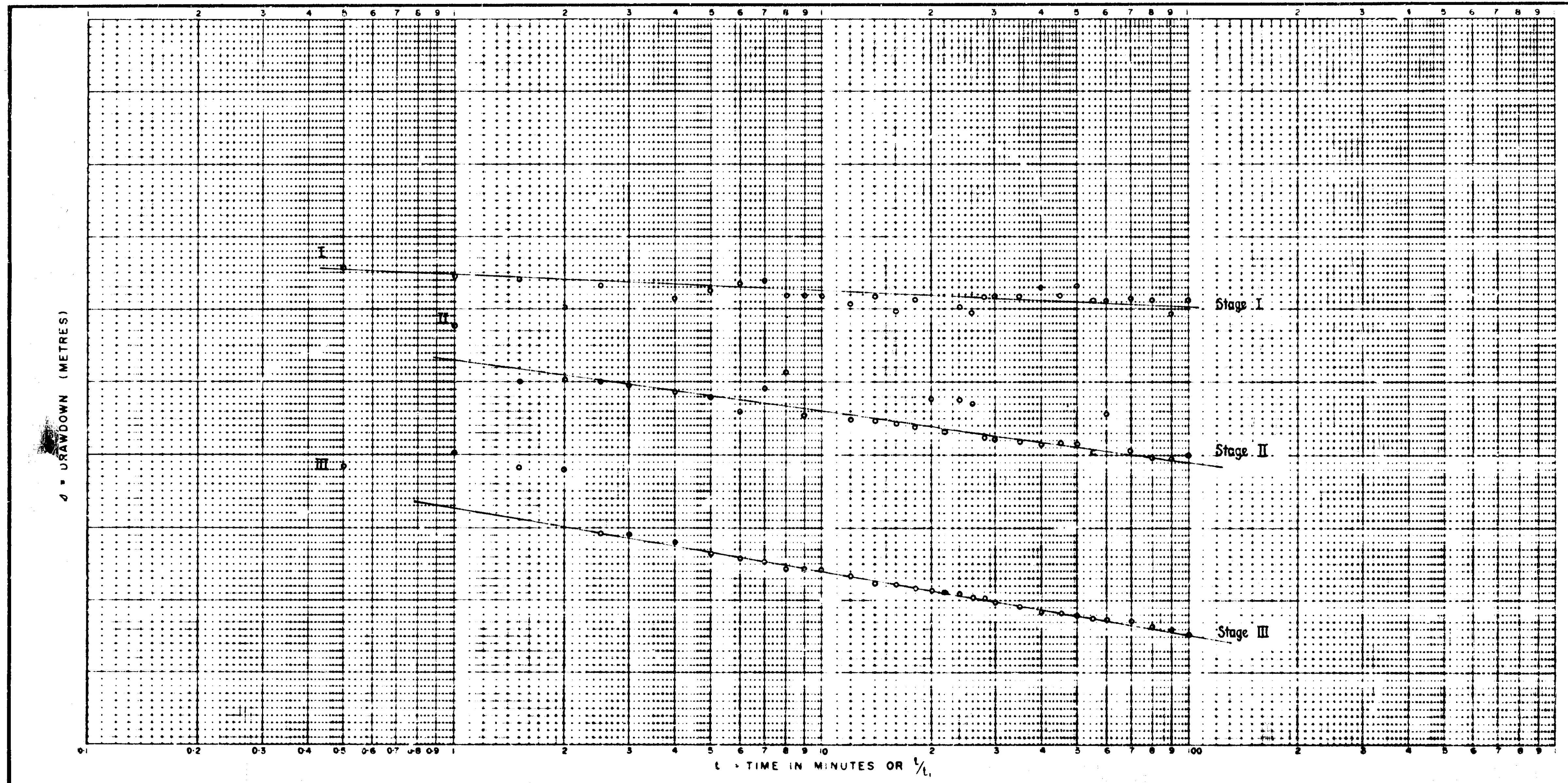


Fig. 1

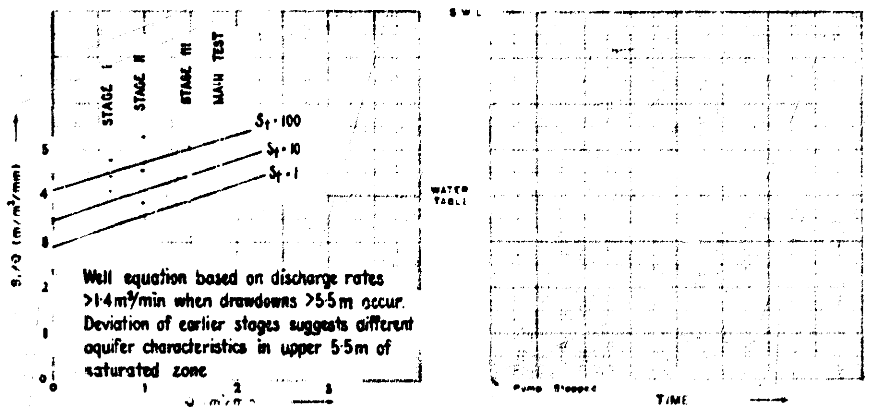
		DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE: AS SHOWN
COMPILED: M.A. Cobb		IRRIGATION WELL - D.J. MOUNT, KARTE SECTION 11 HD. KINGSFORD LOCALITY PLAN	DATE: DEC. 1978
DRN: M.H.R.	CKD:		PLAN NUMBER S 13819



STATF / UNIT No. OF WELL 7027 004 WW 00512

REF PT 1 (m) above ground
AQUIFER FROM 60 TO 182 (m)
HOLE DEPTH 207 (m)
AQUIFER TYPE ....
LITHOLOGY ....

TYPE OF PUMP LINE - SHAFT
LENGTH OF TEST 3 × 100 mins
DEPTH PUMP INTAKE (l_1) 100 (m)
DEPTH WATER LEVEL AT TEST START (l_2) 48·12 (m)
AVAILABLE DRAWDOWN 52 (m)



	Q (m³/min)	$S_t = 1$	$\frac{S_t = 1}{Q}$	$S_t = 10$	$\frac{S_t = 10}{Q}$	$S_t = 100$	$\frac{S_t = 100}{Q}$	Δs	$\frac{\Delta s}{Q}$
STEP 1	0·624	2·52	4·04	2·75	4·41	2·96	4·74		
STEP 2	0·972	2·71	3·82	4·4	4·53	5·1	5·25		
STEP 3	1·480	5·75	3·89	6·6	4·46	7·46	5·04		
MAIN	1·793	7·4	4·11	8·36	4·65	9·34	5·19		

WELL EQUATION $S_t = aQ + cQ^2 + bQ\log_{10}t$

or $S_t/Q = (a + b\log_{10}t) + cQ$

From S_t/Q versus Q   a = 2·30   b = 0·55   c = 0·65

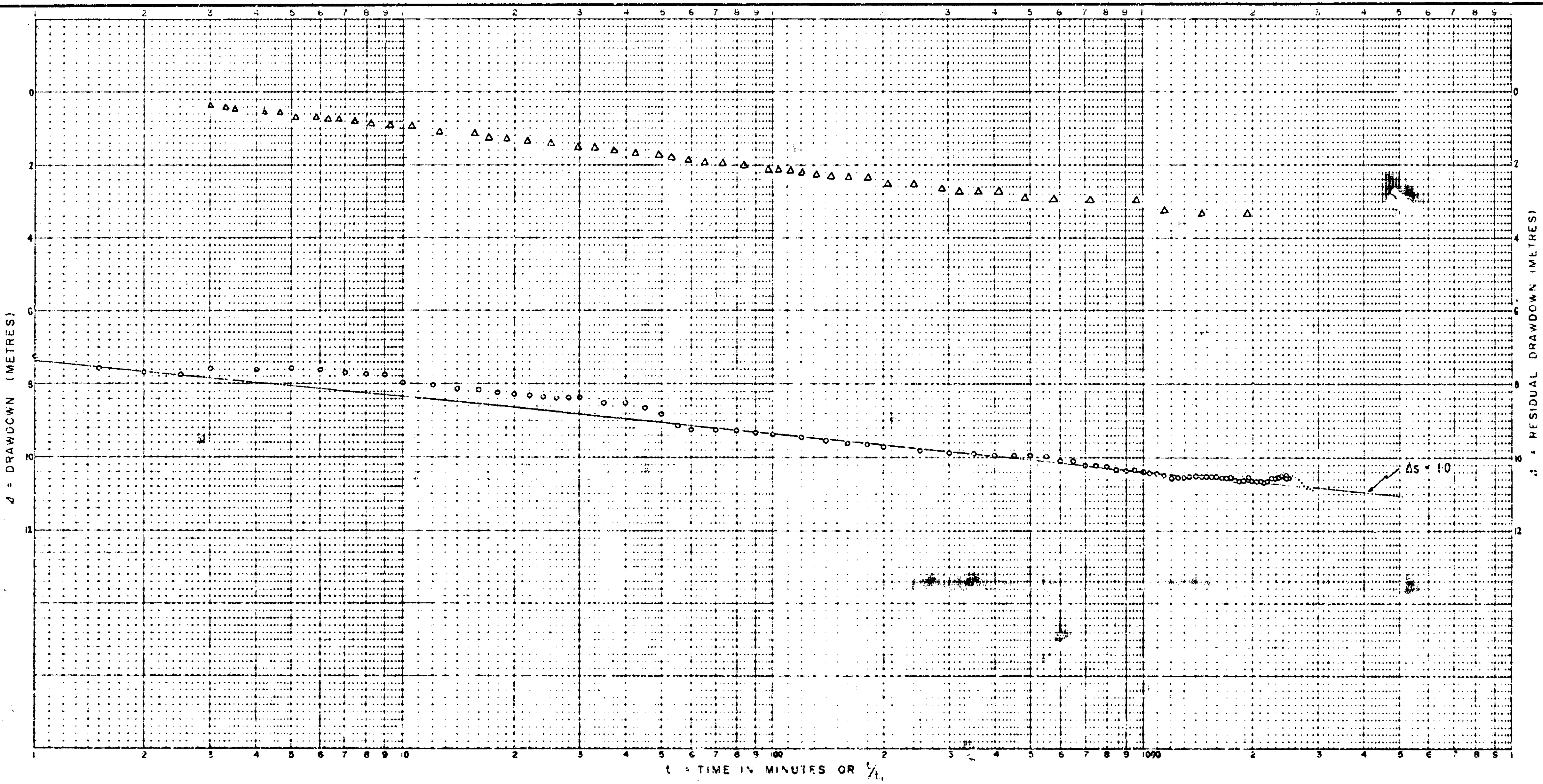
TRANSMISSIVITY = $\frac{0.183Q}{\Delta s}$ = (m³/day/m)

THEREFORE WELL EQUATION $S_t = 2{\cdot}3Q + {\cdot}65Q^2 + {\cdot}55\log_{10}t\,Q$

FIG. 2

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE 537/77
SUPPLIED M A Cobb	IRRIGATION WELL – D. J. MOUNT, KARTE	DATE 9th JAN 1979
T.E.	SECTION 11 HD. KINGSFORD STEP DRAWDOWN WELL TEST SEMI – LOG DRAWDOWN PLOT	PLAN NUMBER 79-19
GZ		

PF No. 69—953 WH



BOREHOLE STATE UNIT No 7027 004 WW 00512

REF PT 1 (m) above ground

AQUIFER FROM 60 TO 182 (m)

HOLE DEPTH 207 (m)

TYPE OF PUMP LINE-SHAFT

LENGTH OF TEST 48 hours

DEPTH WATER LEVEL AT TEST START (ℓ_2) 48·29 (m)

DEPTH PUMP INTAKE (ℓ_1) 100 (m)

* AVAILABLE DRAWDOWN 52 (m)

EQUATIONS

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

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_o = Zero drawdown time (mins)

r = Distance to Observation Bore (m)

1 day = 8.64×10^4 secs

DATA

Q	Δ_s	t_o	r
2590 m^3/day	1		

CALCULATIONS

$T = \frac{0.183 \times 2590}{1} = 475$ m^3/day/m

* Available drawdown = $\ell_1 - \ell_2$

FIG. 3

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

M. A. Cobb

T.E.

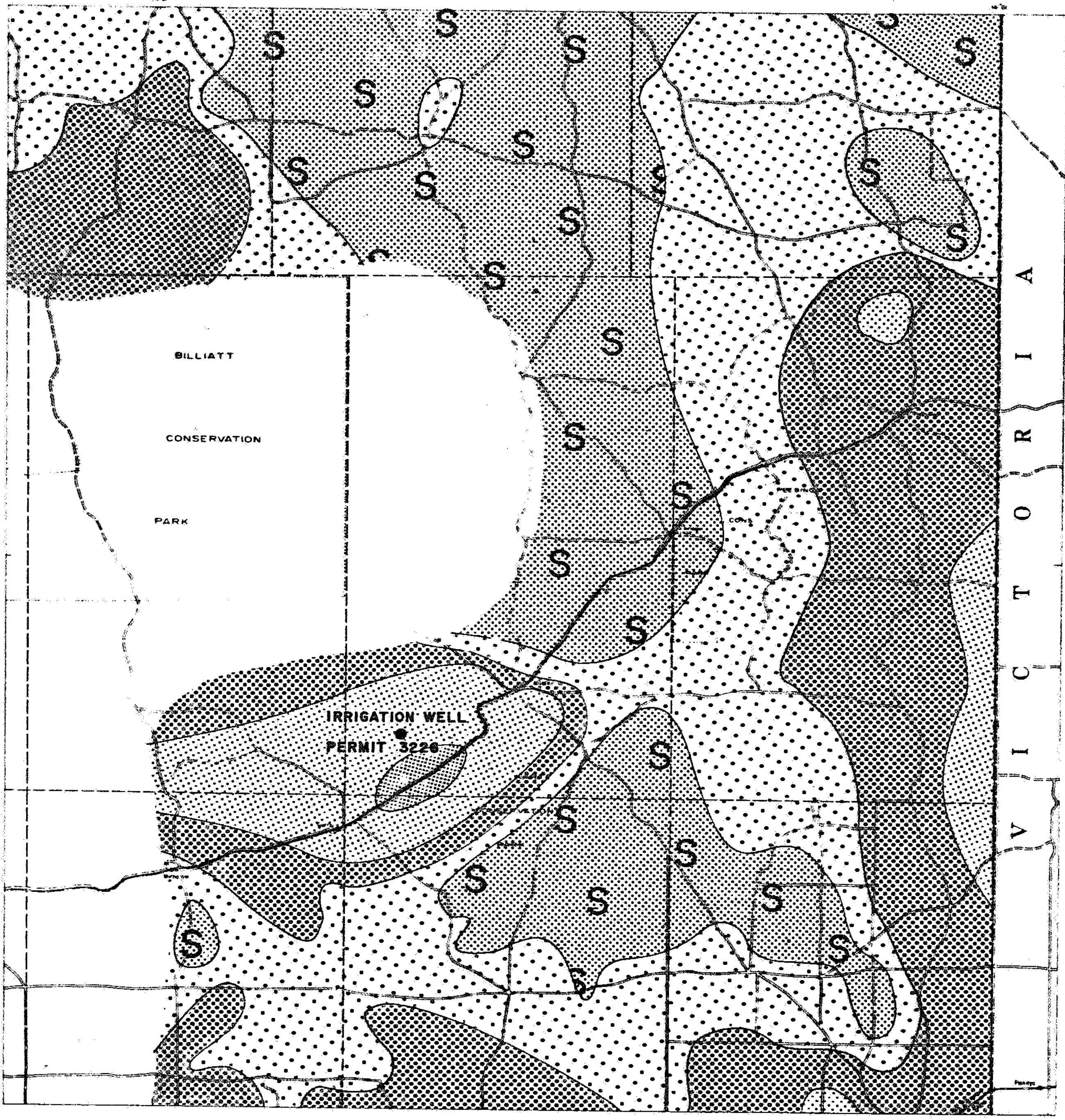
IRRIGATION WELL – D. J. MOUNT, KARTE
SECTION 11 HD. KINGSFORD
CONSTANT RATE WELL TEST
SEMI-LOG DRAWDOWN PLOT

D.M. 537/77

9th JAN 1979

79-20

I-F No. 69-953 MH



This plan is based on all salinity data available in the Department of Mines and Energy well record system. It reflects the salinity distribution in the uppermost portions of the unconfined Morgan–Mannum Limestone aquifer. Stratification of water quality in the limestone aquifer is known to occur.

SALINITY (mg/l)

No data	1,000 – 1,500
< 500	1,500 – 2,000
500 – 1,000	S > 2,000

FIG. 4

	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE: As shown
COMPILED: M.A. Cobb	IRRIGATION WELL – D. J. MOUNT, KARTE SECTION 11 HD. KINGSFORD	DATE: 15th JAN 1979
DRN. T.E. CKD	SALINITY DISTRIBUTION UPPER LIMESTONE AQUIFER	PLAN NUMBER S 13838
EJR		

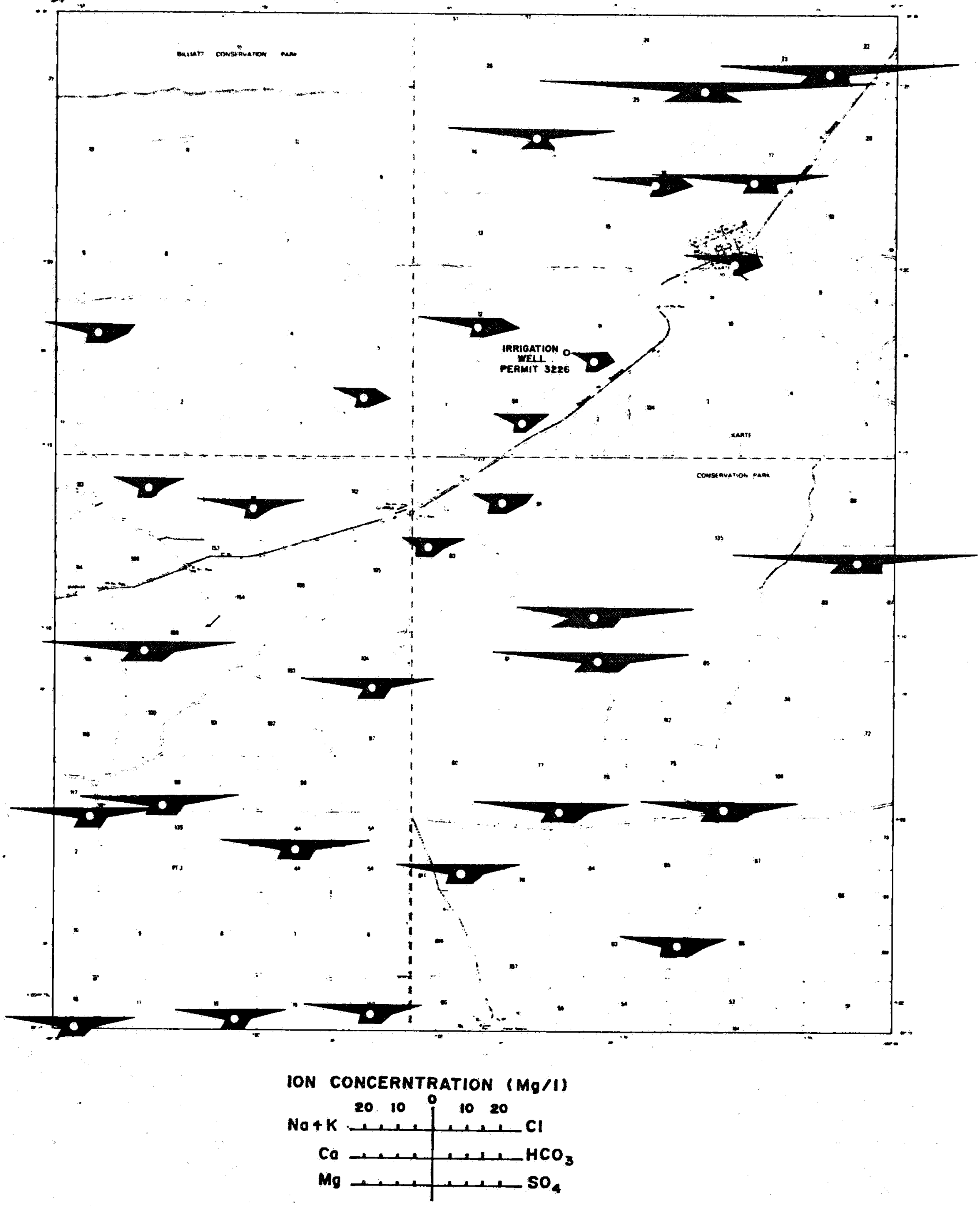


FIG. 5

		DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE: 1:
COMPILED: M. A. Cobb		IRRIGATION WELL — D. J. MOUNT, KARTE SECTION 11 HD. KINGSFORD STIFF DIAGRAMS	DATE: 15th JAN 1979
DRN: T.E.	CKD:		PLAN NUMBER S 13839